TACKLING MALNUTRITION:

IMPACT AND NUTRITIONAL SOLUTIONS LATER IN LIFE

Marije H. Verwijs

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CHAPTER 1

General introduction

General Introduction

Increased longevity

During the past centuries our life-expectancy has increased significantly. While in the 19th century reaching your 40th birthday was exceptional in Europe, reaching an age of 90 years of older is becoming more common nowadays[1,2]. Many reasons underly the more than doubled life-expectancy of human beings living in industrialized countries. Our general hygiene has improved enormously, but improved medicine and the change in lifestyle during the past decades also play an important role in our general health. While drinking, smoking and working in harsh circumstances from an early age were considered normal in the 19th century, it is known that these various factors have major negative effects on general health and life-expectancy.

Growing population of older adults

With the increasing life expectancy the number of older adults will continue to increase in the coming decades. In 2019, the percentage of adults aged 65 years and older in Europe was 20.3% and it is expected that this proportion will reach 31.3% in 2100[3]. This change in population composition may have consequences for many aspects in our society, such as the importance of maintenance of vitality, in which nutrition plays an important role.

Physical and mental deterioration in ageing

Even though happily turning 90 years old sounds wonderful, ageing often goes hand in hand with physical and mental deterioration[4–6]. The existence of two or more chronic diseases, also indicated as multimorbidity, is much more prevalent at a higher age[7–9]. Additionally, ageing is naturally associated with a reduction in muscle mass[10,11], leading to a reduced strength and physical capacities[12,13]. As a result, older adults may experience problems during their daily activities. Decreased muscle mass and function can also lead to an increased risk of falls or other accidents[14]. Additionally, ageing affects the brain. From approximately 30 years of age, brain volume starts to decrease[15]. At an older age, the decrease in brain volume and other factors may lead to decreased cognitive functioning[16]. In some persons, decrease in cognitive functioning seems to be more severe than in others. Eventually, this may lead to mild cognitive impairment or dementia. Dementia can have a significant impact on the daily lives of patients and their social environment[17–19].

The influence of lifestyle on healthy ageing

Some adults age healthier than others and this may be influenced by several lifestyle factors. Being overweight or obese, smoking and excessive alcohol consumption, but also nutrient inadequacy are known to decrease life expectancy, increase the risk of many diseases[20–24] and reduce cognitive functioning[25–27]. On the other hand, it is known that a healthy lifestyle and diet may increase our general health, even

in the case of multimorbidity[28,29]. A healthy dietary pattern as a whole or intakes of specific food groups and nutrients may have a protective effect on cognitive decline or may even improve specific cognitive domains[30–35]. With regard to retaining physical function during ageing, an adequate intake of dietary protein may play an important role[36]. Observational and intervention studies have shown that, to maintain adequate muscle synthesis and consequently physical function, older adults require a higher protein intake compared to younger adults[37–39]. The combination of physical exercise, in particular resistance training, with an adequate intake of nutritional protein has shown to reduce age-related decrease in muscle mass[40–43].

Malnutrition and consequences

Appetite of adults often declines and/or adults tend to eat less as they turn older[44]. This is known as the phenomenon "anorexia of ageing"[45–47]. Causes may lie in the social and environmental domain, but may also include age-related metabolic and sensory changes[48–50]. Altogether, this can lead to unintentional weight loss which is often accompanied by a decrease in muscle mass[48]. As a consequence, malnutrition is frequently present among older adults[51].

Malnutrition, also referred to as undernutrition, is defined as "a state resulting from lack of intake or uptake of nutrition that leads to altered body composition (decreased fat mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease"[52]. The development of malnutrition is complex and causes can be multifactorial[53]. Besides anorexia of ageing, many other factors can underlie the onset of malnutrition. Figure 1 displays various causes of malnutrition (first two layers around "malnutrition"), but also different levels to focus on in the prevention and treatment of malnutrition (outer layer). However, this figure mainly displays factors that are explained in more detail in this thesis.

The prevalence of malnutrition among older adults in Europe is high, ranging from 10% to over 50%[51,54–56], depending on the healthcare setting. However, it is challenging to measure the exact prevalence of (risk of) malnutrition, as many malnutrition screening tools and diagnostic tools have been developed in the past decades and not all tools are shown to be valid to use in every healthcare setting[57]. Therefore, it is important to identify the prevalence of malnutrition (risk) based on valid screening tools for each healthcare setting.

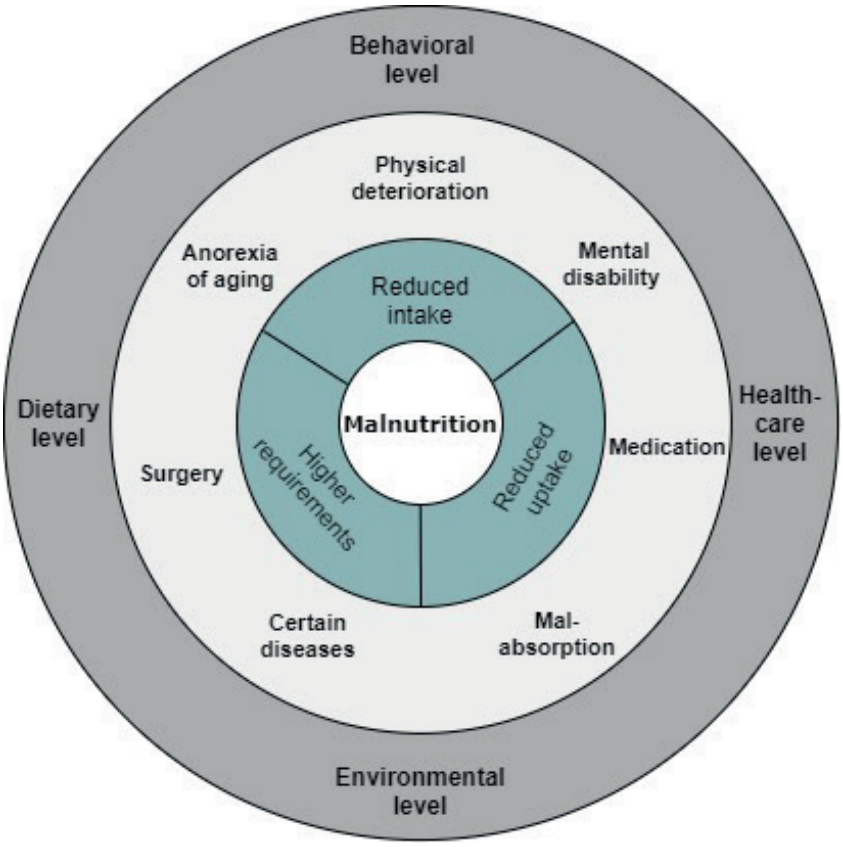

Figure 1: Possible causes of malnutrition (blue and light grey layer) and levels that will be focused on in this thesis for the prevention and treatment of malnutrition (dark grey outer layer)

Malnutrition may have large consequences for older adults, as it is a risk factor for physical and mental deterioration and even increases the risk of hospitalization and institutionalization[58]. Accordingly, malnutrition may impact healthcare costs considerably[59]. Even though it is difficult to identify the exact costs of malnutrition, in 2011 the total costs of disease-related malnutrition were estimated at €1.8 billion in the Netherlands. It is estimated that almost half of these costs are due to hospital costs of malnutrition in patients in the age of 60 years and older[60].

Current knowledge

Due to the increasing population of older adults and their growing healthcare demands, many studies have focused on the consequences of malnutrition later in life and on the possible benefits of nutrition interventions. Several (clinical) intervention studies have specifically investigated the effect of protein supplementation without and in combination with physical exercise. However, there are still a number of "knowledge gaps" that need to be explored to remedy and prevent malnutrition among older adults. Until now, current prevalence rates of malnutrition (risk) have often been limited to specific healthcare settings or specific research populations. As a result, the size of the malnutrition problem cannot properly be identified. Furthermore, multimorbidity is frequently present among older adults and this often increases the demand for healthcare. As lifestyle and diet have been proven to improve several health outcomes, it is important to investigate current practices in nutritional care across different healthcare settings. Additionally, it remains unclear how findings of intervention studies can be translated into practice in a way that older adults, who are undernourished or at risk of malnutrition, change their behavior and increase their energy and protein intake.

General aim

In conclusion, malnutrition affects the overall physical and mental health of older adults and our society. As this population is expected to increase vastly in the near future, it is important to gain more insights into the current diet of older adults and to look for nutritional strategies to prevent and treat malnutrition among older adults. Therefore, the overall aim of this thesis is to address the magnitude of the malnutrition problem among older adults, current practices in nutritional care and possible nutritional solutions to tackle malnutrition later in life. The nutritional solutions will focus on four different aspects: healthcare level, behavioral level, dietary level and environmental level.

Thesis outline

Chapter 2 provides insights into the magnitude of the malnutrition problem in Europe. Through a systematic review and meta-analyses the prevalence of malnutrition across different healthcare settings is presented. In *Chapter 3* we investigated current practices in nutritional care across different healthcare settings in the Netherlands, through perspectives of healthcare professionals, older adults themselves and their caregivers. *Chapter 4* provides insights into different behavioral determinants in relation to the risk of low protein intake among Dutch community-dwelling older adults. In *Chapter 5* we assessed data of the Dutch National Food Consumption Survey – Older Adults 2010-2012 to identify the "protein gap" in the diet of Dutch older adults. In *Chapter 6* the effect of a food odor intervention on the appetite and food intake of Dutch nursing home residents with dementia is shown. Finally, *Chapter 7* comprises the main findings of this thesis

including a discussion of the results, practical implications and aspirations for future research and nutritional care for older adults.

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CHAPTER 2

2

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

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Background

This systematic review and meta-analysis assesses the prevalence of protein-energy malnutrition risk across different healthcare settings in European older adults, using 22 malnutrition screening tools recently validated for use in older adults.

Methods

Systematic searches were performed in six electronic databases (2006 through 2017). Included were studies which reported malnutrition risk in adults aged ≥65y in Europe. Frequency of high and moderate malnutrition risk for each malnutrition screening tool was collated. Meta-analyses of malnutrition risk using a random-effects model were performed where data from at least 10 study samples were available.

Results

Of 21,465 studies, 196 studies were available for data extraction, representing 223 study samples from 24 European countries and 583,972 older adults. Pooled prevalence rates of high malnutrition risk across all countries and malnutrition screening tools were 28.0% ($n = 127$ study samples), 17.5% ($n = 30$), and 8.5% ($n = 32$), for the hospital, residential care and community settings respectively. Using meta-regression, prevalence rates were higher in adults aged >80y ($p < 0.0001$), in women ($p = 0.03$) and in patients with one or multiple comorbidities ($p < 0.0001$). Prevalence rates differed by country, from 15.2% in Spain to 37.7% in Switzerland, and by screening tool, from 14.9% using MNA-SF to 40.6% using NRS-2002.

Conclusion

In conclusion, the prevalence of high malnutrition risk in European older adults varies widely between countries and across healthcare settings. Malnutrition risk is associated with older age, gender and presence of disease. As prevalence rates differ depending on the screening tool used, the use of one preferred malnutrition screening tool per setting is strongly recommended.

Abstract

Introduction

The European population is estimated at 515 million inhabitants, of which 19% is currently aged 65 years and older. This is expected to increase to 29% in 2060[1,2]. Longevity is one of the main causes for the increasing number of people aged 65 years and older in Europe. Ageing is both wonderful and problematic, the latter because increased longevity often brings health-related issues[3], among which protein-energy malnutrition (PEM) is frequently observed[4,5]. PEM is associated with delayed recovery from disease, poorer quality of life and increased risk of morbidity and mortality[6]. The condition appears to be more prevalent among fragile elderly and in those having higher care needs, with prevalence rates dependent on age, the functional and marital status of participants, the health care setting and the tools or parameters used to determine malnutrition risk[7-10] Crichton et al. recently reported PEM prevalence rates between 2.5 and 16.5% among European community-dwelling adults, depending on the European region[11].

Screening is advised as a first step prior to a diagnosis of malnutrition[12], in order to identify persons at risk of malnutrition. Screening should be a standardized procedure, intended for application in a large number of persons, be quick, easy and practical, have high validity, and screening parameters should be easily accessible[13]. Identification of risk is the first step to starting timely, tailored nutritional interventions. Systematically screening medical inpatients on hospital admission for risk of malnutrition, independent of their medical condition, followed by individualized nutritional support in patients identified at risk of malnutrition improved important clinical outcomes, including survival, in a recent large Swiss study[14].

Numerous malnutrition screening tools have been designed over the past decades. However, most malnutrition screening tools are aimed at a specific target population, such as patients in a particular health care- or community setting[15-17]. In addition, malnutrition screening tools for younger adults are often used in older populations. Of all existing malnutrition screening tools worldwide, only 34 have been validated for use with older adults, and only 22 of these demonstrated acceptable validity for older adults in the specific setting in which they were tested[13]. Existing estimates of the prevalence of PEM risk among European older adults are generally restricted to specific settings, with non- and poorly validated malnutrition screening tools frequently included in analyses. Consequently, an accurate estimate of PEM risk in older adults across all health care and community settings is timely given the beneficial effects of systematic screening for malnutrition and early nutrition intervention in the recent Swiss study14.

The current study aimed to estimate the prevalence of malnutrition risk in older adults in Europe across different health care settings by performing a systematic review and pooled meta-analysis using data based on the 22 malnutrition screening tools recently selected for best validity in adults >65 years.

Methods

This review describes the results of work package 2.3 of the Joint Programming Initiative Healthy Diet for a Healthy Life MalNutrition in the ELderly (MaNuEL) Knowledge Hub[1]. The Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) statement was followed[18]. The project was registered in the PROSPERO database of systematic reviews with number CRD42017073246[19].

2.1 Search strategy

Systematic searches were performed in the bibliographic databases Medline (via EBSCO), PubMed, EMBASE (via OVID), CINAHL (via EBSCO), Cochrane and Web of Science from January 2006 to July 2017. Search terms included controlled terms from MeSH in Medline and PubMed, EMtree in EMBASE.com, CINAHL Headings in CINAHL, key words in Cochrane and Web of Science, and topic searches as well as free text terms in titles and abstracts. Search terms expressing 'malnutrition' and 'prevalence' were used in combination with search terms for 'adults', 'elderly', 'nutrition screening tools', and similar text or key words. The complete search strategies are presented in Supplementary Appendix A. Studies were imported and checked for duplicates in Endnote (Version 8.0) and then imported into Rayyan[20] for further screening.

2.2 Study selection criteria

As screening for PEM risk was recognized as important by the Council of Europe from 2003 onwards[21], it was decided to review studies published in the 10 years before the start of the MaNuEL project (2016–2018). Thus, studies published between January 2006 and July 2017 that reported malnutrition risk in European adults aged 65 years and older were eligible for inclusion. Manuscript titles and abstracts were screened using the following inclusion criteria: 1) older adults with a mean/median age ≥65 years or subgroups of older adults with a mean/median age ≥65 years, 2) malnutrition risk determined by at least one of the 22 validated malnutrition screening tools for older adults in the health care setting the screening tool was validated for, see Table 1[13], 3) in one or more European countries[22], and 4) data for sample size and number or percentage of older adults at risk of malnutrition were available. Studies were included if published in the Dutch, English, French, German, Italian, Portuguese or Spanish languages. Abstracts, reviews, editorials, letters, case studies, presentations or interviews were excluded. If the selection criteria could not be verified based on the title and/or abstract, full text screening was applied using the same criteria. Prospective observational, cross-sectional or retrospective cohort studies were eligible for inclusion; intervention studies were eligible if baseline data were reported (both intervention and control groups were considered). Screening and selection were performed by pairs of two reviewers (SL and SH, MHV and PG) independently, and

discrepancies were managed by consensus. Requested full text manuscripts that were not received by January 31, 2018, were not considered.

2.3 Data collection, extraction and quality assessment

Eligible study data were extracted from each individual study into a standardized database created in Excel (Microsoft Office 2013©). Studies that reported malnutrition rating scores only – without frequency data for malnutrition risk categories – were excluded during data extraction. Studies could provide data for one or more samples. In the case of several studies reporting the prevalence of malnutrition based on the same sample and when various malnutrition screening tools were applied to one sample, the sample was only included in the overall analyses once. For intervention studies, control and intervention groups were considered as one study sample, using baseline data only. The following characteristics for each sample were collected: sample size, gender, age (mean or median), country, year, malnutrition screening tool used, health care setting (i.e. hospital, rehabilitation, residential care, or community setting), a specific disease being an inclusion criterion in the study (yes/no), (co)morbidities (none, one, multi, unknown) and number of persons at moderate or high risk of malnutrition.

If a single underlying clinical condition was an inclusion criterion, morbidity was rated as "one"; if several comorbidities for the sample were reported, this was rated as "multi" for this sample. If only the percentage of those at risk of malnutrition was reported, the number at risk was calculated from the total sample. Studies in which the number of persons at risk could not be obtained were excluded during data extraction.

Study quality was assessed using a quality checklist for prevalence studies that contains criteria for external and internal validity, see Supplementary Appendix B[23]. This allocated one point for each answer that indicated high risk of study bias, to a maximum of 9 points. A score of 0–3 indicated low, 4–6 moderate and 7–9 high risk of bias. For the purpose of this study, the internal criterion 6 specified whether acceptable scoring of malnutrition risk for the given malnutrition screening tool was applied, i.e. correct cut-off values for the risk categories of the tool. Internal criterion 7 established whether the malnutrition screening tool was used in the health care setting in which it had been validated and studies not meeting this criterion were excluded a priori.

2.4 Outcome measures

The predefined primary outcome measure was high malnutrition risk as identified by each malnutrition screening tool included in this review. The number of persons in the high malnutrition risk category was reported for the total sample. As a secondary outcome measure, the combination of moderate and high malnutrition risk was calculated, thus providing prevalence data for any malnutrition risk within the sample. The combined

data were extracted from the studies when available. If unavailable, the sum of moderate and high risk prevalence data was calculated from the moderate and high risk categories separately.

2.5 Statistical analysis

Descriptive analyses were performed using IBM SPSS version 23 (Chicago, Ill., USA). General information for the sample was summarized. This included malnutrition screening tool used, country, year the study was conducted, health care setting and morbidity. The sample size, the number of persons at high malnutrition risk and the number at moderate and high malnutrition risk combined were summarized for each malnutrition screening tool separately and reported per country, health care setting (hospital, rehabilitation, residential care, or community setting) and gender. The mean age of each sample was calculated when only medians were reported[24]. Mean age was categorized into two age groups (65–80 y and >80 y)[25] and the number of persons per age group was calculated.
Pooled prevalence rates of high and combined moderate plus high malnutrition risk were calculated for all studies. In addition, stratified analyses were conducted for health care setting, country and screening tool separately. Within the stratified analyses for country and screening tool, additional analyses were conducted for each setting. To present valid estimates (i.e. to prevent conclusions based on too few data), data were pooled if at least ten samples were available for any subgroup estimate. Freeman-Tukey double arcsine transformation of prevalence data was applied before pooling and results were back transformed. A random effect was used for all pooled prevalences and pooled prevalence was reported with 95%CI, number of studies (n), sample size (ss) and heterogeneity based on I2 statistics.

To study whether malnutrition risk prevalence rates differed between countries, health care settings, malnutrition screening tool, gender, comorbidity or age group, univariate meta-regression analyses were performed. In these analyses "Spain", "hospital", "MNA-SF v1", "male", "comorbidity none" and "age 65–80 years" were used as reference group, respectively. Differences between other categories were tested based on 'Q-test on moderators coefficients'. R software version 3.5.1 (Metafor) was used to perform meta-analyses. A sensitivity analysis was performed on high and combined moderate plus high malnutrition risk whereby studies with moderate or high study bias were excluded. For all analyses a P-value <0.05 was considered significant.

Table 1: The 22 best validated malnutrition screening tools for older adults[13].

MALNUTRITION SCREENING TOOL abbreviation	MALNUTRITION SCREENING TOOL full name	Setting (validated)*
ANST African	Admission Nutritional Screening Tool - African	C RC
BAPEN Based NST	Bapen Nutritional Screening Tool	H
CNAQ	Council on Nutrition Appetite Questionnaire	RC R
CNS Chinese	Chinese Nutrition Screening	RC
CNST Canadian	Canadian Nutrition Screening Tool	H
CONUT	Controlling Nutritional Status	H
DETERMINE	DETERMINE Your Nutritional Health Checklist of the of the Nutrition Screening Initiative	C RC
GNRI	Geriatric Nutrition Risk Index	C H RC
INST Icelandic	Icelandic Nutrition Screening Tool7	H
Manchester NST	Manchester Nutrition Screening Tool	H
MNA-SF V1	Mini Nutritional Assessment Short Form V1	C H RC
MNA-SF V2	Mini Nutritional Assessment Short Form V2 (revised SF with calf circumference)	C RC R
MRST-H	Malnutrition Risk Screening Tool-Hospital	C
MST	Malnutrition Screening Tool	H RC R
MUST	Malnutrition Universal Screening Tool	C H RC
NRAT	Nutritional Risk Assessment Tool	C
NRS-2002	Nutritional Risk Screening 2002	H
NUFFE	Nutritional Form For the Older adults (Sweden)	R
SCREEN II	Seniors in the Community Risk Evaluation for Eating and Nutrition, version II	C
SNAQ	Short Nutritional Assessment Questionnaire (Netherlands)	C
SNAQ ^{RC}	Short Nutritional Assessment Questionnaire Residential Care (Netherlands)	RC
SNAQ	Simplified Nutritional Appetite Questionnaire (United States)	R

* C = community, H = hospital, RC = Residential Care, R = Rehabilitation

Results

3.1 Study characteristics

From a total of 21,465 articles, 196 studies were included for data extraction and analyses (Fig. 1). Within studies, multiple samples could be described and several malnutrition screening tools had been applied. Therefore, 196 studies resulted in 223 unique samples, providing data for 252 sub-samples, i.e. when a study reported on the same sample with either two (n = 25), three (n = 5) or four (n = 1) malnutrition screening tools. Samples were included from a single setting (n = 188) or from multiple settings (n = 35). The majority (84%) of studies used a prospective observational design, the remainder were intervention (9%), retrospective cohort (5%) or combined (2%) studies. Data from 10 of the 22 preferred malnutrition screening tools [13] were available in the selected studies: Controlling Nutritional Status (CONUT; n = 8), Geriatric Nutritional Risk Index (GNRI; n = 19), Mini Nutritional Assessment-short form version 1 (MNA-SFv1; n = 107), Mini Nutritional Assessment-short form version 2 (MNA-SFv2, n = 5), Malnutrition Screening Tool (MST; n = 4), Malnutrition Universal Screening Tool (MUST; n = 50), Nutrition Risk Screening (NRS-2002; n = 49), Nutritional Form For the Older adults (NUFFE; n = 1), Seniors in the Community Risk Evaluation for Eating and Nutrition (SCREEN II; n = 1) and the Short Nutritional Assessment Questionnaire (SNAQ; n = 8). The studies were performed in 26 European countries, with the number of studies per country ranging from 1 (Albania, Czech Republic, Croatia, Hungary, Romania, Slovakia) to 44 (Spain). In eight countries, 10 or more samples were derived: France (n = 16), Germany (n = 24), Italy (n = 26), Spain (n = 44), Sweden (n = 17), Switzerland (n = 15), Turkey (n = 18) and the United Kingdom (n = 25). However, data on both high and combined moderate plus high malnutrition risk were provided in only 140 samples (Supplementary Appendix C). Studies had been conducted between 2000 and 2016.

3.2 Quality of the studies

The risk of study bias was low (n = 178) or moderate (n = 18) in the studies included in the meta-analysis (Supplementary Appendix C). The contribution of the individual items to the checklist showed that external validity was low in 93% of the 196 studies as the target population was not nationally representative for the country, and in 54% of the studies due to non-response bias, i.e. malnutrition risk was not assessed in all persons included in the study. Study bias was mainly increased due to poor application of an acceptable definition of malnutrition being indicated, for example, in 22% of studies, incorrect cut-off values for the different categories of malnutrition risk had been applied (n = 42).

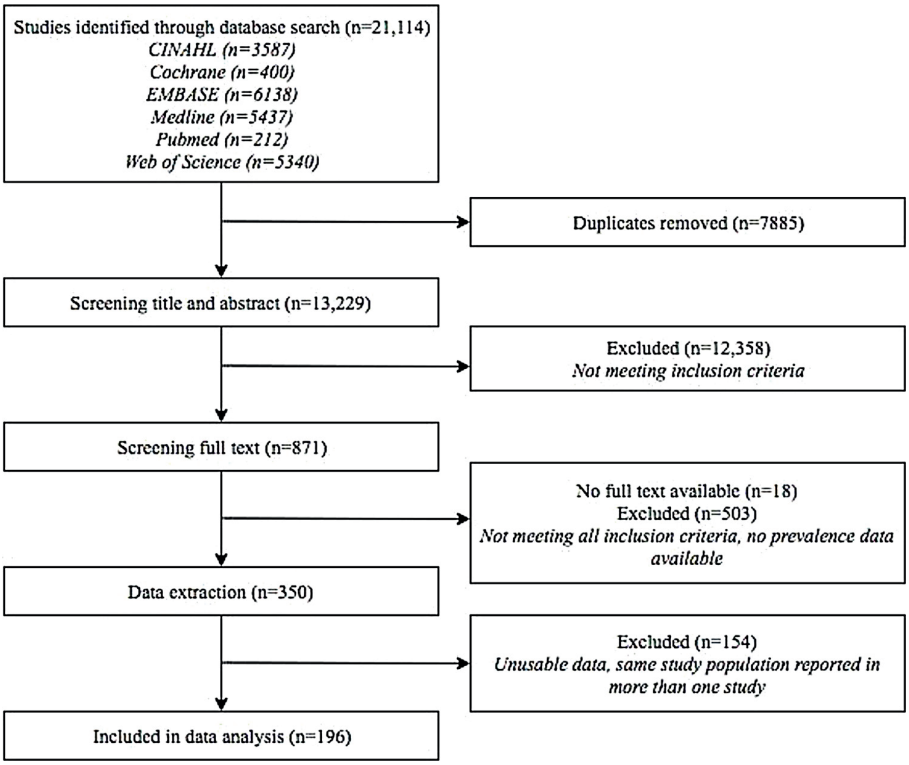

Figure 1: PRISMA flow-chart of studies screened and reviewed for inclusion in this MaNuEL study.

3.3 Sample characteristics

Descriptive statistics for the 223 samples are presented in Table 2. In 55% of studies, an inclusion criterion for age of at least 65 years or older had been applied. In the remainder of the studies, no age criterion (n = 54), age ≥18 years (n = 29) or age ≥60 years (n = 17) were applied; these studies were included based on mean/median age of at least 65 years. One-third (n = 79) of the studies applied an inclusion criterion for a single underlying clinical condition, e.g. hip fracture, heart disease, Parkinson's disease or cancer.

3.4 Prevalence of malnutrition risk

3.4.1 Prevalence of high malnutrition risk

High malnutrition risk, pooled for Europe (all countries combined), all health care settings and all malnutrition screening tools was 22.6% [95%CI: 20.9–24.3, n = 191, ss = 567,682, I2 = 99%] (Table 3a). For hospital, residential care and community settings this was 28.0% [95%CI: 26.0–30.1, n = 127, ss = 523,520, I2 = 98%], 17.5% [95%CI: 12.1–23.6, n = 30, ss = 19,735, I2 = 99%] and 8.5% [95%CI: 5.7–11.7, n = 32, ss = 24,280, I2 = 98%], respectively. Too few data (<10 samples) were available to perform meta-analyses for the rehabilitation

setting. For all malnutrition screening tools and all settings combined, sufficient data from seven individual countries were available to perform pooled prevalence analyses (Table 3a). The highest overall malnutrition risk was recorded in Switzerland (37.7% [95%CI: 28.0–47.9, n = 15, ss = 11,277, I2 = 98%]) and the lowest risk in Spain (15.2% [95%CI: 9.2–22.3, n = 36, ss = 19436, I2 = 98%]. Similar risk prevalence data were seen for the hospital setting across all countries.

3.4.2 Prevalence of combined moderate and high malnutrition risk

Pooled prevalence rates of combined moderate and high malnutrition risk using all malnutrition screening tools was 48.4% [95%CI: 45.1–51.8, n = 203, ss = 107,607, I2 = 99] (Table 3b). Risk of malnutrition was highest in the hospital setting (53.0%[95%CI: 48.9–57.1, n = 114 ss = 52,950, I2 = 99%], followed by 51.8% [95%CI: 44.4–59.0, n = 38 ss = 23,522, I2 = 99%] in residential care and 32.7% [95%CI: 27.0–38.7, n = 48, ss = 28,338, I2 = 99%] in the community setting. Too few data (<10 samples) were available to perform meta-analyses for the rehabilitation setting. Sufficient data were available for country-specific estimates for France, Germany, Italy, Spain, Sweden, Turkey and the United Kingdom (Table 3b). This analysis revealed a malnutrition risk (moderate and high risk combined) ranging from 41.3% in Spain [95%CI: 33.1–49.7, n = 38, ss = 18,894, I2 = 99%] to 67.4% in Sweden [95%CI: 58.5–75.7, n = 13, ss = 4,239, I2 = 97%]. For the hospital setting, prevalence of combined moderate and high malnutrition risk was highest in Spain and lowest in Germany.

3.4.3 Sensitivity analyses

Sensitivity analyses were performed whereby studies with moderate risk of bias (n = 21) were removed; none of the studies had high risk of bias. This resulted in an overall prevalence of high malnutrition risk of 22.2% [95%CI: 20.4–24.0, n = 174, ss = 561,496, I2 = 99%], and combined moderate and high malnutrition risk of 48.9 [95%CI: 44.5–51.5, n = 187, ss = 105,234, I2 = 99%], using all malnutrition screening tools combined.

3.4.4 Prevalence of malnutrition risk per malnutrition screening tool

Sufficient malnutrition risk data were available to allow pooled prevalence estimates for four malnutrition screening tools: GNRI, MNA-SFv1, MUST and NRS-2002. Table 4a shows that malnutrition risk (hospital setting) differed by screening tool from 18.8% [95%CI: 14.7–23.3, n = 41, ss = 13,208, I2 = 97%] for MNA-SFv1 to 41.5% [95%CI: 34.3–48.9, n = 42, ss = 29,919, I2 = 99%]) for NRS-2002. For moderate plus high malnutrition risk combined, this ranged from 39.9% [95%CI: 32.3–47.7, n = 23, ss = 20583, I2 = 99%] for MUST to 63.1%[95%CI: 47.8–77.3, n = 16, ss = 7,355, I2 = 99%]) for NRS-2002 (Table 4b). Data for residential care and community settings were only available for MNA-SFv1, being 18.5% [95%CI: 13.0–24.8, n = 13, ss = 11,754, I2 = 98%] and 5.2% [95%CI: 3.1–7.7, n = 19, ss = 13697, I2 = 97%] respectively.

Table 2: Characteristics of the study samples

	Number of study samples	Sample size	
	(n)	(n)	(%)
Total	223	583,972	100
Males	183	263,005	45
Females	183	285,487	49
Gender not reported	41	35,480	6
Health care setting			
Hospital	138	528,822	91
Rehabilitation	3	2,797	<1
Residential care	35	22,183	4
Community	47	30,170	5
Inclusion criterion for disease[a]			
No	144	545,523	93
Yes	79	38,449	7
Morbidity[b]			
None	20	8,568	1
Mono	13	3,050	1
Multi	108	516,794	88
Not reported	82	55,560	10
Age group based on sample mean			
65-80 year	85	45,189	8
>80 year	68	28,899	5
Not reported	70	509,884	87

[a]A single underlying clinical condition was an inclusion criterion, e.g. patients with heart disease, cancer, Parkinson's disease, etc.
[b]Baseline characteristics based on inclusion criteria and reported morbidity of study sample

3.5 Meta regression analyses

Meta-regression analyses showed that the pooled prevalence of high malnutrition risk was different between malnutrition screening tools (model: $P < 0.0001$), countries (model: $P < 0.0001$), and health care settings (model: $P < 0.0001$). Meta-regression also showed that pooled prevalence of malnutrition risk was higher in persons aged >80 years and in women (Table 5). Pooled prevalence rates for high malnutrition risk were different between persons with different numbers of morbidities, i.e. none, one or multi-morbidity ($P < 0.05$ for the model), but this was not the case for combined moderate and high malnutrition risk ($P = 0.51$). Multivariate analyses including country, setting and screening tool were not possible due to the small numbers, i.e. less than 10 samples for which data were available within the strata. The heterogeneity of the malnutrition risk prevalence data was higher than 90%, indicating high heterogeneity in our dataset.

Table 3a: Pooled prevalence rates of high malnutrition risk in European older adults and per health care setting, all malnutrition screening tools combined[a]

Countries	Number of study samples	Sample size	Prevalence of malnutrition risk		Hetero geneity I^2	Health care setting											
						Hospital				Residential care				Community			
						Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2
	(n)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)
Europe	191	567,682	22.6	20.9 – 24.3	99.3	128	28.0	26.0 – 30.1	99.3	30	17.5	12.1-23.6	99.1	32	8.5	5.7-11.7	98.5
Germany	22	10,068	24.4	18.3 – 31.1	98.1	15	33.9	26.4-41.8	97.3	-	-	-	-	-	-	-	-
Italy	16	7,595	24.9	14.4 – 37.2	99.2	-	-	-						-	-	-	-
Spain	36	19,436	15.2	9.2 – 22.3	99.3	20	23.5	12.8-36.2	99.3					10	3.3	1.3-6.0	94.7
Sweden	12	1,906	29.6	21.6 – 38.3	93.0	-	-	-	-		-	-	-	-	-	-	-
Switzerland	15	11,277	37.7	28.0 – 47.9	99.1	14	36.2	26.3-46.7	99.1		-	-	-	-	-	-	-
Turkey	16	4,990	24.6	16.6 – 33.6	97.7	13	27.7	16.7-40.3	97.8		-	-	-	-	-	-	-
United Kingdom	23	17,551	25.4	20.4 – 30.4	97.4	18	24.5	19.5-29.9	97.3		-	-	-	-	-	-	-

[a]prevalence estimated if number of study samples was ≥10; insufficient data from Belgium, France, Greece, and the Netherlands.

Table 3b: Pooled prevalence rates of combination of moderate and high malnutrition risk in European older adults and per health care setting, all malnutrition screening tools combined[a]

Countries	Number of study samples	Sample size		Prevalence of malnutrition risk	Hetero geneity I^2	Health care setting											
						Hospital				Residential care				Community			
						Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2
	(n)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)
Europe	203	107,607	48.4	45.1-51.8	99.2	114	53.0	48.9-57.1	98.8	38	51.8	44.4-59.0	99.2	48	32.7	27.0 -38.7	99.1
France	16	6,321	50.5	40.3-60.6	98.4	10	49.4	40.6-58.3	96.2								
Germany	19	5,550	63.9	49.7-77.0	99.1	12	78.5	66.0-88.9	98.3								
Italy	25	12,940	47.1	36.0-58.3	99.4					11	42.1	23.9-61.5	99.5				
Spain	38	18,894	41.3	33.1-49.7	99.2	20	44.9	38.4-51.6	95.6					11	24.7	15.6-35.1	98.6
Sweden	13	4,239	67.4	58.5-75.7	96.8					-	-	-	-	-	-	-	-
Turkey	15	7,048	52.2	41.6-62.7	98.6	11	53.0	38.8-66.9	97.8	-	-	-	-	-	-	-	-
United Kingdom	22	17,745	45.1	37.8 -52.4	98.5	16	43.0	36.2-50.0	97.9	-	-	-	-	-	-	-	-

[a]prevalence estimated if number of study samples was ≥10; insufficient data available from Belgium, Greece, the Netherlands, and Switzerland

Table 4a: Pooled prevalence rates of high malnutrition risk in European older adults per malnutrition screening tool, all countries combined[a]

Malnutrition screening tool[b]	Number of study samples	Sample size	Prevalence of malnutrition risk, all countries combined		Hetero geneity I^2	Health care setting											
						Hospital				Residential care				Community			
						Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2
	(n)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)
GNRI	12	2,918	19.0	9.7-30.6	97.9	-				-	-	-	-	-	-	-	-
MNA-SFv1	74	38,708	14.9	12.0-18.1	98.5	41	18.8	14.7-23.3	97.3	13	18.5	13.0-24.8	98.4	19	5.2	3.1-7.7	96.7
MUST	43	146,431	26.9	22.0-32.0	99.4	27	31.9	26.5-37.6	99.3	-	-	-	-	-	-	-	-
NRS-2002	43	30,117	40.6	33.5-47.9	99.3	42	41.5	34.3-48.9	99.3	-	-	-	-	-	-	-	-

[a]prevalences estimated if number of study samples was ≥10; insufficient data available for CONUT, MNA-SFv2, SCREEN II, and SNAQ.
[b]GNRI=Geriatric Nutrition Risk Index[43], MNA-SFv1=Mini Nutritional Assessment Short Form version 1[44], MUST=malnutrition universal screening tool[45]; NRS-2002=Nutritional Risk Screening 2002[38]

Table 4b: Pooled prevalence rates of the combination of moderate and high malnutrition risk in European older adults per malnutrition screening tool, all countries combined[a]

Malnutrition screening tool[b]	Number of study samples	Sample size	Prevalence of malnutrition risk, all countries combined		Hetero geneity I^2	Health care setting											
						Hospital				Residential care				Community			
						Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2	Number of study samples	Prevalence of malnutrition risk		Hetero geneity I^2
	(n)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)	(n)	(%)	[95%CI]	(%)
GNRI	17	5,417	39.7	31.2-48.4	97.4	-	-	-	-	-	-	-	-				
MNA-SFv1	102	52,004	53.6	48.7-58.5	99.2	50	60.8	54.6-66.9	98.2	18	67.6	59.9-74.8	98.9	32	32.4	25.6-39.6	99.1
MUST	41	27,674	39.0	32.3-45.9	99.2	23	39.9	32.3-47.7	99.0	-	-	-	-				
NRS-2002	17	7,553	62.3	47.7-75.9	99.3	16	63.1	47.8-77.3	99.3	-	-	-	-	-	-	-	-

[a]prevalences estimated if number of study samples was ≥10; insufficient data available for CONUT, MNA-SFv2, SCREEN II, and SNAQ
[b]GNRI=Geriatric Nutrition Risk Index[43], MNA-SFv1=Mini Nutritional Assessment Short Form version 1[44], MUST=malnutrition universal screening tool[45]; NRS-2002=Nutritional Risk Screening 2002[38].

Table 5: Pooled prevalence rates for high malnutrition risk and the combination of moderate and high malnutrition risk in European older adults in age groups and gender

Malnutrition risk	High						Combined moderate and high					
	Number of study samples	Sample size	Prevalence of malnutrition risk		Hetero geneity I^2	P-value*	Number of study samples	Sample size	Prevalence of malnutrition risk		Hetero geneity I^2	P-value*
	(n)		(%)	[95%CI]	(%)		(n)	(n)	(%)	[95%CI]	(%)	
Age group												
65-80 years	68	35,672	20.6	15.9-25.7	99	<0.0001	74	40,733	40.1	35.2-45.1	99	<0.0001
>80 years	56	22,176	22.6	18.4-27.0	98		69	29,802	56.9	51.5-62.3	99	
Gender												
Females	41	244,815	23.5	20.9-26.1	99	0.03	64	251,989	41.2	37.4 – 45.0	99	<0.001
Males	37	235,166	20.4	18.0-22.9	99		58	238,804	36.5	32.8 – 40.3	99	

*meta-regression analyses of between age-groups or gender

Discussion

To our knowledge, this is the first meta-analysis that provides general prevalence data for protein-energy malnutrition risk in older adults across Europe as well as prevalence data within different health care settings, based on the identification of risk by malnutrition screening tools validated for use in older adults. Our systematic review shows that as many as 23% of European older adults are at high risk of malnutrition and that more than double this number (48.4%) is at some malnutrition risk, i.e. moderate and high malnutrition risk combined. Considerable differences in high malnutrition risk were observed between the four settings in our study; these ranged from 8.5% in community-dwelling older adults to 28.0% in the hospital setting. These prevalence data are consistent with previous estimates in older persons[9,26-28].

Both in previous studies as in ours, the majority of data was obtained from the hospital setting. The prevalence of high malnutrition risk in the rehabilitation setting (only two studies) was higher than that observed in the hospital setting. In the residential care setting in countries outside the EU, the reported prevalence of high malnutrition risk ranged from 31% to 70%[28-31], depending on the screening tool used and the level of care required. This is in line with the European findings from this meta-analysis.

Based on European data, the lowest prevalence of malnutrition risk was observed in the community. Low prevalence data for the community were also observed in a review by Cereda, covering all continents, indicating malnutrition risk to be less than 5%, using the MNA[32]. In contrast, a meta-analysis of ten studies within and outside Europe indicated that malnutrition risk in community-dwelling older adults, again assessed by the MNA (both short and long forms), was as high as 19%[33]. The mean age in that population was 77.2 ± 6.7 years and 49.2% of those at malnutrition risk were frail, suggesting selection bias i.e. the inclusion of patients with higher health risks. This underlines the importance of recording clinical background, as differences between malnutrition risk in the community may be attributed to differences in characteristics and (co)morbidities of the older adults included. This is confirmed in the current review which showed that persons with one or more reported morbidities were more often at high malnutrition risk than those with none. Both Cereda's review[32] and a recent Australian review[11] concluded that malnutrition was directly associated with the level of dependence, and that this in turn was related to the care setting.

Malnutrition risk was higher in the older old than in the younger old in our review. This has been previously described in the hospital setting[28,34,35], but we have now shown that this is consistent across settings, and independent of the screening tool used. A review by Elia and Stratton[36] highlighted that age per se is better in predicting adverse outcomes than

any malnutrition screening tool. Our review confirms that the older old require additional consideration of their malnutrition risk. In line with previous reviews[9,11,37], malnutrition risk was higher in females than in males. Although higher frailty has been observed in female elderly[38] it is still unclear what factors may play a role in this difference in risk.

Our data show that the malnutrition screening tool used significantly affects the prevalence of malnutrition risk. Many of the malnutrition screening tools used in the published literature have not been validated for specific use in older adults. This may have distorted the results from studies that have previously attempted to estimate the prevalence of malnutrition risk. In our study, the overall pooled prevalence of high malnutrition risk was lowest in studies using MNA-SFv1 and highest in studies using NRS-2002[39]. When any malnutrition risk was considered, i.e. moderate and high risk combined, the pooled prevalence was highest in studies applying either MNA-SFv1 or NRS-2002. A previous systematic review has already suggested that MNA-SF may overestimate moderate malnutrition risk, based on low specificity of the tool[16]. In addition, MNA-SF relies on questions reflecting general health. Thus, this commonly used tool may be appropriate for estimating high risk, but not for moderate risk of malnutrition. Our study data cannot confirm this hypothesis, but we suggest that the accuracy of the MNA-SF should be further defined, for example, by comparison with the recently defined Global Leadership Initiative on Malnutrition (GLIM) criteria as a reference[12]. The high prevalence of malnutrition risk in studies using NRS-2002 may be explained by the fact that the tool adds one point for those aged over 70, and the presence of chronic disease adds at least another point. As most older adults admitted to hospital have at least one or more (co) morbidities, achieving the three points required to be categorized as at risk of malnutrition with NRS-2002 is likely to occur too frequently.

It must be acknowledged that many other factors are associated with increased malnutrition risk, such as hospitalization, functional capacity and marital status[10]. These parameters are not often incorporated into malnutrition screening tools, although more holistic tools assessing any nutritional risk, such as DETERMINE or SCREEN, do consider these aspects[40,41]. In the recent review by Power[13], DETERMINE scored most highly for identification of malnutrition risk in the community setting when the quality of the validation studies, the parameters included in the tool and the practicability of the tool for use with older persons were considered. Unfortunately, there were too few studies applying DETERMINE and SCREEN to be able to collate an estimate of the prevalence of malnutrition risk based on these two tools.

Limitations

Our prevalence estimates show a high heterogeneity (>90%) which probably reflect factors within the studies included: for the majority of studies, the selected study sample(s) were not nationally representative; studies were predominantly conducted in the hospital setting and/or contained data from one or two sites only within one country. In addition, patient and disease characteristics differed between the studies. Despite the inclusion of almost 200 studies, the variation between these studies hindered sensitivity analyses. To create subgroups of at least ten study samples with more or less homogeneous study characteristics proved impossible. Nevertheless, this meta-analysis has established an estimate of overall prevalence based on 223 study samples and a total of 583,972 persons. Most importantly, only data from malnutrition screening tools that have been specifically validated in the older population were included[42].

Implications for practice

Malnutrition is a major burden for patients and health care professionals. In 2014, the Optimal Nutritional Care for All campaign was started to facilitate greater screening for risk of malnutrition and nutrition care implementation in Europe[43]. To improve the overall outcomes from nutritional treatment, it is necessary to first identify patients at risk of malnutrition[14]. Knowing which tools are validated for use in older adults, and knowing the (sub)populations at higher risk (depending on age, gender, disease background, care setting) is a first step towards designing cost-effective malnutrition risk screening strategies.

In conclusion, this systematic review showed that in studies published over the past decade, the prevalence of high malnutrition risk among older adults in Europe was 28.0% in the hospital, 17.5% in residential care and 8.5% in the community setting. As only data from validated malnutrition screening tools were used to calculate these overall risk prevalences, our estimates are currently the most accurate available. Prevalence differed by health care setting, country and malnutrition screening tool used and was higher in the older old and females. To facilitate the implementation of routine malnutrition risk screening, to accurately compare the risk of malnutrition in older adults across countries and health care settings, and to initiate and evaluate effective interventions for malnutrition, the standardized use of one preferred malnutrition screening tool per health care setting is strongly recommended.

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Appendices

Appendix A – Search Strategies

Search strategy in Cinahl July 11, 2017

Set	Search terms
1	(TI (GNRI* OR (Geriatric W0 Nutrition* W0 Risk*) OR NUFFE OR (Nutritional W0 Form W3 Elderly))) OR (AB (GNRI* OR (Geriatric W0 Nutrition* W0 Risk*) OR NUFFE OR (Nutritional W0 Form W3 Elderly))) OR (SU (GNRI* OR (Geriatric W0 Nutrition* W0 Risk*) OR NUFFE OR (Nutritional W0 Form W3 Elderly)))
2	(TI (bapen* or CNAQ or (NRS N1 2002) or (screen N0 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* W1 screening W1 tool*) or (malnutrition* W1 screening W1 tool*) or (Nutrition* W1 Risk W1 Assessment W1 Tool*) or (Nutrition* N1 Appetite N1 Questionnaire*) or (Nutrition* W1 Risk* W1 Screening) or conut* or mnasf or (mna N1 sf) or (MRST N1 H*) OR (Short W1 Nutrition* W1 Assessment W1 Questionnaire*) or (determine N1 checklist) OR (your N0 nutritional N0 health))) OR (AB (bapen* or CNAQ or (NRS N1 2002) or (screen N0 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* W1 screening W1 tool*) or (malnutrition* W1 screening W1 tool*) or (Nutrition* W1 Risk W1 Assessment W1 Tool*) or (Nutrition* N1 Appetite N1 Questionnaire*) or (Nutrition* W1 Risk* W1 Screening) or conut* or mnasf or (mna N1 sf) or (MRST N1 H*) OR (Short W1 Nutrition* W1 Assessment W1 Questionnaire*) or (determine N1 checklist) OR (your N0 nutritional N0 health))) OR (SU (bapen* or CNAQ or (NRS N1 2002) or (screen N0 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* W1 screening W1 tool*) or (malnutrition* W1 screening W1 tool*) or (Nutrition* W1 Risk W1 Assessment W1 Tool*) or (Nutrition* N1 Appetite N1 Questionnaire*) or (Nutrition* W1 Risk* W1 Screening) or conut* or mnasf or (mna N1 sf) or (MRST N1 H*) OR (Short W1 Nutrition* W1 Assessment W1 Questionnaire*) or (determine N1 checklist) OR (your N0 nutritional N0 health)))
3	(MH "aged+" or MH "Dental Care for Aged" OR MH "Health Services for the Aged" OR MH "Senior Centers" OR MH "Rehabilitation, Geriatric" OR MH "Gerontologic Nursing+" OR MH "Gerontologic Care" OR MH "Geriatric Functional Assessment" OR MH "Geriatric Psychiatry" OR MH "Geriatric Nutrition" OR MH "Geriatric Nutritional Physiology" OR MH "Geriatric Assessment" OR MH "Gerontologic Nurse Practitioners" or (TI (elder* or eldest or frail* or geriatri* or (old N1 age*) or (oldest N1 old*) or senior* or senium or (very N1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older N1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*)))) OR (AB (elder* or eldest or frail* or geriatri* or (old N1 age*) or (oldest N1 old*) or senior* or senium or (very N1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older N1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*)))) OR (SU (elder* or eldest or frail* or geriatri* or (old N1 age*) or (oldest N1 old*) or senior* or senium or (very N1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older N1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*)))))
4	S2 AND S3
5	(MH "Weight Control" OR MH "Cachexia" OR MH "Deficiency Diseases" OR MH "Malnutrition" OR MH "Wasting Syndrome" OR MH "Protein Deficiency+" OR MH "Nutrition Disorders)
6	(PT "Validation Studies" OR MH "reproducibility of results" OR MH "psychometrics" OR MH "observer variation" OR MH "discriminant analysis" OR MH "Prevalence" OR TI prevalence* OR AB prevalence* OR SU Prevalence*)
7	S3 AND S5 AND S6

8	MH "Nutritional Assessment" OR (TI (Nutrition* N1 assess*)) OR (AB (Nutrition* N1 assess*)) OR (SU (Nutrition* N1 assess*))
9	S8 AND S3
10	(TI (((Deficiency N1 Disease*) OR ((energy OR protein*) N1 deficien*) OR (Mal N1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* N1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under N1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* N1 assessment) OR starvation* OR cachexia OR underweight OR (under N1 weight)) N9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* OR questionnaire*))) OR (AB (((Deficiency N1 Disease*) OR ((energy OR protein*) N1 deficien*) OR (Mal N1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* N1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under N1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* N1 assessment) OR starvation* OR cachexia OR underweight OR (under N1 weight)) N9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* OR questionnaire*))) OR (SU (((Deficiency N1 Disease*) OR ((energy OR protein*) N1 deficien*) OR (Mal N1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* N1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under N1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* N1 assessment) OR starvation* OR cachexia OR underweight OR (under N1 weight)) N9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* OR questionnaire*)))
11	S3 AND S10
12	S1 OR S4 OR S7 OR S9 OR S11
13	Filter date of publication: 20060101-20171231

Total obtained: 3587

Search strategy in Cochrane July 11, 2017

Set	Search terms
1	(GNRI* OR (Geriatric NEAR/1 Nutrition* NEAR/1 Risk*) OR NUFFE OR (Nutritional NEAR/1 Form NEAR/3 Elderly)):ti,ab,kw
2	(bapen* or CNAQ or (NRS NEAR/1 2002) or (screen NEAR/1 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* NEAR/1 screening NEAR/1 tool*) or (malnutrition* NEAR/1 screening NEAR/1 tool*) or (Nutrition* NEAR/1 Risk NEAR/1 Assessment NEAR/1 Tool*) or (Nutrition* NEAR/1 Appetite NEAR/1 Questionnaire*) or (Nutrition* NEAR/1 Risk* NEAR/1 Screening) or conut* or mnasf or (mna NEAR/1 sf) or (MRST NEAR/1 H*) OR (Short NEAR/1 Nutrition* NEAR/1 Assessment NEAR/1 Questionnaire*) or (determine NEAR/1 checklist) OR (your NEAR/1 nutritional NEAR/1 health)):ti,ab,kw
3	(elder* or eldest or frail* or geriatri* or (old NEAR/1 age*) or (oldest NEAR/1 old*) or senior* or senium or (very NEAR/1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older NEAR/1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*))):ti,ab,kw
4	#2 AND #3
5	((Deficiency NEAR/1 Disease*) OR ((Vitamin* OR energy OR protein*) NEAR/1 deficien*) OR (Mal NEAR/1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* NEAR/1 (Assessment* OR deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under NEAR/1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* NEAR/1 assessment) OR starvation* OR cachexia OR underweight OR (under NEAR/1 weight)):ti,ab,kw
6	prevalence*:ti,ab,kw
7	#3 AND #5 AND #6
8	(Nutrition* NEAR/1 assess*):ti,ab,kw
9	#3 AND #8
10	(((Deficiency NEAR/1 Disease*) OR ((Vitamin* OR energy OR protein*) NEAR/1 deficien*) OR (Mal NEAR/1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* NEAR/1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under NEAR/1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* NEAR/1 assessment) OR starvation* OR cachexia OR underweight OR (under NEAR/1 weight)) NEAR/9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* or questionnaire*)):ti,ab,kw
11	#3 AND #10
12	#1 OR #4 OR #7 OR #9 OR #11
13	Limit to 2006 to 2017

Total obtained: 400

Search strategy in Embase July 14, 2017

Set	Search terms
1	(GNRI* OR (Geriatric ADJ1 Nutrition* ADJ1 Risk*) OR NUFFE OR (Nutritional ADJ1 Form ADJ3 Elderly)).ti,ab,kw
2	(bapen* or CNAQ or (NRS ADJ1 2002) or (screen ADJ1 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* ADJ1 screening ADJ1 tool*) or (malnutrition* ADJ1 screening ADJ1 tool*) or (Nutrition* ADJ1 Risk ADJ1 Assessment ADJ1 Tool*) or (Nutrition* ADJ1 Appetite ADJ1 Questionnaire*) or (Nutrition* ADJ1 Risk* ADJ1 Screening) or conut* or mnasf or (mna ADJ1 sf) or (MRST ADJ1 H*) OR (Short ADJ1 Nutrition* ADJ1 Assessment ADJ1 Questionnaire*) or (determine ADJ1 checklist) OR (your ADJ1 nutritional ADJ1 health)).ti,ab,kw
3	exp aged/ or exp aged hospital patient/ or exp geriatrics/ or exp elderly care/ or exp geriatric assessment/ or exp geriatric care/ or (elder* or eldest or frail* or geriatri* or (old adj1 age*) or (oldest adj1 old*) or senior* or senium or (very adj1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older adj1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*))).ti,ab,kw
4	2 AND 3
5	(nutritional disorder/ OR nutritional deficiency/ OR exp malnutrition/ OR exp nutritional status/)
6	(instrumentation.sh OR exp reproducibility/ OR exp psychometry/ OR exp discriminant analysis/ OR prevalence/ OR prevalence*.ti,ab,kw.)
7	3 AND 5 AND 6
8	*nutritional assessment/ OR (Nutrition* ADJ1 assess*).ti,ab,kw
9	3 AND 8
10	(((Deficiency ADJ1 Disease*) OR ((Vitamin* OR energy OR protein*) ADJ1 deficien*) OR (Mal ADJ1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* ADJ1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under ADJ1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* ADJ1 assessment) OR starvation* OR cachexia OR underweight OR (under ADJ1 weight)) ADJ9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* or questionnaire*)).ti,ab,kw
11	3 AND 10
12	1 OR 4 OR 7 OR 9 OR 11
13	Limit 12 to conference abstract status
13	12 NOT 13
	limit 13 to yr="2006 -Current"

Total obtained: 6138

Search strategy in Pubmed July 11, 2017

Set	Search terms
1	(GNRI*[tiab] OR Geriatric Nutrition Risk*[tiab] OR Geriatric Nutritional Risk*[tiab] OR NUFFE[tiab] OR Nutritional Form For the Elderly[tiab])
2	(bapen*[tiab] OR CNAQ[tiab] OR NRS 2002[tiab] OR screen II[tiab] OR snaq[tiab] OR mininutrition*[tiab] OR Nutritional Appetite Questionnaire*[tiab] OR Nutrition Appetite Questionnaire*[tiab] OR conut*[tiab] OR mnasf[tiab] OR mna sf[tiab] OR mini nutrition*[tiab] OR nutrition screening tool*[tiab] OR nutritional screening tool*[tiab] OR Malnutrition Screening Tool*[tiab] OR Malnutrition Universal Screening Tool*[tiab] OR Nutritional Risk Assessment Tool*[tiab] OR Nutritional Risk Screening[tiab] OR nutrition risk screen*[tiab] OR Short Nutritional Assessment Questionnaire*[tiab] OR controlling nutritional status[tiab] OR MRST-H*[tiab] OR must[tiab])
3	("Aged"[Mesh] OR "Geriatric Assessment"[Mesh] OR "Geriatrics"[Mesh] OR "Geriatric Psychiatry"[Mesh] OR "Geriatric Nursing"[Mesh] OR "Geriatric Dentistry"[Mesh] OR "Dental Care for Aged"[Mesh] OR "Health Services for the Aged"[Mesh] OR elder*[tiab] OR eldest[tiab] OR frail*[tiab] OR geriatri*[tiab] OR old age*[tiab] OR oldest old*[tiab] OR senior*[tiab] OR senium[tiab] OR very old*[tiab] OR septuagenarian*[tiab] OR octagenarian*[tiab] OR octogenarian*[tiab] OR nonagenarian*[tiab] OR centarian*[tiab] OR centenarian*[tiab] OR supercentenarian*[tiab] OR older people[tiab] OR older subject*[tiab] OR older patient*[tiab] OR older age*[tiab] OR older adult*[tiab] OR older man[tiab] OR older men[tiab] OR older male[tiab] OR older woman[tiab] OR older women[tiab] OR older female[tiab] OR older population*[tiab] OR older person*[tiab] OR sarcopen*[tiab])
4	#2 AND #3
5	#1 OR #4
6	MEDLINE[sb]
7	#5 NOT #6

Total obtained: 212

Search strategy in Medline July 11, 2017

Set	Search terms
1	(TI (GNRI* OR (Geriatric W0 Nutrition* W0 Risk*) OR NUFFE OR (Nutritional W0 Form W3 Elderly))) OR (AB (GNRI* OR (Geriatric W0 Nutrition* W0 Risk*) OR NUFFE OR (Nutritional W0 Form W3 Elderly))) OR (SU (GNRI* OR (Geriatric W0 Nutrition* W0 Risk*) OR NUFFE OR (Nutritional W0 Form W3 Elderly)))
2	(TI (bapen* or CNAQ or (NRS N1 2002) or (screen N0 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* W1 screening W1 tool*) or (malnutrition* W1 screening W1 tool*) or (Nutrition* W1 Risk W1 Assessment W1 Tool*) or (Nutrition* N1 Appetite N1 Questionnaire*) or (Nutrition* W1 Risk* W1 Screening) or conut* or mnasf or (mna N1 sf) or (MRST N1 H*) OR (Short W1 Nutrition* W1 Assessment W1 Questionnaire*) or (determine N1 checklist) OR (your N0 nutritional N0 health))) OR (AB (bapen* or CNAQ or (NRS N1 2002) or (screen N0 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* W1 screening W1 tool*) or (malnutrition* W1 screening W1 tool*) or (Nutrition* W1 Risk W1 Assessment W1 Tool*) or (Nutrition* N1 Appetite N1 Questionnaire*) or (Nutrition* W1 Risk* W1 Screening) or conut* or mnasf or (mna N1 sf) or (MRST N1 H*) OR (Short W1 Nutrition* W1 Assessment W1 Questionnaire*) or (determine N1 checklist) OR (your N0 nutritional N0 health))) OR (SU (bapen* or CNAQ or (NRS N1 2002) or (screen N0 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* W1 screening W1 tool*) or (malnutrition* W1 screening W1 tool*) or (Nutrition* W1 Risk W1 Assessment W1 Tool*) or (Nutrition* N1 Appetite N1 Questionnaire*) or (Nutrition* W1 Risk* W1 Screening) or conut* or mnasf or (mna N1 sf) or (MRST N1 H*) OR (Short W1 Nutrition* W1 Assessment W1 Questionnaire*) or (determine N1 checklist) OR (your N0 nutritional N0 health)))
3	(MH "aged+" or MH "Geriatrics" OR MH "Geriatric Psychiatry" OR MH "Geriatric Nursing" OR MH "Geriatric Dentistry" OR MH "Dental Care for Aged" OR MH "Health Services for the Aged" OR MH "Senior Centers" OR MH "Geriatric Assessment" OR MH "Geriatric Psychiatry" OR (TI (elder* or eldest or frail* or geriatri* or (old N1 age*) or (oldest N1 old*) or senior* or senium or (very N1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older N1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*)))) OR (AB (elder* or eldest or frail* or geriatri* or (old N1 age*) or (oldest N1 old*) or senior* or senium or (very N1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older N1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*)))) OR (SU (elder* or eldest or frail* or geriatri* or (old N1 age*) or (oldest N1 old*) or senior* or senium or (very N1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older N1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*)))))
4	S2 AND S3
5	(MH "Weight Loss+" OR MH "Nutrition Disorders" OR MH "Malnutrition" OR MH "Deficiency Diseases" OR MH "Protein Deficiency+" OR MH "Severe Acute Malnutrition")
6	(PT "Validation Studies" OR MH "reproducibility of results" OR MH "psychometrics" OR MH "observer variation" OR MH "discriminant analysis" OR MH "Prevalence" OR TI prevalence* OR AB prevalence* OR SU Prevalence*)
7	S3 AND S5 AND S6
8	MH "Nutrition Assessment" OR (TI (Nutrition* N1 assess*)) OR (AB (Nutrition* N1 assess*)) OR (SU (Nutrition* N1 assess*))
9	S8 AND S3

10	(TI (((Deficiency N1 Disease*) OR ((energy OR protein*) N1 deficien*) OR (Mal N1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* N1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under N1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* N1 assessment) OR starvation* OR cachexia OR underweight OR (under N1 weight)) N9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* OR questionnaire*))) OR (AB (((Deficiency N1 Disease*) OR ((energy OR protein*) N1 deficien*) OR (Mal N1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* N1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under N1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* N1 assessment) OR starvation* OR cachexia OR underweight OR (under N1 weight)) N9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* OR questionnaire*))) OR (SU (((Deficiency N1 Disease*) OR ((energy OR protein*) N1 deficien*) OR (Mal N1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* N1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under N1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* N1 assessment) OR starvation* OR cachexia OR underweight OR (under N1 weight)) N9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* OR questionnaire*)))
11	S3 AND S10
12	S1 OR S4 OR S7 OR S9 OR S11
13	Filter date publication: 20060101-20171231

Total obtained: 5437

Search strategy in Web of Science July 11, 2017

Set	Search terms
1	TS=(GNRI* OR (Geriatric NEAR/1 Nutrition* NEAR/1 Risk*) OR NUFFE OR (Nutritional NEAR/1 Form NEAR/3 Elderly))
2	TS=(bapen* or CNAQ or (NRS NEAR/1 2002) or (screen NEAR/1 II) or snaq or mininutrition* or (mini W0 nutrition*) or (nutrition* NEAR/1 screening NEAR/1 tool*) or (malnutrition* NEAR/1 screening NEAR/1 tool*) or (Nutrition* NEAR/1 Risk NEAR/1 Assessment NEAR/1 Tool*) or (Nutrition* NEAR/1 Appetite NEAR/1 Questionnaire*) or (Nutrition* NEAR/1 Risk* NEAR/1 Screening) or conut* or mnasf or (mna NEAR/1 sf) or "MRST H" OR (Short NEAR/1 Nutrition* NEAR/1 Assessment NEAR/1 Questionnaire*) or (determine NEAR/1 checklist) OR (your NEAR/1 nutritional NEAR/1 health))
3	TS=(elder* or eldest or frail* or geriatri* or (old NEAR/1 age*) or (oldest NEAR/1 old*) or senior* or senium or (very NEAR/1 old*) or septuagenarian* or octagenarian* or octogenarian* or nonagenarian* or centarian* or centenarian* or supercentenarian* or (older NEAR/1 (people or subject* or patient* or age* or adult* or man or men or male or woman or women or female or population* or person*)))
4	#2 AND #3
5	TS=((Deficiency NEAR/1 Disease*) OR ((Vitamin* OR energy OR protein*) NEAR/1 deficien*) OR (Mal NEAR/1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* NEAR/1 (Assessment* OR deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under NEAR/1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* NEAR/1 assessment) OR starvation* OR cachexia OR underweight OR (under NEAR/1 weight))
6	TS=prevalence*
7	#3 AND #5 AND #6
8	TS=(Nutrition* NEAR/1 assess*)
9	#3 AND #8
10	TS=(((Deficiency NEAR/1 Disease*) OR ((Vitamin* OR energy OR protein*) NEAR/1 deficien*) OR (Mal NEAR/1 (nourish* OR nutrition*)) OR Malnourish* OR Malnutrition* OR (Nutrition* NEAR/1 (deficien* OR risk* OR stat* OR deplet* OR deprivat* OR deteriorat* OR derang* OR problem* OR screen* OR evaluat*)) OR (Under NEAR/1 (fed* OR feed* OR nourish* OR nutrition*)) OR Underfe* OR Undernouris* OR Undernutrition* OR (mininutrition* NEAR/1 assessment) OR starvation* OR cachexia OR underweight OR (under NEAR/1 weight)) NEAR/9 (Measur* OR Assess* OR Scale* OR Tool* OR instrument* or screen* OR test OR tests OR survey* or questionnaire*))
11	#3 AND #10
12	#1 OR #4 OR #7 OR #9 OR #11
13	Limit to publication year from 2006 to 2017

Total obtained: 5340

Appendix B – Quality Checklist[23]

Name of author(s): Year of publication: Study title:		
Risk of bias items	**Risk of bias levels**	**Points scored**
1. Was the study's target population a close representation of the national population in relation to relevant variables, e.g. age, sex, occupation?	**Yes** (**LOW RISK**): The study's target population was a close representation of the national population.	0
	No (**HIGH RISK**): The study's target population was clearly NOT representative of the national population.	1
2. Was the sampling frame a true or close representation of the target population?	**Yes** (**LOW RISK**): The sampling frame was a true or close representation of the target population.	0
	No (**HIGH RISK**): The sampling frame was NOT a true or close representation of the target population.	1
3. Was some form of random selection used to select the sample, OR, was a census undertaken?	**Yes** (**LOW RISK**): A census was undertaken, OR, some form of random selection was used to select the sample (e.g. simple random sampling, stratified random sampling, cluster sampling, systematic sampling).	0
	No (**HIGH RISK**): A census was NOT undertaken, AND some form of random selection was NOT used to select the sample.	1
4. Was the likelihood of non-response bias minimal?	**Yes** (**LOW RISK**): The response rate for the study was ≥75%, OR, an analysis was performed that showed no significant difference in relevant demographic characteristics between responders and non- responders	0
	No (**HIGH RISK**): The response rate was <75%, and if any analysis comparing responders and non-responders was done, it showed a significant difference in relevant demographic characteristics between responders and non-responders	1
5. Were data collected directly from the subjects (as opposed to a proxy)?	**Yes** (**LOW RISK**): All data were collected directly from the subjects.	0
	No (**HIGH RISK**): In some instances, data were collected from a proxy.	1
6. Was an acceptable case definition used in the study?	**Yes** (**LOW RISK**): An acceptable case definition was used. **No** (**HIGH RISK**): An acceptable case definition was NOT used	0 1
7. Was the study instrument that measured the parameter of interest (e.g. prevalence of low back pain) shown to have reliability and validity (if necessary)?	**Yes** (**LOW RISK**): The study instrument had been shown to have reliability and validity (if this was necessary), e.g. test-re- test, piloting, validation in a previous study, etc.	0
	No (**HIGH RISK**): The study instrument had NOT been shown to have reliability or validity (if this was necessary).	1
8. Was the same mode of data collection used for all subjects?	**Yes** (**LOW RISK**): The same mode of data collection was used for all subjects.	0
	No (**HIGH RISK**): The same mode of data collection was NOT used for all subjects.	1
9. Were the numerator(s) and denominato r(s) for the parameter of interest appropriate	**Yes** (**LOW RISK**): The paper presented appropriate numerator(s) AND denominator(s) for the parameter of interest (e.g. the prevalence of low back pain).	0
	No (**HIGH RISK**): The paper did present numerator(s) AND denominator(s) for the parameter of interest but one or more of these were inappropriate.	1
10. Summary on the overall risk of study bias	**LOW RISK**	0-3
	MODERATE RISK	4-6
	HIGH RISK	7-9

Appendix C – List of references

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Aartolahti, 2014	Finland	MNA-SFV1	community	182	52 (29%)	130 (71%)	80 (4)	3	low	7.1 (4.2 - 11.8)	
Aartolahti, 2014	Finland	MNA-SFV1	community	157	43 (27%)	114 (73%)	82 (5)	3	low	17.8 (12.6 - 24.6)	
Abizanda, 2015	Spain	MNA-SFV1	institution	91	27 (30%)	64 (70%)	86 (6)	2	low	58.2 (48.0 - 67.8)	15.4 (9.4 - 24.2)
Aeberhard, 2016	Switzerland	NRS-2002	hospital	342	206 (60%)	136 (40%)	66 (17)	2	low		45.9 (40.7 - 51.2)
Alfonso García, 2012	Spain	NRS-2002	hospital	112	63 (56%)	49 (44%)	73(14)	3	low	43.8 (34.9 - 53.0)	2.7 (0.9 - 7.6)
Amaral, 2010	Portugal	NRS-2002	hospital	460				2	low	44.6 (40.1 - 49.1)	
Arslan, 2016	Turkey	NRS-2002	hospital	90	49 (54%)	41 (46%)	69 (11)	1	low	52.2 (42.0 - 62.2)	27.8 (19.6 - 37.8)
Aubert, 2015	France	MNA-SFV1	hospital	65	20 (31%)	45 (69%)	83 (5)	2	low	46.2 (34.6 - 58.2)	
Aubert, 2015	France	MNA-SFV1	hospital	105	23 (22%)	82 (78%)	84(5)	2	low	39.1 (30.3 - 48.6)	
Aukner, 2013	Sweden	MUST	institution	309				4	moderate	32.7 (27.7 - 38.1)	12.7 (9.4 - 16.8)
Badia-Tahull, 2014	Spain	NRS-2002	hospital	45	33 (73%)	12 (27%)		3	low		57.8 (43.3 - 71.0)
Bahat, 2013	Turkey	MNA-SFV1	hospital	217	217 (100%)	0		3	low	33.6 (27.7 - 40.2)	6.9 (4.3 - 11.1)
Bahat, 2014	Turkey	MNA-SFV1	hospital	463	0	463 (100%)		3	low	39.1 (34.8 - 43.6)	10.4 (7.9 - 13.5)
Ballesteros-Pomar, 2016	Spain	MUST	hospital	309	167 (54%)	142 (46%)		3	low	31.1 (26.2 - 36.4)	26.9 (22.2 - 32.1)
Banks, 2010	Ireland	MNA-SFV1	hospital	30	11 (37%)	19 (63%)		2	low	60.0 (42.3 - 75.4)	
Barichella, 2013	Italy	MUST	hospital	208	141 (68%)	67 (32%)	68 (9)	2	low	17.3 (12.8 - 23.0)	
Basta, 2016	Italy	CONUT	hospital	335			79 (5)	3	low	56.0 (50.7 - 61.2)	
Bermejo, 2015	Spain	MNA-SFV1	institution	4297	1457 (34%)	2840 (66%)	82(10)	0	low	79.9 (78.6 - 81.0)	30.4 (29.1 - 31.8)
Bermejo, 2017	Spain	CONUT	hospital	145	90 (62%)	55 (38%)	70 (11)	2	low	15.2 (10.2 - 21.9)	
Bilotta, 2010	Italy	MNA-SFV1	hospital	105	34 (32%)	71 (68%)	83 (5)	3	low	71.4 (62.2 - 79.2)	20.0 (13.5 - 28.7)
Bonaccorsi, 2015	Italy	MUST	institution	2395	611 (26%)	1784 (74%)		1	low	76.3 (74.5 - 77.9)	65.3 (63.4 - 67.2)
Bonaccorsi, 2016	Italy	MUST	community	321	92 (29%)	229 (71%)	93 (3)	2	low	25.2 (20.8 - 30.3)	13.7 (10.4 - 17.9)
Bourdel-Marchasson, 2009	France	MNA-SFV1	institution	601	148 (25%)	453 (75%)	84 (9)	2	low	59.9 (55.9 - 63.7)	
Brabcová, 2016	Czech Republic	MNA-SFV1	community	320	115 (36%)	205 (64%)		4	moderate	37.5 (32.4 - 42.9)	
Budzynski, 2016	Poland	NRS-2002	hospital	6583				3	low		11.1 (10.4 - 11.9)
Burri, 2008	Switzerland	NRS-2002	hospital	50	17 (34%)	33 (66%)	67 (-)	2	low		44.0 (31.2 - 57.7)
Cabré, 2015	Spain	CONUT	hospital	2155	834 (39%)	1321 (61%)	85 (-)	2	low	40.7 (38.6 - 42.8)	7.3 (6.3 - 8.5)
Calleja Fernandez, 2015	Spain	NRS-2002	hospital	201	98 (49%)	103 (51%)		2	low	35.8 (29.5 - 42.7)	35.8 (29.5 - 42.7)

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Calleja Fernandez, 2015	Spain	MUST	hospital	201	98 (49%)	103 (51%)		2	low	53.7 (46.8 - 60.5)	18.4 (13.7 - 24.3)
Camina, 2014	Spain	GNRI	institution	54	20 (37%)	34 (63%)		3	low	61.1 (47.8 - 73.0)	13.0 (6.4 - 24.4)
Cankurtaran, 2013	Turkey	MNA-SFV1	institution	1708	847 (50%)	861 (50%)		3	low	50.2 (47.9 - 52.6)	11.9 (10.5 - 13.6)
Cansado, 2009	Portugal	MUST	hospital	550				2	low	93.3 (90.9 - 95.1)	93.3 (90.9 - 95.1)
Cecile, 2009	France	MNA-SFV1	hospital	112	34 (30%)	78 (70%)	82 (8)	3	low	67.0 (57.8 - 75.0)	
Cecile, 2009	France	MNA-SFV1	hospital	711	292 (41%)	419 (59%)	81 (8)	3	low	50.9 (47.2 - 54.6)	
Cereda, 2007	Italy	GNRI	institution	231	88 (38(%)	143 (62%)	80 (8)	2	low	20.4 (15.7 - 26.0)	5.2 (3.0 - 8.90
Cereda, 2007	Italy	GNRI	institution	153	71 (46%)	82 (54%)	75 (8)	2	low	18.3 (13.0 - 25.2)	4.6 (2.2 - 9.1)
Cereda, 2008	Italy	GNRI	institution	130	61 (47%)	69 (53%)	79 (6)	2	low	22.3 (16.0 - 30.2)	
Cereda, 2008	Italy	GNRI	institution	245	51 (21%)	194 (79%)	84 (9)	3	low	35.1 (29.4 - 41.3)	5.7 (3.4 - 9.4)
Cereda, 2010	Italy	GNRI	institution	241	94 (39%)	147 (61%)	80 (8)	2	low	20.8 (16.1 - 26.3)	
Cereda, 2011	Italy	GNRI	institution	358	91 (25%)	267 (75%)	85 (8)	3	low	37.4 (32.6 - 42.6)	
Cereda, 2015	Italy	GNRI	hospital	667	377 (57%)	290 (43%)	75 (7)	1	low	32.8 (29.4 - 36.5)	
Christner, 2016	Germany	MNA-SFV2	hospital	197				1	low	93.4 (89.0 - 96.1)	45.7 (38.9 - 42.7)
Clugston, 2006	United Kingdom	MUST	hospital	35				2	low	45.7 (30.5 - 61.8)	31.4 (18.6 - 48.0)
Clugston, 2006	United Kingdom	MUST	hospital	21				3	low	4.8 (0.1 - 22.7)	0 (0.0 - 15.5)
Collas, 2017	Belgium	MNA-SFV1	hospital	113	53 (47%)	60 (53%)	82 (5)	3	low	81.4 (73.3 - 81.7)	
Collins, 2011	United Kingdom	MUST	community	424	222 (52%)	202 (48%)	73 (10)	3	low	78.1 (73.9 - 81.7)	
De Breucker, 2010	Belgium	MUST	hospital	111	31 (28%)	80 (72%)	84 (5)	5	moderate	58.6 (49.3 - 67.3)	
de Luis, 2011	Spain	MNA-SFV1	institution	873	312 (36%)	561 (64%)	83 (8)	0	low	58.0 (54.7 - 61.2)	
Diekmann, 2013	Germany	MUST	institution	198				2	low	49.5 (42.6 - 56.4)	8.6 (5.4 - 13.3)
Diekmann, 2013	Germany	NRS-2002	institution	198				2	low	16.2 (11.7 - 21.9)	8.6 (5.4 - 13.3)
Donini, 2016	Italy	MUST	institution	246	82 (33%)	164 (67%)		1	low	38.2 (32.4 - 44.4)	24.0 (19.1 - 29.7)
Donini, 2016	Italy	MNA-SFV1	institution	246	82 (33%)	164 (67%)		1	low	85.4 (80.4 - 89.2)	26.8 (21.7 - 32.7)
Donini, 2017	Italy	MNA-SFV1	community	226	101 (45%)	125 (55%)		2	low	32.3 (26.5 - 38.7)	8.4 (5.5 - 12.8)
Dorner, 2014	Austria	MNA-SFV2	hospital	133	52 (39%)	81 (61%)		1	low	76.7 (68.8 - 83.1)	25.6 (18.9 - 33.6)
Drescher, 2010	Switzerland	NRS-2002	hospital	104	23 (22%)	81 (78%)	84 (-)	2	low		33.7 (25.3 - 43.2)
Durán, 2012	Spain	MNA-SFV1	hospital	40	11 (28%)	29 (73%)		2	low	77.5 (62.5 - 87.7)	47.5 (32.9 - 62.5)

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Durán, 2012	Spain	GNRI	hospital	40	11 (28%)	29 (73%)		2	low	32.5 (20.1 - 48.0)	
Eide, 2013	Norway (EFTA)	MUST	institution	302				1	low	35.4 (30.3 - 41.0)	16.9 (13.1 - 21.5)
Eide, 2015	Norway (EFTA)	NRS-2002	hospital	453	229 (51%)	219 (48%)		4	moderate		44.4 (39.9 - 49.0)
Elkan, 2008	Sweden	MUST	hospital	60	10 (17%)	50 (83%)		2	low	36.7 (25.6 - 49.3)	8.3 (3.6 - 18.1)
Ernsth Bravell, 2011	Sweden	MNA-SFV1	community	315	90 (29%)	225 (71%)	85 (7)	2	low	59.4 (53.9 - 64.6)	
Eschbach, 2016	Germany	NRS-2002	hospital	20	9 (45%)	11 (55%)		4	moderate	100 (83.9 - 100)	70.0 (48.1 - 85.5)
Felder, 2015	Switzerland	NRS-2002	hospital	3186	1763 (55%)	1423 (45%)		4	moderate		27.8 (26.3 - 29.4)
Felder, 2016	Switzerland	NRS-2002	hospital	529	302 (57%)	227 (43%)		5	moderate		33.8 (29.9 - 38.0)
Fernández Lopez, 2015	Spain	NRS-2002	hospital	174				3	low	29.3 (23.1 - 36.5)	
Fernández Lopez, 2015	Spain	MNA-SFV1	hospital	174	109 (63%)	65 (37%)	78 (8)	3	low	70.1 (62.9 - 76.4)	15.5 (10.9 - 21.6)
Ferrero López, 2014	Spain	CONUT	hospital	182	93 (51%)	89 (49%)	78 (12)	3	low	70.9 (63.9 - 77.0)	
Fogg, 2017	United Kingdom	MUST	hospital	9631				2	low	27.0 (26.1 - 27.9)	17.5 (16.8 - 18.3)
Fogg, 2017	United Kingdom	MUST	hospital	1598				2	low	41.1 (38.7 - 43.5)	28.0 (25.9 - 30.3)
Fogg, 2017	United Kingdom	MUST	hospital	2570				2	low	44.1 (42.2 - 46.1)	33.7 (31.9 - 35.5)
Frangos, 2016	Switzerland	MNA-SFV1	hospital	238	87 (37%)	151 (63%)	84 (6)	2	low	53.8 (47.4 - 60.0)	12.2 (8.6 - 17.0)
Frangos, 2016	Switzerland	MNA-SFV1	hospital	154	36 (23%)	118 (77%)	85 (6)	2	low	63.6 (55.8 - 70.8)	16.2 (11.2 - 22.9)
Gamaletsou, 2012	Greece	GNRI	hospital	236	122 (52%)	114 (48%)	75 (8)	3	low	27.5 (22.2 - 33.6)	8.9 (5.9 - 13.2)
Garcia-Meseguer, 2013	Spain	MNA-SFV2	institution	895	372 (42%)	523 (58%)	82 (7)	1	low	44.5 (41.2 - 47.7)	8.4 (6.7 - 10.4)
Garcia-Meseguer, 2013	Spain	MNA-SFV1	institution	895	372 (42%)	523 (58%)	82 (7)	1	low	41.8 (38.6 - 45.1)	5.3 (4.0 - 6.9)
Garcia-Santano, 2010	Spain	SNAQ	hospital	141	78 (55%)	63 (45%)	66 (-)	2	low	36.9 (29.4 - 45.1)	23.4 (17.2 - 31.0)
Gärtner, 2017	Germany	GNRI	hospital	500	253 (51%)	247 (49%)		2	low	77.0 (73.1 - 80.5)	48.8 (44.4 - 53.2)
Gentile, 2013	France	MNA-SFV1	hospital	157	65 (41%)	92 (59%)	84 (5)	2	low	26.1 (19.9 - 33.5)	26.1 (19.9 - 33.5)
Geurden, 2015	Belgium	NRS-2002	hospital	208	109 (52%)	99 (48%)	75 (7)	2	low	51.4 (44.7 - 58.2)	
Geurden, 2015	Belgium	MUST	community	100	22 (22%)	78 (78%)	75 (18)	3	low	29.0 (21.0 - 38.5)	
Ghisla, 2007	Italy	MNA-SFV1	rehabilitation	2650	610 (23%)	2040 (77%)	82 (7)	2	low	55.9 (54.0 - 57.8)	
Gimeno, 2009	Spain	CONUT	hospital	44	18 (41%)	26 (59%)	79 (7)	2	low	13.6 (6.4 - 26.7)	0 (0.0 - 8.0)
Gomes, 2016	United Kingdom	MUST	hospital	537	274 (51%)	263 (49%)	75 (-)	2	low	36.3 (32.3 - 40.5)	29.1 (25.4 - 33.0)
Gomez-Busto, 2014	Spain	MNA-SFV1	community	80	35 (44%)	45 (56%)	84 (6)	3	low	50.0 (39.3 - 60.7)	11.3 (6.0 - 20.0)

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Goost, 2016	Germany	MNA-SFV1	hospital	50	16 (32%)	34 (68%)	85 (5)	2	low	62.0 (48.2 - 74.1)	
Goost, 2016	Germany	NRS-2002	hospital	50	16 (32%)	34 (68%)	85 (5)	2	low	100 (92.9 - 100)	38.0 (25.9 - 51.9)
Hallgren, 2016	Sweden	MNA-SFV1	institution	429	125 (29%)	304 (71%)	85 (7)	3	low	60.4 (55.7- 64.9)	16.3 (13.1 - 20.1)
Hansen, 2008	Denmark	NRS-2002	hospital	116				2	low	82.8 (74.9 - 88.6)	31.0 (23.3 - 40.0)
Harris, 2008	United Kingdom	MUST	community	100	31 (31%)	69 (69%)	79 (6)	2	low	10.0 (5.5 - 17.4)	
Hedman, 2016	Sweden	MNA-SFV1	hospital	40				4	moderate	67.5 (52.0 - 79.9)	17.5 (8.8 - 32.0)
Helminen, 2017	Finland	MNA-SFV1	hospital	594	169 (28%)	425 (72%)		3	low	46.8 (42.8 - 50.8)	7.1 (5.3 - 9.4)
Helminen, 2017	Finland	MNA-SFV1	hospital	985	254 (26%)	704 (71%)		2	low	47.2 (44.1 - 50.3)	7.8 (6.3 - 9.7)
Henderson, 2008	United Kingdom	MUST	hospital	92				2	low	48.9 (39.0 - 59.0)	34.8 (25.8 - 45.0)
Hernandéz, 2015	Spain	NRS-2002	hospital	352	178 (51%)	174 (49%)	69 (17)	2	low		42.6 (37.6 - 47.8)
Holmén, 2006	Sweden	MNA-SFV1	hospital	40	16 (40%)	24 (60%)	84 (-)	3	low	100 (91.2 - 100)	52.5 (37.5 - 67.1)
Holst, 2013	Denmark	NRS-2002	hospital	101	42 (42%)	59 (58%)	75 (7)	3	low		68.3 (58.7 - 76.6)
Holst, 2013	Denmark	MUST	hospital	101	42 (42%)	59 (58%)	75 (7)	3	low		54.5 (44.8 - 63.8)
Holst, 2013	Sweden	NRS-2002	hospital	45	18 (40%)	27 (60%)	81 (7)	3	low		75.6 (61.3 - 85.8)
Holst, 2013	Sweden	MUST	hospital	45	18 (40%)	27 (60%)	81 (7)	3	low		55.6 (41.2 - 69.1)
Holst, 2013	Sweden	NRS-2002	hospital	87	21 (24%)	66 (76%)	85 (6)	3	low		29.9 (21.3 - 40.2)
Holst, 2013	Sweden	MUST	hospital	87	21 (24%)	66 (76%)	85 (6)	3	low		32.2 (23.3 - 42.6)
Huisman, 2015	Multiple EU + other	NRS-2002	hospital	328	125 (38%)	203 (62%)		3	low		12.2 (9.1 - 16.2)
Ihle, 2017	Germany	NRS-2002	hospital	112				2	low		31.3 (23.4 - 40.3)
Ihle, 2017	Germany	NRS-2002	hospital	21				2	low		100 (84.5 - 100)
Jaafar, 2010	United Kingdom	MUST	community	136	59 (43%)	77 (57%)		3	low	91.9 (86.1 - 95.4)	76.5 (68.7 - 82.8)
Jobse, 2015	Germany	MNA-SFV1	hospital	35	2 (6%)	33 (94%)	87 (7)	4	moderate	85.8 (70.7 - 93.8)	22.9 (12.1 - 39.1)
Jodaitis, 2015	Belgium	MNA-SFV1	hospital	285	131 (46%)	154 (54%)	85 (5)	3	low		62.8 (57.1 - 68.2)
Johansson, 2017	Sweden	MNA-SFV1	institution	469				1	low	74.6 (70.5 - 78.4)	
Johansson, 2017	Sweden	MNA-SFV1	community	1443				1	low	74.2 (71.9 - 76.4)	
Jönsson, 2017	Sweden	MNA-SFV1	hospital	39				2	low	61.5 (45.9 - 75.1)	
Jurschik, 2014	Spain	MNA-SFV1	community	640	254 (40%)	386 (60%)	81 (5)	4	moderate	14.2 (11.7 - 17.1)	1.1 (0.5 - 2.2)

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Jyrkka, 2011	Finland	MNA-SFV1	community	140	55 (39%)	85 (61%)	81 (4)	2	low	10.0 (6.1 - 16.1)	
Jyrkka, 2011	Finland	MNA-SFV1	community	102	28 (27%)	74 (73%)	82 (5)	2	low	16.0 (10.1 - 24.3)	
Jyrkka, 2011	Finland	MNA-SFV1	community	52	8 (15%)	44 (85%)	82 (5)	2	low	31.0 (20.1 - 44.5)	
Kaiser, 2011	Germany	MNA-SFV1	institution	286	32 (11%)	254 (89%)	86 (7)	4	moderate	63.3 (57.6 - 68.7)	16.8 (12.9 - 21.6)
Kaiser, 2011	Germany	MNA-SFV1	community	272	91 (33%)	164 (67%)	81 (6)	4	moderate	14.3 (10.7 - 19.0)	0 (0.0 - 1.4)
Kaiser, 2011	Italy	MNA-SFV2	rehabilitation		98			4	moderate	86.7 (78.6 - 92.1)	53.1 (43.3 - 62.6)
Kalkan, 2016	Turkey	GNRI	hospital	155	63 (41%)	92 (59%)	74 (9)	5	moderate		65.8 (58.0 - 72.8)
Karl, 2009	Germany	NRS-2002	hospital	897	751 (84%)	146 (16%)		3	low	95.0 (93.4 - 96.2)	16.1 (13.8 - 18.6)
Kaya, 2014	Turkey	GNRI	hospital	160	82 (51%)	78 (49%)	73 (6)	4	moderate	15.0 (10.3 - 21.4)	
Kazancioglu, 2014	Turkey	MNA-SFV1	hospital	121	68 (56%)	53 (44%)	73 (6)	3	low	42.2 (33.7 - 51.1)	8.3 (4.6 - 14.6)
Kazancioglu, 2014	Turkey	MNA-SFV1	hospital	83	37 (45%)	46 (55%)	77 (8)	3	low	78.3 (68.3 - 85.8)	33.7 (24.5 - 44.4)
Kazancioglu, 2014	Turkey	MNA-SFV1	hospital	46	20 (43%)	26 (57%)	76 (6)	3	low	39.1 (26.4 - 53.5)	4.4 (1.2 - 14.5)
Kelaiditi, 2014	France	MNA-SFV1	institution	773	198 (26%)	575 (74%)	86 (8)	2	low	84.4 (81.6 - 86.7)	25.6 (22.7 - 28.8)
Kezachian, 2012	France	MUST	community	81	39 (48%)	42 (52%)	78 (6)	2	low	18.5 (11.6 - 28.3)	
Kezachian, 2012	France	MNA-SFV1	community	81	39 (48%)	42 (52%)	78 (6)	2	low	33.3 (24.0 - 44.2)	
Khalatbari Soltani, 2016	Switzerland	NRS-2002	hospital	670	335 (50%)	335 (50%)		1	low		64.6 (60.9 - 68.2)
Khalatbari Soltani, 2016	Switzerland	NRS-2002	hospital	1869	921 (49%)	948 (51%)		1	low		62.7 (60.5 - 64.9)
Kiesswetter, 2014	Germany	MNA-SFV1	community	309	112 (36%)	197 (64%)	81 (8)	2	low	56.0 (50.4 - 61.4)	14.9 (11.4 - 19.3)
Kizilarslanoglu, 2017	Turkey	MNA-SFV1	hospital	191	92 (48%)	99 (52%)	75 (8)	2	low	41.4 (34.6 - 48.5)	16.8 (12.1 - 22.7)
Komlanvi, 2012	France	GNRI	hospital	1306	461 (35%)	845 (65%)	85 (6)	1	low	44.1 (41.4 - 46.8)	
Kos, 2016	Turkey	CONUT	hospital	225	111 (49%)	114 (51%)		2	low	74.2 (68.1 - 79.5)	27.6 (22.1 - 33.7)
Kozakova, 2012	Multiple EU	MUST	community	120	61 (51%)	59 (49%)	73 (-)	4	moderate	30.8 (23.3 - 39.6)	17.5 (11.7 - 25.3)
Kozakova, 2014	Czech Republic	MUST	community	470	214 (46%)	256 (54%)	77 (-)	5	moderate	48.3 (43.8 - 52.8)	11.1 (8.5 - 14.2)
Kruizenga, 2016	Netherlands	SNAQ	hospital	336043	1 6 5 1 2 1 (49%)	170922 (51%)		2	low		13.7 (13.6 - 13.8)
Kruizenga, 2016	Netherlands	MUST	hospital	116051	57505 (50%)	58546 (50%)		2	low		14.9 (14.7 - 15.1)
Krzyminska-Siemanszko, 2015	Poland	MNA-SFV1	community	4482	2340 (52%)	2142 (48%)	79 (9)	1	low	46.4 (44.9 - 47.9)	7.5 (6.8 - 8.3)
Kvamme, 2011	Norway	MUST	community	3111	1558 (50%)	1553 (50%)		3	low		2.6 (2.1 - 3.3)

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Lahmann, 2016	Germany	MNA-SFV1	community	450				2	low	48.4 (43.9 - 53.1)	9.4 (7.0 - 12.4)
Lahmann, 2016	Germany	MUST	community	535				2	low	18.1 (15.0 - 21.6)	11.2 (8.8 - 14.1)
Lambert, 2017	Germany	NRS-2002	hospital	317	133 (42%)	184 (58%)		2	low		45.1 (39.7 - 50.6)
Lang, 2007	France	MNA-SFV1	hospital	137	37 (27%)	100 (73%)	84 (6)	2	low	81.8 (74.5 - 87.3)	
Lannering, 2016	Sweden	MNA-SFV1	institution	331	96 (29%)	235 (71%)	84 (7)	1	low	58.0 (52.6 - 63.2)	
Lawson, 2012	United Kingdom	MST	hospital	145				2	low	32.4 (25.3 - 40.4)	0 (0.0 - 2.6)
Lawson, 2012	United Kingdom	MUST	hospital	147				2	low		38.8 (31.3 - 46.8)
Lelovics, 2009	Hungary	MST	institution	1381	399 (29%)	982 (71%)	78 (9)	0	low	38.2 (35.6 - 40.8)	30.1 (27.8 - 32.6)
Lilamand, 2015	France	MNA-SFV1	hospital	265	86 (32%)	179 (68%)	82(6)	3	low	24.9 (20.1 - 30.5)	1.9 (0.8 - 4.3)
Lilamand, 2015	France	MNA-SFV1	institution	773	196 (25%)	577 (75%)	86 (8)	0	low	74.4 (71.2 - 77.3)	15.7 (13.3 - 18.4)
Lirola, 2016	Spain	MNA-SFV1	hospital	907	436 (48%)	471 (52%)		0	low		74.0 (71.0 - 76.7)
Lirola, 2016	Spain	NRS-2002	hospital	907	436 (48%)	471 (52%)		0	low		77.0 (74.1 - 79.6)
Lomivorotov, 2013	Russia	MUST	hospital	192				1	low	16.2 (11.6 - 22.0)	
Lomivorotov, 2013	Russia	NRS-2002	hospital	192				2	low		6.8 (4.0 - 11.2)
Lomivorotov, 2013	Russia	SNAQ	hospital	192				1	low	18.8 (13.9 - 24.9)	
Lopez-Gomez, 2011	Spain	GNRI	hospital	113	71 (63%)	42 (37%)	81 (4)	1	low	61.1 (51.9 - 69.6)	27.4 (20.1 - 36.3)
Lorini, 2014	Italy	MUST	institution	641	197 (31%)	444 (69%)		1	low	20.1 (17.2 - 23.4)	12.0 (9.7 - 14.8)
Lucchin, 2009	Italy	NRS-2002	hospital	561	276 (49%)	285 (51%)	75 (7)	1	low		41.9 (37.9 - 46.0)
Marques-Vidal, 2017	Switzerland	NRS-2002	hospital	2200	1014 (46%)	1186 (54%)	76 (-)	2	low		63.6 (61.5 - 65.5)
Martinez Velilla, 2012	Spain	MNA-SFV1	hospital	85	37 (44%)	48 (56%)	87 (6)	0	low	74.1 (63.9 - 82.2)	34.1 (24.9 - 44.7)
Martínez-Reig, 2017	Spain	MNA-SFV1	community	827	335 (41%)	492 (59%)	79 (6)	2	low	27.2 (24.3 - 30.3)	2.5 (1.7 - 3.9)
Martins, 2006	Portugal	MST	hospital	150	47 (31%)	103 (69%)	73(-)	2	low	30.0 (23.2 - 37.8)	
Martins, 2006	Portugal	MST	hospital	57	17 (30%)	40 (70%)	72(-)	2	low	35.1 (24.0 - 48.1)	
Maseda, 2016	Spain	MNA-SFV1	community	749	295 (39%)	454 (61%)	76 (7)	1	low	14.3 (12.0 - 17.0)	
Maseda, 2017	Spain	CONUT	community	749	295 (39%)	454 (61%)	76 (7)	2	low	14.3 (12.0 - 17.0)	0.8 (0.4- 1.7)
Mazzola, 2017	Italy	MNA-SFV1	hospital	415	309 (74%)	106 (26%)	84 (7)	3	low	63.4 (58.6 - 67.9)	18.8 (15.3 - 22.8)
Mercadal-Orfila, 2012	Spain	NRS-2002	hospital	1075	626 (58%)	449 (42%)	68 (18)	1	low		62.1 (59.1 - 64.9)
Miguel Montoya, 2017	Spain	MNA-SFV1	hospital	581	294 (51%)	287 (49%)	68 (16)	2	low	47.3 (43.3 - 51.4)	

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Mihalache, 2015	Romania	MNA-SFV1	institution	156	62 (40%)	94 (60%)	78 (7)	2	low	30.8 (24.1 - 38.4)	6.4 (3.5 - 11.4)
Montana, 2011	Spain	MNA-SFV1	community	728	265 (36%)	463 (64%)	81 (7)	2	low	59.2 (55.6 - 62.7)	12.4 (10.2 - 15.0)
Monteferrario, 2013	Italy	MNA-SFV1	hospital	11	5 (45%)	6 (55%)	81 (8)	3	low	100 (74.1 - 100)	63.6 (35.4 - 84.8)
Montejano Lozoya, 2017	Spain	MNA-SFV1	community	660	319 (48%)	341 (52%)	74 (7)	2	low	27.4 (24.2 - 31.0)	0.9 (0.4 - 1.9)
Montejano, 2017	Spain	MNA-SFV2	community	660	319 (48%)	341 (52%)	74 (7)	2	low	27.7 (24.5 - 31.3)	1.5 (0.8 - 2.8)
Mora, 2012	Spain	MNA-SFV1	community	313	153 (49%)	160 (51%)	77 (7)	3	low		3.8 (2.2 - 6.6)
Mountford, 2016	United Kingdom	MUST	institution	205	66 (32%)	139 (68%)	84 (9)	1	low	36.6 (30.3 - 43.4)	20.0 (15.1 - 26.0)
Noè, 2012	Italy	MUST	hospital	307			69 (16)	1	low	57.3 (51.7 - 62.7)	48.5 (43.0 - 54.1)
Norris, 2011	United Kingdom	MUST	institution	375			86 (8)	2	low	33.2 (28.6 - 38.1)	15.3 (12.0 - 19.3)
Norris, 2011	United Kingdom	MUST	institution	134			84 (4)	2	low	50.0 (41.7 - 58.4)	31.3 (24.1 - 39.6)
Nuotio, 2016	Finland	MNA-SFV1	hospital	472	117 (25%)	355 (75%)		2	low	51.1 (46.6 - 55.5)	8.7 (6.5 - 11.6)
Nykänen, 2013	Finland	MNA-SFV1	community	696	213 (31%)	483 (69%)	81 (5)	2	low	15.2 (12.8 - 18.1)	1.0 (0.5 - 2.1)
Ocón Bretón, 2012	Spain	NRS-2002	hospital	57	30 (53%)	27 (47%)	71 (16)	3	low	38.6 (27.1 - 51.6)	8.8 (3.8 - 18.9)
Ofei, 2015	Denmark	NRS-2002	hospital	71	35 (49%)	36 (51%)	66 (14)	5	moderate	66.0 (54.4 - 75.9)	
Ortega, 2016	Spain	MNA-SFV1	hospital	38	16 (42%)	22 (58%)	81 (6)	2	low	36.8 (19.2 - 59.0)	7.9 (2.7 - 20.8)
O'Shea, 2017	Ireland	MNA-SFV1	hospital	602	292 (49%)	310 (51%)		1	low	63.1 (59.2 - 66.9)	17.6 (14.8 - 20.9)
Ozbilgin, 2016	Turkey	NRS-2002	hospital	152			67 (16)	4	moderate		80.3 (73.2 - 85.8)
Ozbilgin, 2016	Turkey	MNA-SFV1	hospital	152			67 (16)	2	low	93.4 (88.3 - 96.4)	32.9 (25.9 - 40.7)
Pavic, 2012	Croatia	NRS-2002	hospital	1696	948 (56%)	748 (44%)		1	low		19.4 (17.6 - 21.4)
Pérez Llamas, 2011	Spain	GNRI	institution	19				5	moderate	73.7 (51.2 - 88.2)	31.6 (15.4 - 54.0)
Pezzana, 2015	Italy	MNA-SFV1	institution	1394	368 (26%)	1026 (74%)	84 (8)	2	low	87.8 (86.0 - 89.4)	35.2 (32.8 - 37.8)
Poulia, 2012	Greece	GNRI	hospital	248	129 (52%)	119 (48%)	75 (9)	1	low		8.8 (5.9 - 13.1)
Poulia, 2012	Greece	MNA-SFV1	hospital	248	129 (52%)	119 (48%)	75 (9)	1	low		35.5 (29.8 - 41.6)
Poulia, 2012	Greece	MUST	hospital	248	129 (52%)	119 (48%)	75 (9)	1	low		52.0 (45.8 - 58.2)
Poulia, 2012	Greece	NRS-2002	hospital	248	129 (52%)	119 (48%)	75 (9)	1	low		29.4 (24.1 - 35.4)
Pourhassan, 2017	Germany	MUST	hospital	342	120 (35%)	222 (65%)	83 (7)	1	low	49.7 (44.4 - 55.0)	44.7 (39.6 - 50.0)
Pourhassan, 2017	Germany	NRS-2002	hospital	342	120 (35%)	222 (65%)	83 (7)	1	low	74.0 (69.1 -78.3)	
Pourhassan, 2017	Germany	MNA-SFV1	hospital	342	120 (35%)	222 (65%)	83 (7)	1	low	55.9 (51.0 - 61.0)	11.1 (8.2 - 14.9)

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Priegnitz, 2014	Germany	NRS-2002	hospital	365				2	low		19.7 (16.0 - 24.1)
Rasheed, 2013	United Kingdom	MUST	hospital	126	63 (50%)	63 (50%)	79 (10)	1	low		43.7 (35.3 - 52.4)
Rasheed, 2013	United Kingdom	MUST	hospital	149	74 (50%)	75 (50%)	77 (7)	1	low	26.2 (19.8 - 33.8)	16.1 (11.1 - 22.9)
Rasheed, 2014	United Kingdom	MNA-SFV1	hospital	149	74 (50%)	75 (50%)	77 (7)	1	low	49.0 (41.1 - 56.9)	13.4 (8.9 - 19.8)
Redondo, 2015	Spain	CONUT	hospital	310	142 (46%)	168 (54%)	80 (7)	1	low	33.2 (28.3 - 38.7)	4.5 (2.7 - 7.4)
Reinert, 2013	Switzerland	MNA-SFV1	rehabilitation	49	9 (18%)	40 (82%)	83 (-)	2	low	100 (92.7 - 100)	61.2 (47.3 - 73.6)
Roberts, 2015	United Kingdom	MUST	community	57	34 (60%)	23 (40%)		1	low		5.3 (1.8 - 14.4)
Salomon du Mont, 2017	France	GNRI	hospital	106	71 (67%)	35 (33%)	77 (12)	2	low	74.5 (65.5 - 81.9)	23.6 (16.5 - 32.5)
Salvi, 2008	Italy	MNA-SFV1	hospital	275	167 (61%)	108 (39%)	77 (7)	2	low	46.2 (40.4 - 52.1)	
Sanz-Paris, 2016	Spain	MNA-SFV1	hospital	1014	504 (50%)	510 (50%)	78 (7)	1	low	60.1 (57.0 - 63.0)	22.8 (20.3 - 25.5)
Schilp, 2012	Netherlands	SNAQ	community	1267			77 (7)	3	low	18.3 (16.3 - 20.5)	10.7 (9.1 - 12.5)
Schilp, 2012	Netherlands	SNAQ	community	1878			75 (7)	3	low	14.0 (12.5 - 15.7)	11.8 (10.4 - 13.4)
Schilp, 2012	Netherlands	SNAQ	community	814			82 (7)	3	low	44.0 (40.6 - 47.4)	34.8 (31.6 - 38.1)
Schrader, 2016	Germany	MNA-SFV1	hospital	190	53 (28%)	137 (72%)		3	low	45.3 (38.4 - 52.4)	9.0 (5.7 - 13.9)
Schreiber, 2016	Germany	MNA-SFV1	hospital	338	136 (40%)	202 (60%)	81 (7)	4	moderate	65.7 (60.5 - 70.5)	21.9 (17.8 - 26.6)
Schwegler, 2010	Switzerland	NRS-2002	hospital	186	121 (65%)	65 (35%)	67 (12)	2	low	60.8 (53.6 - 67.5)	39.3 (32.5 - 46.4)
Serra-Prat, 2010	Spain	MNA-SFV1	community	313	153 (49%)	160 (51%)		3	low	3.8 (2.2 - 6.6)	
Serra-Prat, 2017	Spain	MNA-SFV1	community	172	75 (39%)	97 (61%)	79 (5)	2	low	8.7 (5.4 - 13.9)	1.2 (0.3 - 4.1)
Shakersain, 2016	Albania	MNA-SFV1	community	3041	1108 (36%)	1933 (64%)	74 (11)	2	low	26.4 (24.8 -28.0)	1.7 (1.3 - 2.2)
Slee, 2015	United Kingdom	MNA-SFV1	hospital	69	44 (64%)	25 (36%)	82 (8)	2	low	91.3 (82.3 - 96.0)	44.9 (33.8 - 56.6)
Slee, 2015	United Kingdom	MUST	hospital	69	44 (64%)	25 (36%)	82 (8)	2	low	20.3 (12.5- 31.2)	13.0 (7.0 - 23.0)
Slee, 2015	United Kingdom	MNA-SFV1	hospital	78	49 (63%)	29 (37%)	82 (8)	2	low	91.0 (82.6 - 95.6)	46.2 (35.5 - 57.1)
Slee, 2015	United Kingdom	MUST	hospital	78	49 (63%)	29 (37%)	82 (8)	2	low	23.1 (15.1 - 33.6)	14.1 (8.1 - 23.5)
Söderhamn, 2012	Norway (EFTA)	NUFFE	hospital	1907				3	low	22.3 (20.5 - 24.3)	3.7 (2.9 - 4.6)
Söderhamn, 2012	Norway (EFTA)	MNA-SFV1	hospital	1915				3	low	13.5 (12.0 - 15.1)	1.7 (1.2 - 2.4)
Soysal, 2013	Turkey	MNA-SFV1	hospital	615	239 (39%)	376 (61%)	73 (9)	3	low	66.2 (62.4 - 69.8)	21.8 (18.7 - 25.2)
Soysal, 2016	Turkey	MNA-SFV1	community	116	51 (44%)	65 (56%)	78 (9)	3	low	53.5 (44.4 - 62.3)	11.2 (6.7 - 18.2)

Appendix C – Continued

Name, year	Country	Malnutrition screening tool	Setting	Number of persons in study population	Number of		Mean age	Risk of bias	Risk bias category	Malnutrition risk	
					Males	Females				moderate plus high	High
Stratton, 2006	United Kingdom	MUST	hospital	1000	574 (57%)	426 (43%)	71 (19)	1	low	42.0 (39.0 - 45.1)	28.0 (25.3 - 30.9)
Stratton, 2006	United Kingdom	MUST	hospital	150	50 (33%)	100 (67%)	85 (6)	2	low	58.0 (50.0 - 65.6)	41.3 (33.8 - 49.3)
Tailliere, 2015	France	GNRI	hospital	858				2	low	41.4 (38.1 - 44.7)	15.9 (13.6 - 18.5)
Tangvik, 2014	Norway (EFTA)	NRS-2002	hospital	3279	1646 (50%)	1633 (50%)		2	low	29.0 (27.5 - 30.6)	
Tannen, 2013	Austria	MUST	hospital	2283	1018 (45%)	1265 (55%)	68 (17)	1	low	17.3 (15.8 - 18.9)	11.3 (10.1 - 12.7)
Tavares, 2007	Portugal	NRS-2002	hospital	85	48 (56%)	34 (40%)		2	low		54.1 (43.6 - 64.3)
Tevik, 2015	Norway	NRS-2002	hospital	131	89 (68%)	42 (32%)		3	low		57.3 (48.7 - 65.4)
Thibault, 2015	Switzerland	NRS-2002	hospital	1092	628 (58%)	464 (42%)	69 (20)	2	low	61.5 (58.5 - 64.3)	30.0 (27.4 - 32.8)
Timpini, 2011	Italy	MNA-SFV1	community	698	290 (42%)	408 (58%)	76 (6)	3	low	7.3 (5.6 - 9.5)	
Törmö, 2013	Sweden	MNA-SFV1	institution	172	102 (59%)	70 (41%)	86 (8)	0	low	93.0 (88.2 - 96.0)	30.2 (23.9 - 37.5)
Toussaint, 2015	Netherlands	MNA-SFV1	community	345	160 (46%)	185 (54%)	67 (6)	2	low		0 (0.0 - 1.1)
Toussaint, 2015	Netherlands	MNA-SFV1	community	138	47 (34%)	91 (66%)	81 (8)	2	low	60.1 (51.8 - 67.9)	15.9 (10.8 - 23.0)
Tsaousi, 2016	Greece	MUST	hospital	90	42 (47%)	48 (53%)		2	low	71.1 (61.0 - 79.5)	54.4 (44.2 - 64.3)
Ülger, 2010	Turkey	MNA-SFV1	community	2327	848 (36%)	1479 (64%)	72 (6)	1	low	28.0 (26.2 - 29.8)	
Ulger, 2013	Turkey	MNA-SFV1	institution	534	187 (35%)	347 (65%)	80 (7)	1	low	69.5 (65.4 - 73.2)	15.9 (13.1 - 19.3)
van den Broeke, 2017	Netherlands	MNA-SFV1	hospital	657	279 (42%)	378 (58%)	77 (5)	2	low	37.0 (33.4 - 40.7)	7.0 (5.3 - 9.2)
Vandewoude, 2013	Belgium	MNA-SFV1	institution	784				0	low	66.5 (63.1 - 69.7)	
Vandewoude, 2013	Belgium	SNAQ	community	55				0	low	12.7 (6.3 - 24.0)	
Vandewoude, 2013	Belgium	MNA-SFV1	community	55				0	low	65.5 (52.3 - 76.6)	
Varan, 2016	Turkey	NRS-2002	hospital	122	54 (44%)	68 (56%)		2	low		50.0 (41.3 - 58.7)
Velghe, 2014	Belgium	MNA-SFV1	hospital	70	36 (51%)	34 (49%)	77 (5)	2	low	81.4 (70.8 - 88.8)	20.0 (12.3 - 30.8)
Verlaan, 2017	Netherlands	SNAQ	hospital	378	192 (51%)	186 (49%)	80 (6)	2	low	34.4 (29.8 - 39.3)	
Villafane, 2016	Italy	MNA-SFV1	hospital	344			78 (7)	2	low	70.6 (65.6 - 75.2)	
Villaverde-Gutiérrez, 2015	Spain	MNA-SFV1	community	76	25 (33%)	51 (67%)	80 (7)	2	low	48.7 (37.8 - 59.7)	9.2 (4.5 - 17.8)
Vischer, 2012	Switzerland	MNA-SFV1	hospital	164	50 (30%)	104 (63%)	85 (6)	1	low	67.7 (60.2 - 74.4)	17.7 (12.6 - 24.2)
Vischer, 2012	Switzerland	MNA-SFV1	hospital	444	115 (26%)	329 (74%)	85 (7)	1	low	75.9 (71.7 - 79.7)	25.5 (21.6 - 29.7)
Westergren, 2015	Sweden	SCREEN II	community	465	216 (46%)	249 (54%)	79 (4)	2	low	65.0 (60.5 - 69.1)	30.1 (26.1 - 34.4)
Wikby, 2008	Sweden	MNA-SFV1	community	127	40 (31%)	87 (69%)		3	low	70.1 (61.6 - 77.4)	19.7 (13.7 - 27.5)
Wirth, 2011	Germany	NRS-2002	hospital	4095	1174 (29%)	2921 (71%)		0	low		23.9 (22.7 - 25.3)
Zeanandin, 2012	France	MNA-SFV1	community	190	71 (37%)	119 (63%)		1	low	34.7 (28.3 - 41.8)	
Zietarska, 2017	Poland	NRS-2002	hospital	75			66 (10)	2	low		76.0 (65.2 - 84.3)

CHAPTER 3

3

Interdisciplinary communication and collaboration as key to improved nutritional care of malnourished older adults across healthcare settings – a qualitative study

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Abstract

Background

Malnutrition is a risk factor for impaired functionality and independence. For optimal treatment of malnourished older adults close collaboration and communication between all stakeholders involved (older adults, their caregivers, health care and welfare professionals) is important. This qualitative study assesses current collaboration and communication in nutritional care over the continuum of health care settings and provides recommendations for improvement.

Methods

Eleven structured focus group interviews and five individual interviews took place in three regions across the Netherlands from November 2017 until February 2018, including older adults, caregivers, health care and welfare professionals. Various aspects of collaboration and communication between all stakeholders were discussed. Interviews were transcribed and analyzed using a thematic approach.

Results

Six main themes emerged: causes of malnutrition, knowledge and awareness, recognition and diagnosis of malnutrition, communication, accountability and food preparation and supply. Physical and social aspects were recognized as important risk factors for malnutrition. Knowledge and awareness regarding malnutrition were acknowledged as being insufficient among all involved. This may impair timely recognition and diagnosis. Responsibility for nutritional care and its communication to other disciplines is low. Food preparation and supply in hospitals, rehabilitation centers and home care are below expected standards.

Conclusion

Many stakeholders are involved in nutritional care of older adults and lack of communication and collaboration hinders continuity of nutritional care over health care settings. Lack of knowledge is an important risk factor. Establishing one coordinator of nutritional care is suggested to improve collaboration and communication across health care settings.

Introduction

Currently, 19% of the total Dutch population is aged 65 years and older, and this percentage is expected to rise to 26% in 2040[1,2]. Longevity is not by definition associated with healthy ageing. At older age, the majority of older adults (OA) suffer from multimorbidity[3], leading to increased health care needs. Yet, Dutch health care policy is aimed at encouraging OA to live at home as long as possible, assisted by family and health care professionals, when necessary[4]. Herein, they are expected to coordinate their own health, relying on (remaining) physical function and self-management as much as possible[5]. Maintaining a good nutritional status plays an important role in the physical and mental wellbeing of OA and may be crucial to living at home as long as possible.

Nutritional risk factors seem highly prevalent among Dutch community-dwelling OA (CDOA). A recent study based on SCREEN II found that over 80% (n=2470) of Dutch CDOA has more than one nutritional risk factor[6], such as eating alone, difficulties doing groceries, poor appetite, mobility limitations. These nutritional risk factors are common in older age and can lead to a decreased nutritional status and eventually malnutrition[7].
Malnutrition is characterized by loss of body weight and muscle mass, resulting in immune dysfunction and increased risk of falls, slower recovery and increased risk of complications in disease and after surgery[8]. The prevalence of malnutrition is reported to range from 11% to 35% in Dutch CDOA[9], whereby prevalence rates increase with age[6,9]. The most vulnerable patients at nutritional risk may be the ones who are in transition of care, for example, from hospital or rehabilitation center to home[10]. Furthermore, malnutrition risk factors are more likely to occur in persons with higher care complexity[11] as malnutrition is often co-existent with other geriatric symptoms such as depression or frailty[12]. Thus, optimal nutritional care and malnutrition screening and treatment should be an interplay between different health care and welfare professionals (professionals), centered around the patients and their caregiver(s). However, general practice proves the opposite[13]. Ideally, nutritional care and malnutrition prevention and treatment should be a continuum across health care settings[14,15].So far, little research is available investigating nutritional care collaboration and communication between OA themselves, their caregivers, and professionals across the continuum of health care. This qualitative study investigates how nutritional care collaboration and communication is organized in the Netherlands, by investigating possible barriers, facilitators, stakeholders' experiences (OA, caregivers and professionals), wishes and needs in order to optimize collaboration and communication in nutritional care.

Methods

2.1 Design

A qualitative design was used to investigate current practice and to assess possible barriers and facilitators with regard to collaboration and communication in nutritional care in Dutch OA across health care settings. Focus group interviews with Dutch OA, their caregivers (social network; i.e. relatives, friends, neighbors) and professionals (i.e. GPs, nurses, dietitians, social workers, cooks) were held to collect all necessary information and to discover possible niches.

Between November 2017 and February 2018 focus group interviews were held in three different regions across the Netherlands: Gorinchem, Sneek and Nijmegen. These include both rural and urban regions. They were held on familiar locations, nearby the residence or working area of the respondents. SPH, a trained moderator, conducted the focus group interviews, supported by local project leaders, who made notes about non-verbal communication. Respondents were asked to share their experiences with nutritional care across health care settings and were encouraged to be as candid about their thoughts as possible. Focus group interviews lasted 1.5-2 hours and were audio taped.

2.2 Study population and recruitment

CDOA and caregivers were recruited for participation through personal approach in community centers or with the help of OA's associations and personal contacts. No specific inclusion or exclusion criteria were applied with regard to the respondents' usual nutritional habits or risk of malnutrition. Additionally, to study communication across health care settings, OA who stayed at a rehabilitation center (after a hip fracture, in transition to home) were invited by local project leaders. Local project leaders approached professionals employed at hospitals, rehabilitation centers and in home care within their network, and through snowball sampling. Four focus group interviews with adults aged 65 years or older (n=18; table 1) and caregivers (n=5; table 2) took place.

After the focus group interview with OA and caregivers living in Nijmegen it appeared that a few respondents did not feel safe enough to share all their experiences during the focus group. One respondent was not able to be present during the focus group. In order to complete OA's experiences, supplementary individual interviews were held with four of the respondents of that particular focus group.

In addition, one couple from Moroccan origin was recruited from the Nijmegen area. Both respondents were not fluent in Dutch, therefore an interpreter was present during the interview. The interpreter was a social worker who supported the couple. Additionally, the couple's daughter was also present during the interview. The couple indicated that

they did not want the interview to be audio-taped. Therefore, notes were made and summarized, and the couple signed this summary of the interview.

The individual interviews with the couple from Moroccan origin and the four respondents from Nijmegen lasted 30 minutes to 1 hour and were also audio-taped. Baseline data of the interviews are added to table 1.

Seven focus group interviews with professionals took place, including 41 care professionals in total. The professionals who participated in the study included different disciplines in health care and welfare (Table 3).

All interviews were transcribed verbatim by an external party. Respondents' names were replaced by pseudonyms to ensure anonymity and confidentiality.

Table 1: Baseline characteristics of respondents to focus groups and individual interviews: older adults

		Total	Gorinchem	Nijmegen	Sneek
n		21	9	7	5
Mean age (y)		71.6	72.4	71.7	70.8
Age range (y)		58-88	65 – 86	58 – 88	67 – 77
Sex					
	Female	14	8	3	4
	Male	5	1	4	1
Education					
	Primary education	2	-	2	-
	Lower vocational/ advanced secondary education	10	6	2	2
	Intermediate vocational/higher secondary education	2	2	-	-
	Higher vocational education/university	6	-	3	3
	Unknown	1	1	-	-
Marital status					
	Single	3	1	1	1
	Married/living together	10	3	5	2
	Married/living apart	1	1	-	-
	Divorced	2	2	-	-
	Widow(er)	5	2	1	2
	Other	-	-	-	-
Help at home					
	None	12	3	4	5
	Caregiver (children, family, friends, neighbors)	3	1	2	-
	Home care	4	2	2	-
	Household help	6	5	1	-
	Meal service	-	-	-	-
	Other	-	-	-	-
Nutritional advice by					
	None	8	4	2	2
	GP	6	2	4	-
	GP's nurse practitioner	4	2	1	1
	Medical specialist	2	1	1	-
	Dietitian	8	3	3	2
	Physiotherapist	2	1	1	-
	Occupational therapist	-	-	-	-
	Speech therapist	-	-	-	-
	Pharmacist	2	-	2	-
	Dentist	2	-	2	-
	Other	-	-	-	-

Table 2: Baseline characteristics of respondents to focus groups and individual interviews: caregivers

		Total	Gorinchem	Nijmegen	Sneek
n		5	2	1	2
Mean age (y)		66.5	49.5	89	61
Age range (y)		32-89	32-67	89	51-71
Sex					
	Female	4	1	1	2
	Male	1	1	-	-
Education					
	Primary education	-	-	-	-
	Lower vocational/advanced secondary education	1	1	-	-
	Intermediate vocational/higher secondary education	-	-	-	-
	Higher vocational education/university	4	1	1	2
	Unknown	-	-	-	-
Marital status					
	Single	1	-	1	-
	Married/living together	4	1	1	2
	Married/living apart	-	-	-	-
	Divorced	-	-	-	-
	Widow(er)	-	-	-	-
	Other	-	-	-	-
Help at home					
	None	3	2	-	1
	Caregiver (children, family, friends, neighbors)	-	-	-	-
	Home care	1	-	-	1
	Household help	2	-	1	1
	Meal service	-	-	-	-
	Other	-	-	-	-
Nutritional advice by					
	None	3	2	1	-
	GP	-	-	-	-
	GP's nurse practitioner	-	-	-	-
	Medical specialist	-	-	-	-
	Dietitian	1	-	-	1
	Physiotherapist	-	-	-	-
	Occupational therapist	-	-	-	-
	Speech therapist	-	-	-	-
	Pharmacist	-	-	-	-
	Dentist	-	-	-	-
	Other	-	-	-	-

Table 3: Baseline characteristics of respondents to focus groups: health care and welfare professionals

		Total	Gorinchem	Nijmegen	Sneek
n		41	16	12	13
Mean age (y)		44.3	44.9	39.9	47.5
Age range (y)		21 – 63	21 – 61	21 – 62	23 – 63
Sex					
	Female	34	12	10	12
	Male	7	4	2	1
Education					
	Primary education	-	-	-	-
	Lower vocational/ advanced secondary education	7	4	-	3
	Intermediate vocational/higher secondary education	1	-	-	1
	Higher vocational education/university	33	12	12	9
Employed at					
	Hospital	10	2	5	3
	Rehabilitation center	10	7	-	3
	Home care	15	4	7	4
	Combination	6	3	-	3
Profession					
	GP	1	1	-	-
	GP's nurse practitioner	2	-	-	2
	Dietitian	3	1	1	1
	Physiotherapist	3	1	1	1
	Speech therapist	4	2	1	1
	Social worker	5	-	4	1
	Nurse	10	4	3	3
	Geriatrician	1	1	-	-
	Psychologist	1	1	-	-
	Occupational therapist	2	1	-	1
	Cook	1	-	-	1
	Nutrition assistant	1	-	-	1
	Business manager local hospital	1	-	1	-
	Health broker	1	-	1	-
	Care coordinator	3	2	-	1
	Sports coach	1	1	-	-

2.3 Focus group interviews

Discussion guides were developed based on Evers[16] to ensure all key-concept areas were discussed. The topics of the discussion guide consisted of two main topics including twelve subtopics, presented in table 4.

Table 4: Construction of the discussion guides

Main topic	Subtopic
Identifying barriers and facilitators in nutritional care across health care settings	Problem detection
	Application of existing guidelines
	Expectations of clients / health care professionals
	Personal care plans
	Continuity in care between health care settings
	Transfer report
	Coordination of care and welfare
	Case management
	Inventory and involvement of stakeholders
	Advanced care planning
Inventory of experiences, wishes and needs of older adults, caregivers and health care professionals	Facilitators
	Barriers

2.4 Ethical issues

The study was judged by the HAN ethical advisory board, and they advised that no further ethical approval was necessary, as "The study does not fall within the remit of the Medical Research Involving Human Subjects Act (WMO)". All respondents received detailed information about the aim of the study and the content of the focus group interviews in advance. Furthermore, respondents were requested to sign an informed consent form and they were aware of the right to withdraw at any time.

2.5 Data analysis

The interviews were analyzed using a thematic approach[17]. Prior to data analysis, two authors (SPH and MHV) listened to the recorded interviews separately. They went through the data and searched for meanings and patterns to make an initial list of recurring topics, after which the formal coding process started. Both authors assigned open codes to pieces of text that had the same underlying meaning, using Atlas.ti version 8.2. Codes were discussed and discrepancies were managed by consensus. In case discrepancies arose, the codebook was revised and previous transcripts were recoded. Codes were grouped into categories and categories were then classified into themes. In case topics occurred that could not be grouped under the topics that were identified initially, extra themes were added in order to include possible niches in the analysis.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available for privacy or ethical restrictions.

Results

After nine of the eleven focus group interviews, saturation was considered to be achieved. No extra codes nor themes arose during the analysis of the remaining focus group interviews and personal interviews. The following five themes were identified: 1. Causes of malnutrition; 2. Knowledge and awareness; 3. Recognition and diagnosis of malnutrition; 4. Communication; 5. Accountability. While coding the interviews, another theme arose naturally before the formal coding process started: 6. Food preparation and food supply; within each focus group interview something was said about food supply and food preparation during and after admission to hospital or rehabilitation center. Barriers and facilitators with regard to collaboration and communication in nutritional care across the continuum of health care settings were discussed.

3.1 Causes of malnutrition

3.1.1 Physical Decline

Physical decline was recognized as an important cause of malnutrition. Also loss of appetite and taste, the ability to take care of oneself, dementia and cognitive decline, side-effects of medication, and dysphagia were frequently mentioned. These aspects were said to cause shame and fear, such as the fear of falling. This, in turn, often results in a vicious circle in which OA continued to deteriorate physically.

3.1.2 Social Aspects

Also social aspects were mentioned as possible causes of malnutrition. A small or shrinking network and/or loneliness were said to have a major influence on appetite and the positive experience of eating and drinking. Additionally, OA come from a generation that is reluctant to ask for help from their social network or from professionals. Another important social aspect mentioned is the importance of proper meals in relation to what they cost.

Various opportunities were mentioned in response to the social aspects described above. An important opportunity could lie within social cohesion of neighborhoods. Social-cultural and medical facilities could improve social networks around OA and could be an easily accessible way for OA to do groceries and prepare and consume meals together. Quotes of paragraph 3.1 are depicted in table 5.

Table : Quotes Paragraph 3.1 "Causes of malnutrition"

Quote 1:
Physiotherapist: "What I encounter in the home situation in terms of nutrition and medication problems and things you see when you come in people's homes, then, it often starts with less appetite, not feeling well, postponing meal moments, not finishing meals or just forgetting about meals. They find it hard to take care of themselves, and lose their self-sufficiency."

Quote 2:
Nutrition assistant: "No, but I think that's also the fact that, isolation of the older adults. You have to sit alone at the table, that's what a lot of people refuse to do […] and if no one is around who says "come on, let's sit at the table together", that's the thing, then they'll eat a lot less."

Quote 3:
Cook: "[…] and besides that, there's the financial problem, we all want that everyone gets a proper meal, which is rich in all nutrients, freshly cooked. But often, the family checks the price of such meals […]"

Quote 4:
Older adult (OA): "[…] there should be a medical-social facility, consisting of a place where one can eat, a place where one can get a blood test, a place where a physiotherapist or podiatrist or whatever, where they have their small consulting rooms, where older adults can be cared for."

Quote 5:
OA1: "It also depends on what the older adult is still capable of themselves."
OA2: "And how much family they still have."
OA1: "And how much help someone has or if there is a caregiver or professional help involved."

3.2 Knowledge and awareness

All focus group interviews revealed that there is a lack of knowledge and awareness towards malnutrition, its causes and consequences (table 6). Also, the importance of nutrition on health and wellbeing was under recognized.

Respondents suggested that the solution may lie in giving more information: OA should be well informed about the causes, consequences and solutions to malnutrition, for example through newspapers, magazines or via the television. Caregivers and health care professionals wanted to be educated how they can detect signs of malnutrition and undertake adequate interventions.

Table 6: Quotes Paragraph 3.2 "Knowledge and Awareness"

Quote 6: *Care coordinator: "[…] many people don't know the importance of nutrition. And I really think we should do something about it, I also notice it when I am on the phone with people, when I say nutrition is your medicine and you really need to keep eating healthy, "Oh really? Oh malnutrition?" everyone reacts so surprised."*
Quote 7: *Caregiver (CG): "[…] due to the nutritional supplements, he regained some weight and strength, but from the health care professionals involved, no, that is a very blind spot for doctors, nurses, nutrition and weight. […] apparently it is not a matter that really has their attention."*

3.3 Recognition and diagnosis of malnutrition

As stated before, lack of knowledge and awareness was recognized a factor withholding stakeholders from taking preventive measures or starting adequate interventions. Furthermore professionals do not always know which professional should be consulted if they recognize signs of malnutrition. In order to consult the right professional, it is required to assess the cause of malnutrition. For example, malnutrition caused by loneliness needs another approach than malnutrition caused by dysphagia.

Another factor that was mentioned explaining the missed diagnosis of malnutrition is the fact that a significant group of frail OA remains beneath the radar, even when health problems arise. This group of OA tends to avoid any involvement of professionals or others because they believe they are able to take care of themselves or do not want to be a burden to others, herewith making monitoring, diagnosing and treatment unable. Quotes on recognition and diagnosis of malnutrition can be found in table 7.

Table 7: Quotes Paragraph 3.3 "Recognition and diagnosis of malnutrition"

Quote 8: *Social worker: "[…] I think that there is a large group that remains beneath the radar, and I think you should focus on that group."*
Quote 9: *GP: "They say: "It's all going well doctor", but when they are admitted to hospital, they can't keep saying that, but prior to the admission, that's the answer you get."* *Sports coach: "I can do it by myself easily."*

3.4 Communication

During all interviews, communication was stated to be an important factor in the treatment and prevention of malnutrition among OA. Several barriers and facilitators were mentioned. Three categories can be distinguished within this theme, which are interrelated: communication between health care professionals, communication towards

OA and caregivers and communication with regard to the transfer report to another health care setting.

3.4.1 Between professionals

Communication with other health care professionals is essential once one of the health care professional has identified a (nutritional) problem. In this way, no duplication of work arises and the right health care professional can be involved. Unfortunately, the interviews revealed that this is not happening yet. For example, results of nutritional screening (by nurses) are not always shared with the doctor or dietitian and no action is taken. Furthermore, it was acknowledged that lack of communication between professionals resulted in cases where patients needed to tell their personal experiences multiple times, or important information remained unknown. It was suggested that these problems could be resolved easily, by interconnecting existing electronic care systems in which professionals can share their findings. However, this is thought to be problematic, given the European General Data Protection Regulation (GDPR).

3.4.2 Towards OA and caregivers

Within the health care system of the Netherlands, self-management has high priority. Several aspects with regard to the communication towards OA and caregivers were mentioned. Respondents stated that information about their health should be given directly to OA, and OA should be involved in the communication about their own health. Also, health advice and contact with health care professionals and social-medical facilities should be easily accessible. When including OA in the communication, this is thought to result in equality between OA and their health care professionals, and this could create a relationship of trust, which could make it easier for the OA to share possible health problems. On the other hand, respondents feared that not every OA is able to self-manage his/her own life and health, for example, due to vulnerability or not having the knowledge to do so.

3.4.3 Transfer report

Within the health care system in the Netherlands, a transfer report is issued when a patient is discharged from an institution to home. This report includes information about a patient's disease, recovery and medication use. Unfortunately, in some cases transfer reports are not issued at all, or issued only days after discharge, causing a delay in information. In some cases, the transfer report is sent to the GP but not to other relevant professionals, or patients receive the transfer report themselves, again leading to a delay in provision of information. In addition, several respondents identified that information about a patient's nutritional status and the involvement of a dietitian or the use of oral nutritional supplement is often not mentioned in such reports. A paper/digital "nutritional passport", or even an overall "health care passport" has been suggested as a means of

communication. In this case, someone should be made responsible for keeping such a document up-to-date. This topic relates to the theme discussed in the next Chapter. Quotes of paragraph 3.4 are depicted in table 8.

Table 8: Quotes Paragraph 3.4 "Communication"

Paragraph 3.4.1 Communication between health care and welfare professionals	**Quote 10:** *Interviewer: "[…] but actually you would want to prevent that a client needs to tell the same story over and over again, which is actually already known in primary care, right?"* *Nutrition assistant: "In case of some older adults indeed. Yes that would be nice."* *Interviewer: "Yes, that would save a lot of talking but might also give the client the feeling of "well, my situation is already known" and that will give them some more confidence maybe."* *Nurse: "Yes, that as well, and it saves us a day or two of identifying what someone can or cannot do, a decline in exercise or nutrition."* Later on in the same interview: *Nutrition assistant: "[…] I am not going to check the whole nursing record, then I'll just ask the patient."*
Paragraph 3.4.2 Towards older adults and caregivers	**Quote 11:** *CG: "With regard to older adults, one often speaks about older adults but rarely with older adults. That's the thing throughout the entire civil world and also in the field service and so on, they think they know what's good for us and for some older adults, but not all older adults are already senile and that is often forgotten. So participation is a nice term but if you indeed want to join in the discussion at a given moment, then they are completely upset because then they no longer know what to do."* **Quote 12:** *GP's nurse practitioner: "the moment you see a patient for the first time, there are sometimes things that you think, what would that be like and then if you then have a follow-up appointment with that patient you will see that you get a bond and that you get more information"*
Paragraph 3.4.3 Transfer report	**Quote 13:** *GP: "[…] sometimes you receive the report four days after a vulnerable older adult returns home, you would say that four days would be acceptable, but a lot can happen. In my opinion, I should receive that report before the patient is at home."* **Quote 14:** *Nurse: "I also think that with regard to the transfer from the hospital, in our practice nutrition isn't included in the transfer report. There is no specific focus on that"*

3.5 Accountability

During all focus group interviews, the GPs and their nurse practitioners were often referred to as being key figures in the (nutritional) care of OA: they are supposed to have all the information about a client, to know when a client is admitted or discharged from hospital, when a client experiences (health) problems at home and which health care professionals are involved in their clients' care (table 9).

The role of home care nurses also appears to be of great importance. They are expected to be able to evaluate nutritional status easily, since they visits their clients at home. However, with regard to taking action, they are limited in time to spend with their client. Formally, they can only signal and monitor nutritional status. Preparing and assisting with meals no longer falls under their duties. However, it depends on the individual employee or home care organization whether they will still assist in serving meals.

A "personal (nutrition/health care) passport" was suggested as being one of the solutions to a better communication between health care professionals. As to whom should be made responsible for keeping it up to date, the GP, nurse practitioner, and/or home care nurses were often being mentioned. Also healthcare mediators and dietitians, and even caregivers were suggested as being appropriate for the job. However, a great deal of responsibility already rests on the caregivers' shoulders and this may be too much for them to handle. Lastly, it was suggested that OA themselves could be made responsible. This is in line with the previously mentioned policy of self-management. However, stakeholders doubted whether this will be feasible and effective: the current generation of OA is not used to this responsibility and they might be too vulnerable, too shy to ask for help, or even too dependent on the idea that they will be taken care of by health care professionals or caregivers.

3.6 Food preparation and supply

Much discussed topics are the quality of the food supply in hospitals and rehabilitation centers, the existence, quality and familiarity of meal services and ready-made meals, use and quality of oral nutritional supplements, and the enjoyment of food at an older age. Together, these topics form the overall theme *food preparation and supply*.

Several OA who (had) stayed in a hospital and/or rehabilitation center stated that the quality of the food served was poor. They lacked variation in meals or meal components and were unable to continue their own diet (table 10). With regard to the quality and familiarity of meal services and ready-made meals, OA are aware of their existence, but believed that those meals are not healthy (e.g. too much salt or too big a portion size). With regard to the use of oral nutritional supplements, professionals often noticed that OA do not like the taste or even forget about taking them. Consequently, they come across large amounts stocked in cupboards and refrigerators. All stakeholders indicate that OA often forget about or skip meals, because of a decrease in the enjoyment of food. This could be a result of changes in their social environment, or a decline in smell or taste. Tailor-made care was mentioned as a possible solution to these problems, taking the ability to taste and smell, taste preferences and social aspects into account.

Table 9: Quotes Paragraph 3.5 "Accountability"

Quote 15:
Occupational therapist: "not to put the responsibility on the shoulders of the GP, but he has the overall picture." Respondent: "That's what you're hoping for, he actually remains the gatekeeper for everything."

Quote 16:
Occupational therapist: "Yes, we also kinda always come back to the GP's nurse practitioner, because he/she also has the function, they are busy with working that out, there is already a part of where our question simply can be added and he/she can bring all the information together and pass it on to other health care professionals if needed, and can also provide feedback to the GP, and the GP will of course know that immediately. This can all be done in one system."

Quote 17:
CG: "In my opinion, the nurse from the home care organization can very well evaluate the nutritional intake of the older adults"

Quote 18:
Nurse: "What I do find difficult in home care, is that you cannot force anything. So you are always dependent on the clients' goodwill. Also, you're not always there, so you can only stimulate, motivate and monitor whether someone is not losing weight or becoming dehydrated or whatever, and that is already a big step, isn't it?"

Quote 19:
Nurse: "[…] and that's when it gets debatable, that health insurances say that nutritional care is not part of personal care, so you almost immediately get financial problems. In our organization we decided that we will do it, we are not going to literally feed someone, but we will heat meals and serve breakfast and so on."

Quote 20:
Nutrition assistant: "[…] many health care professionals are involved with nutritional care and when talking about a nutritional passport, you would want someone to be responsible, who manages it and that's the question, who is going to manage, to all those things, we all do different tasks and I am wondering who would be responsible for this. Would this be the dietitian who can set the lines and how someone's diet should look like and engage everyone, or should this be a medical specialist, someone's care taker, it can be anyone, but someone should monitor, should it be a GP? […]"

Quote 21:
CG: "[…] you could also make sure that older adults themselves keep all adequate data and make clear they are in charge, so you could also leave that to older adults themselves, I don't know.."

Quote 22:
OA1: "It remains true that the whole principle of self-sufficiency of your health care and that it is, because if you cannot do that, then you won't get it either. That is the essence of the problem, if you cannot do that, there will be gaps."
OA2: "That is the nasty thing about that whole political load behind that, that we've been called back since two years, well we, but not me, the self-management in health care and those people have been completely pampered since World War II, a great deal has literally been pre-chewed, even with regard to meals, with the television and all other comforts and then from 2014 onwards they are expected to self-direct everything […]"

Quote 23:
Interviewer: "What I hear is that you have to be very empowered to be able to state things and I don't know if you think, with regard to the other older adults at the rehabilitation unit, would everyone be empowered enough?"
OA: "No, there are people who cannot do that, they are too sad, or unstable."

Table 10: Quotes Paragraph 3.6 "Food preparation and supply

Quote 24: *OA: "And here I notice that the vegetables and the food repeats very often. I am here for two weeks now, and we already had red cabbage three times now with stew, I think that's a lot in only two weeks' time."*
Quote 25: *OA: "[…] at home you just eat more vegetables, with a salad and chicory and endive."*
Quote 26: *OA1: "Ready-made meals, I don't know if you would like that, but you only have to put those in a microwave."* *OA2: "Yes but those meals are such big portions, I only eat a small amount per day and when I look at those ready-made meals I think: hello, I can have dinner twice!"* *OA3: "And they contain a lot of salt."*
Quote 27: *GP: "What I also encounter frequently is that a patient is being viewed very clinical, the patient loses weight, so medical nutrition is being prescribed. And when you visit them at home you see a refrigerator full of bottles of medical nutrition that people just can't consume, or you see that someone cannot eat regular nutrition anymore."*

3.7 Interview couple from Moroccan origin

The interview with the couple from Moroccan origin revealed that they expressed themselves differently from people with a Dutch origin. They indicated that they dealt with illness differently, and that care is mainly provided by their family members and caregivers. Consequently, they rely less on professionals. When in touch with health care professionals, language barriers have been a major problem. Because of the language barrier, the couple experienced that they were not always involved in decisions about their own health care. Furthermore, they indicated that during hospital admission they were not sure whether the food was hallal. They also believed that discharge from hospital to home was too soon, the respondent was not fully recovered. Little had been arranged by the hospital, and home care was not available. At discharge, the respondent received the transfer report and it was the respondents' responsibility to make sure the report was delivered to their GP.

3.8 Suggestions

The respondents made different suggestions to optimize collaboration and communication across the continuum of health care. Table 11 includes these suggestions, summarized per theme.

Table 11: Suggestions for collaboration and communication in nutritional care across the continuum of health care settings

Theme	Suggestions
Causes of malnutrition	Social cohesion: social-cultural and medical facilities to improve social networks of older adults.
Knowledge and awareness	Inform older adults about the causes, consequences and solutions of malnutrition, through local newspapers, supermarkets' magazines and television.
	Inform caregivers and health care professionals about detection and treatment of malnutrition.
Diagnosis of malnutrition	Communicate (nutritional) problems with other health care professionals by using current communication systems.
Communication	Include older adults in communication about their own health.
	Include nutritional information in transfer reports.
Accountability	One single health care professional should be appointed to coordinate nutritional care, consulting the right health care or welfare professional and monitoring health goals in cooperation with the older adult

Discussion

To our knowledge, this is one of the first qualitative studies into barriers, facilitators and needs for collaboration and communication in nutritional care across health care settings. The results of this study show that many stakeholders are involved in nutritional care, but communication and collaboration between stakeholders often fall short and expectations cannot be met. Prerequisites for interdisciplinary communication and collaboration in nutritional care are improved knowledge and awareness of (the causes of) malnutrition to be able to recognize and to adequately act on possible signs of malnutrition.

Causes of malnutrition was identified as an important theme. Causes of malnutrition include physical and mental decline, mainly caused by ageing itself. This is not a novel finding. The decline in the ability to taste and smell, decreased appetite, effects of medication, metabolic changes and many other problems are known to influence food intake and uptake at an older age[18,19]. Additionally, social aspects such as small social networks, loneliness, absence of external stimuli and financial issues are known causes for malnutrition among OA[20,21]. Hence, a number of respondents, both OA and professionals, suggested to create more social and medical facilities in order to solve many of these social problems. In sharp contrast, the interviews also revealed that a large number of facilities already exist, but that OA and health care professionals are mostly unaware of these. Solutions might therefore not lie into organizing new facilities, but into promoting existing facilities and making sure they are known among OA and health care professionals. *Knowledge and awareness* towards malnutrition in OA was the second theme that arose, and has been found to be low among both OA and caregivers and professionals. This could undermine timely recognition and treatment. These findings are in line with a previous studies[13,22-25]. Even though several respondents gave suggestions how to inform and educate all stakeholders involved, the findings of this study do not yet provide specific guidance to this education.

The third theme appointed was *recognition and diagnosis of malnutrition*. This theme strongly relates to *knowledge and awareness*, but also to *communication between professionals*. Knowing how to recognize and diagnose malnutrition in an OA requires knowledge and awareness. A recent study has shown that many European educational institutions for nurses and GPs do not include malnutrition topics in their curricula[23,26]. Including the topic of malnutrition to the curricula of nursing schools and GP vocational training could be an important step in improving knowledge and awareness of malnutrition[26,27]. Additionally, welfare professionals, indicated that they were mostly unaware which signs could indicate (risk of) malnutrition. Welfare professionals are frequently involved when OA have financial or social problems, and educating them may be helpful to improve identification of OA at risk of malnutrition. This could be done

through initial curricula or through in-service training on this topic, preferably addressing a multi-professional group (for example, a community nurse, welfare professional and GP from a municipality). Additionally, professionals, but also caregivers, should be aware of the steps that need to be undertaken when a malnourished OA has been identified. They need to know which professional to contact in case malnutrition is suspected. This strongly relates to the following theme, *communication*.

Communication was a frequently discussed topic during the focus group interviews, both *between health care professionals*, *with OA and their caregivers*, and issuing the *transfer report*. As stated before, when (nutritional) problems are suspected by one professional, it is crucial that is communicated with other professionals. In short, in addition to knowledge about recognition of (signs of) malnutrition, communication with other professionals is considered equally important. However, efficient communication and information management is problematic[28]: offices or workplaces are often not situated in the same location, and organizing meetings with all professionals involved is time-consuming and often logistically impossible. Therefore, innovative solutions should be sought, possibly using modern communication technology (i.e. through mobile phones and digital assistants, electronic group pages and worksheets)[29], keeping the General Data Protection Regulation[30] in mind.

Regarding *communication with OA and their caregivers*, the results of this study showed that OA themselves often feel ignored by professionals. This is in line with previous studies[28,31], showing that patients are often not involved in the decision-making of their treatment, while involving the patient in for instance discharge management showed positive results on several patient outcomes[32]. Health care professionals should learn how to involve patients in the decision making regarding (nutritional) care, in order to make them feel involved in their own care process. This requires new competences, in approaching the client as a person, not as his disease.

Lastly, the *transfer report* was a frequently discussed topic. In many cases, transfer reports were delayed or never reached the proposed recipient. Additionally, nutritional information was often not included in the report. It is suggested that such reports should be issued in all cases, and that there should be a fixed format, including nutrition(al problems) and possible steps undertaken and to be taken. A previous study investigated the effectiveness of transitional care and already concluded that, in order to reduce short-term readmissions, transitional care should consist of communication between the primary care provider and the hospital[33,34].

Nutrition is one of the most important aspects in life. Besides the physical need of nutrition, social aspects play a major role. Herewith, nutrition is a topic that appeals to

everyone. Contrarily, our study shows that no specific professional feels responsible for coordinating nutritional care. This is said to be caused by a lack of knowledge and/or. It was suggested that besides the OA, one specific, or even several professionals should be (made) responsible. These results are in line with a previous qualitative study among 22 Dutch nutrition health care professionals[13], which concluded that awareness towards malnutrition was limited and it was unclear which professionals are responsible and which monitoring procedures are preferred. Thus, in order to prevent (further physical decline caused by) malnutrition in elderly, a coordinator should be appointed. Depending on OA's situation, the GP[23] or nurse practitioner were suggested as coordinators, unless a home care nurse was involved. He/she was then suggested as the coordinator.

When discussing nutritional care across the continuum of health care settings, food preparation and supply is a topic that arises naturally. Many OA pointed out that food prepared and served in institutions is not what they are used to consume: variation is limited and OA cannot always continue their eating habits during admission. This topic was regarded very important by OA and their caregivers.

One of the regions included in the interviews is a multicultural neighborhood. Therefore, it was found important to also include OA with a non-Dutch origin. Unfortunately, due to limited time and resources, only one couple with a non-Dutch origin was included in the study, and no data saturation has occurred. However, the interview did reveal important results. Namely, the couple from Moroccan origin identified the language barrier and cultural differences (e.g. social relations, eating habits) as two of the largest barriers. As a result, they experienced that they were not always included in the decision-making of their treatment. These findings are in line with a previous study which already showed that language and cultural barriers are severe barriers to putting shared decision-making into practice[35]. The results of this study imply that physicians should improve their skills to recognize the limitations within the communication with immigrant patients as well as improving the skills to acknowledge the barriers, which may help to ameliorate shared decision-making in an intercultural setting.

With the increasing number of OA in the Netherlands, Dutch health care policy is aimed at encouraging OA to stay at home as long as possible. Herewith, vitality and independence are of great importance. Nutrition plays a large role to support this. When health problems arise and OA are compelled to be admitted to hospital or rehabilitation center, nutritional care should be one of the most important topics in the communication and collaboration of professionals over the continuum of care. This study indicates that this is not yet the case.

Even though this study is one of the first in addressing this topic, a number of limitations have to be acknowledged. The name of the project, "Nutrition Passport", was communicated as such to all respondents. This might have biased the respondents answers, and steered them into the direction of a passport. Furthermore, the number of caregivers that participated in the focus group interviews was low, with only five respondents. It is therefore debatable whether the view of caregivers has been sufficiently clarified. Research has shown that caregivers could have an important role in nutritional care[36]. Therefore, it might be interesting to further study the view of caregivers regarding nutritional care. Additionally, GPs were appointed as possible coordinators of nutritional care. However, only a small number of GPs participated in the focus group interviews. As a result, their opinion may not have been sufficiently taken into account. Lastly, one interview with a couple with a non-Dutch origin took place. Future research is needed in order to outline the view and experiences of OA with a non-Dutch origin.

Collaboration and communication with regard to nutritional care across the continuum involves many stakeholders. This study has clearly shown that collaboration and communication between different stakeholders is not yet optimal. Improvement could mainly lie in increasing knowledge and awareness regarding recognition and treatment of (mal)nutrition of professionals and OA themselves and their caregivers. Regarding communication, a solution is needed, keeping in mind the General Data Protection Regulation[30]. Linking (digital) communication systems would be a solution that is embraced by all. Additionally, OA should take responsibility for their own health care and a professional should coordinate nutritional care, for instance the GP, the nurse practitioner or a home care nurse. Lastly, further research is needed to fully study the view of elderly immigrants.

The results of this qualitative study will be used to improve communication and collaboration of nutritional care across the continuum of health care settings, by developing a personal nutrition passport. Furthermore, suggestions will be made to improve transfer reports, including at least a patient's disease, recovery, medication use, nutritional status, use of oral nutritional supplements and involvement of other professionals and timely availability of the report[37,38].

In summary, this study identified barriers and facilitators towards communication and collaboration of nutritional care across the continuum of health care settings. Many stakeholders are involved in the nutritional care of older adults. Suggestions are given for improvement, such as nutritional education, improving possibilities for social coherence and establishing one coordinator of nutritional care.

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CHAPTER 4

4

Protein intake among community-dwelling older adults: the influence of (pre-) motivational determinants

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Objective

This study explores the chance of a low protein intake in relation to eight behavioral determinants (I-Change model) among Dutch community-dwelling older adults.

Design

Cross-sectional design, data were collected through an online questionnaire from October 2019 – October 2020.

Setting

Community setting in the Netherlands.

Participants

Eight hundred twenty-four Dutch community-dwelling older adults, recruited via online newsletters, newspapers and by personal approach.

Main outcome measure(s)

Chance of a low protein intake (<1.0g/kg body weight/day) using ProteinScreener55+ and behavioral determinants cognizance, knowledge, risk perception, perceived cues, attitude, social support, self-efficacy and intention by evaluating statements on a 7-point Likert scale.

Analysis

Poisson regression was performed to calculate quartile based Prevalence Ratios (PRs).

Results

Almost 40% of 824 respondents had a high chance of a low protein intake. Univariate analyses indicated that lower scores for all different behavioral determinants were associated with a higher chance of a low protein intake. Independent associations were observed for knowledge (Q4 PR=0.71) and social support (Q4 PR=0.71).

Conclusions and implications

Results of this study can be used in future interventions aiming to increase protein intake in which focus should lie on increasing knowledge and social support.

Introduction

Protein-energy malnutrition (PEM) affects 7 to 12% of Dutch community-dwelling older adults[1]. PEM, in combination with reduced physical activity, may lead to physical limitations, such as the inability to walk stairs or doing groceries[2]. It is known that Dutch older adults are often unaware of the importance of an adequate protein intake and of problems associated with malnutrition[3-5]. To ensure that the increasing number of older adults[6] remains vital and independent as long as possible, an adequate intake of dietary protein is crucial[7,8]. In contrast to WHO recommendations (0.8 g of protein per kg body weight per day)[9], experts recommend an intake of 1.0 gram protein/kg/day[10]. Approximately 50% of Dutch community-dwelling older adults does not meet this recommendation[11] and especially during breakfast, protein intake is low in this population[12]. To counteract this low protein intake more insight into protein-related dietary behavior is needed to look for opportunities for sustainable behavior changes for the majority of this population.

Dietary behavior is influenced by various determinants. Behavioral change theories have been developed describing multiple factors that may explain dietary behavior[109]. One of those theories is the I-Change Model[14-16]. This model distinguishes three phases prior to actual behavior: Awareness, Motivation and Action. All three phases incorporate four behavioral determinants that are relevant to the corresponding phase, and that can eventually influence behavior. Awareness consists of the behavioral determinants *cognizance*, *knowledge*, *risk perception* and *perceived cues*; Motivation comprises *attitude*, *social support*, *self-efficacy* and *intention* while *action planning*, *plan enactment*, *skills* and *barriers* are behavioral determinants within the Action phase.

Since awareness of the importance of an adequate protein intake and problems associated with malnutrition is low among older adults[3-5], older adults can be classified in the Awareness phase of the I-Change Model, rather than the phase in which taking action is considered. Until now, little research has been done concerning behavioral determinants that may influence protein intake in Dutch older adults. Therefore, this study examines the association between the chance of a low protein intake and eight behavioral determinants among Dutch community-dwelling older adults.

Methods

2.1 Study design and sampling

This study was a cross-sectional study in which data were collected through an online questionnaire administered from October 2019 – October 2020. Inclusion criteria were: being 65 years and older; living independently (with or without home care); and being able to complete an online questionnaire (independently or with help). A total of 824 respondents was recruited through multiple strategies: online newsletters of a Dutch association for older adults (n=201), a newsletter of a health insurance company (n=229); a video in a national newspaper and various articles in regional newspapers across the Netherlands (n=296) and through personal approach (n=98).

The questionnaire had been piloted for readability and comprehensibility among twelve older adults, recruited through personal approach. The results of this pilot were used to finalize the questionnaire.

2.2 Measurements

The questionnaire consisted of 50 items and started with a short description of the aim of the study and the content of the questionnaire.

2.2.1 Socio-demographic characteristics

The first 14 items asked for socio-demographic characteristics: age, gender, marital status, living situation, living area, having children (yes/no), country of birth, type of home care (if relevant), educational level, income, self-reported body weight, body height and weight loss. Respondents with incorrect weight and height (<40.0kg and <1.00m) were excluded from the data set (n=8).

2.2.2 Protein intake

The chance of low protein intake is assessed with the Protein Screener 55+ (Pro55+). This screening tool has been validated among Dutch older adults aged >55 years[17]. The tool uses a prediction model to calculate the risk of a low protein intake, the so-called probability score. Based on a validation study[17], a cut-off value for the probability score of 0.3 was used: a score higher than 0.3 indicates a higher chance of low protein intake (<1.0 g/kg BW/day). The probability score is based on body weight and results of ten items regarding consumption frequency and portion size of ten protein-rich food items. Examples of food items are "In the last 4 weeks, how often did you eat eggs with either your breakfast, lunch, evening meal, as snack, or in a meal?" or "In the last 4 weeks, how many slices of bread did you eat on an average day?". Participants were asked to indicate the frequency in "Not in these 4 weeks" to "7 days/week" and the amount in "None/Less than one, or not applicable" to "More than 12".

2.2.3 Behavioral determinants

In the question that assessed the level of *knowledge* concerning protein-rich food items, respondents were asked to indicate which of the listed foods contain nutritional protein. Twelve types of food were shown through pictures (bread, eggs, fruit, vegetables, marmalade, coffee, milk, nuts, olive oil, fruit juice, meat and salmon). The behavioral determinant *Knowledge* was assessed by scoring: +1 for correct answers, -1 for incorrect answers. This led to a minimum score of -6 and a maximum score of +6.

The other items covered the seven other determinants of behavior concerning protein consumption: *cognizance*, *risk perception*, *perceived cues*, *attitude*, *social influences*, *self-efficacy* and *intention*. Since protein intake is known to be low during breakfast, questions were formulated as "throughout the day" and/or specifically "during breakfast". Even though it was intended to analyze the outcomes per timing of the day, outcomes of Spearman's rho correlation were high (>0.50) in most behavioral determinants. This indicates that there were only small differences in outcomes per timing of the day.

The questions were based on existing questionnaires and literature describing how to identify specific behavioral determinants[14, 18-23]. Table 1 gives an overview of the items regarding the behavioral determinants. For every behavioral determinant, two to six items were incorporated into the questionnaire. Respondents were asked to rate to which extent they agreed with the statements on a 7-point Likert scale (totally disagree – totally agree). An average per behavioral determinant was calculated to obtain an overall score of each determinant.

2.3 Procedure

After answering the items regarding the socio-demographic characteristics, Pro55+ and the determinant *Knowledge*, respondents received information on products that naturally contain dietary protein to support appropriate answering to questions on the remaining seven determinants. The questionnaire ended with a thank you note including the possibility to download the information that was given during the questionnaire and links to websites with extra information.

2.4 Internal validation

Cronbach's α of seven behavioral determinants (except *knowledge* as this was only one question) were calculated to check whether the separate items per behavioral determinant could be combined into one scale (table 1). A Cronbach's α ≥0.70 is viewed as an acceptable value for internal consistency[24]. For *cognizance* and *self-efficacy* Cronbach's α was below 0.70. Therefore, sensitivity analyses were performed (*Appendix*; Table 5) by analyzing the separate items of *cognizance* and *self-efficacy* as well as the combined scales as described in the section *Behavioral determinants*. As the separate items of the scale

showed outcomes relatively comparable to the combined scale, we decided to use the combined scale for *cognizance* and *self-efficacy* instead of the separate items despite the low Cronbach's α.

2.5 Ethical considerations and data management

The HAN Ethical Advisory Board judged the study protocol and concluded that this study did not fall within the remit of the Medical Research Involving Human Subjects Act (WMO). Respondents received detailed information about the aim, content, and data storage of the study before the start. By accepting the terms of agreement, informed consent was signed. Respondents were able to discontinue completing the questionnaire at any time. Data were stored confidentially.

2.6 Data analysis

As answers of the behavioral determinants were not evenly distributed over the seven point scale, quartiles were composed. As logistic regressions provide an overestimate of the prevalence (ratio's), Poisson regressions with robust variance estimations were used to calculate prevalence ratios[25]. In these analyses protein score (high vs low chance of a low protein intake) was included as dependent variable and knowledge and the seven behavioral determinants as independent variables. Prevalence ratios (PR) were reported with corresponding 95% confidence intervals (model 0) and additionally adjusted for age (65-74y; 75-84y; >85y), gender (male/female), BMI (<20 kg/m^2; 20 – 27 kg/m^2; >27 kg/m^2), living situation (alone/together) and income (low/high); model 1. A full model was developed in which all behavioral determinants were included (model 2). For the full model, variance inflation factor (VIF) scores were assessed in R version 4.0.2 (Car package) to test for multicollinearity. VIF scores for all variables were <5, indicating no multicollinearity.

Table 1: Items in the questionnaire, presented per determinant of behavior and time of day

Knowledge		
In general	In your opinion, which foods in the figures below contain dietary protein? *Twelve food products were shown*	
	Attitude◊	*Cronbach α = 0.88*
During the day	1. Consuming enough protein-rich foods, spread throughout the day, is important to me.	
	2. Consuming enough protein-rich foods, spread throughout the day, is healthy.	
	3. Consuming enough protein-rich foods, spread throughout the day, is desirable.	
During breakfast	1. Consuming enough protein-rich foods, during breakfast, is important to me.	
	2. Consuming enough protein-rich foods, during breakfast, is healthy.	
	3. Consuming enough protein-rich foods, during breakfast, is desirable.	
	Risk perception◊	*Cronbach α = 0.75*
During the day	1. A low intake of dietary protein during the day has negative consequences for my health status.	
	2. When I don't consume enough protein-rich foods during the day, physical exercise becomes more difficult.	
	3. When I don't consume enough protein-rich foods during the day, I feel more tired.	
	Cognizance◊	*Cronbach α = 0.55*
During the day	1. I think I eat enough protein-rich foods during the day.*	
During breakfast	1. I think I eat enough protein-rich foods during breakfast.*	
	Self-efficacy◊	*Cronbach α = 0.63*
During the day	1. I can eat enough protein-rich foods during the day.*	
During breakfast	1. I can eat enough protein-rich foods during breakfast.*	
	Perceived cues◊	*Cronbach α = 0.69*
During the day	1. No one has ever told me that eating enough protein during the day is important for my health status.	
	2. I know from people around me who had to eat more dietary protein due to disease, that a sufficient intake of protein during the day is important for good health.	
During breakfast	1. No one has ever told me that eating enough protein during breakfast is important for my health status.	
	2. I know from people around me who had to eat more dietary protein due to disease, that a sufficient intake of protein during breakfast is important for good health.	
	Social support◊	*Cronbach α = 0.81*
During the day	1. People that are close to me eat enough dietary protein during the day.*	
	2. People that are close to me motivate/support me to eat enough dietary protein during the day.*	
During breakfast	1. People that are close to me eat enough dietary protein during the day.*	
	2. People that are close to me motivate/support me to eat enough dietary protein during the day.*	
	Intention◊	*Cronbach α = 0.75*
During the day	I plan to eat enough dietary protein throughout the day for the upcoming months.*	
During breakfast	I plan to eat enough dietary protein during breakfast for the upcoming months.*	

* Examples of protein-rich foods were shown below the question; ◊ 7-point scale

Results

Sociodemographic characteristics of the respondents (n=824) are shown in table 3. The chance of a low protein intake (<1.0 g/kg BW/day) was 39.4%. There were no differences in sociodemographic characteristics between respondents with a low and high chance of a low protein intake. Mean age was 72.9 years, 37.5% of the respondents were male and mean BMI was 25.1 kg/m^2.

Poisson regression models of the association between chance of a low protein intake (Pro55+) and behavioral determinants are presented in table 4. Model 0 showed that lower scores for each determinant were associated with a higher risk of a low protein intake. Compared to the first quartile (Q1), especially the third (Q3) and fourth quartile (Q4) showed decreased prevalence ratios (PR) for most determinants on the chance of a low protein intake. When adjusted for age, gender, BMI, living situation and income (model 1), outcomes remained similar for Q3 and Q4 for *cognizance, intention, self-efficacy and social support*. In this model, Q4 remained similar for the other behavioral determinants (*attitude, knowledge, perceived cues and risk perception*). When all behavioral determinants were included in the final model (model 2), prevalence ratios changed and most were no longer significant, except for *knowledge* (PR Q4=0.71) and *social support* (PR Q4=0.71). For all non-significant behavioral determinants the pattern of a decreasing PR over the quartiles remained intact for *attitude, intention* and *self-efficacy*, but no longer for *cognizance, perceived cues* and *risk perception*.

Table 2: Sociodemographic characteristics of the respondents

	Total	Protein screener ≤0.3 Low chance of low protein intake*	Protein screener >0.3 High chance of low protein intake
	824	499 (60.6%)	325 (39.4%)
Age			
Mean (±SD)	72.9 (5.9)	72.6 (5.8)	73.5 (6.1)
65-74	518	328 (65.7%)	190 (58.4%)
75-84	264	149 (29.9%)	115 (35.4%)
≥85	42	22 (4.4%)	20 (6.2%)
Gender			
Male	309 (37.5%)	167 (33.5%)	142 (43.7%)
Female	515 (62.5%)	332 (66.5%)	183 (56.3%)
BMI (kg/m^2)			
Mean (±SD)	25.1 (3.7)	24.6 (4.0)	25.9 (3.2)
<20	44	37 (7.4%)	7 (2.2%)
20-27	567	353 (70.7%)	215 (66.1%)
>27	212	109 (21.8%)	103 (31.7%)
Living situation			
Living alone	310	186 (37.3%)	124 (38.2%)
Living together**	514	313 (62.7%)	201 (61.8%)
Living area			
Urban	394	218 (43.7%)	176 (54.2%)
Suburban	379	249 (49.9%)	130 (40%)
Rural	51	32 (6.4%)	19 (5.8%)
Education			
Low	228	140 (28.1%)	88 (27.1%)
Middle	202	120 (24.0%)	82 (25.2%)
High	394	239 (47.9%)	155 (47.7%)
Income* **			
Low	170	91 (18.2%)	79 (24.3%)
High	654	408 (81.8%)	246 (75.7%)

** Protein intake <1.0 g/kg BW/day*
*** With partner and/or children*
**** Low income was defined as annual income <€30.481 for singles and <€38.945 for couples*

Table 3: Regression analyses of the eight behavioral determinants

Outcomes in bold are considered significant

	Quartile (median (IQR))	N	Model 0: Prevalence ratio (95% C.I.)	Model 1*: Adjusted Prevalence ratio (95% C.I.)	Model 2**: Full model (95% C.I.)
Attitude	Q1 (4.5 (4.0 – 4.8))	222	Ref	Ref	Ref
	Q2 (5.5 (5.3 – 5.7))	195	1.00 (0.81 – 1.22)	1.02 (0.83-1.25)	1.12 (0.90-1.39)
	Q3 (6.0 (6.0 – 6.0))	192	**0.75 (0.59 – 0.95)**	0.79 (0.63-1.00)	1.03 (0.77-1.36)
	Q4 (6.5 (6.3 – 7.0))	215	**0.59 (0.46 – 0.76)**	**0.62 (0.48-0.80)**	0.93 (0.66-1.31)
Cognizance	Q1 (4.0 (3.5 – 4.5))	196	Ref	Ref	Ref
	Q2 (5.5 (5.0 – 5.5))	228	0.84 (0.69 – 1.03)	0.83 (0.68-1.01)	0.93 (0.73-1.19)
	Q3 (6.0 (6.0 – 6.0))	256	**0.64 (0.51 – 0.80)**	**0.66 (0.53-0.83)**	0.91 (0.67-1.23)
	Q4 (7.0 (6.5 – 7.0))	144	**0.60 (0.45 – 0.79)**	**0.63 (0.48-0.84)**	1.30 (0.85-1.99)
Intention	Q1 (4.0 (4.0 – 4.0))	179	Ref	Ref	Ref
	Q2 (5.0 (5.0 – 5.5))	159	0.95 (0.77 – 1.17)	0.95 (0.77-1.17)	0.96 (0.78-1.20)
	Q3 (6.0 (6.0 – 6.0))	273	**0.68 (0.55 – 0.84)**	**0.70 (0.57-0.86)**	0.84 (0.65-1.09)
	Q4 (7.0 (6.0 – 7.0))	213	**0.49 (0.38 – 0.64)**	**0.51 (0.39-0.67)**	0.70 (0.48-1.00)
Knowledge	Q1 (1.0 (1.0 – 2.0))	189	Ref	Ref	Ref
	Q2 (4.0 (3.0 – 4.0))	285	0.98 (0.79 – 1.20)	1.03 (0.84-1.27)	1.01 (0.83-1.23)
	Q3 (5.0 (5.0 – 5.0))	230	**0.76 (0.60 – 0.97)**	0.83 (0.65-1.06)	0.81 (0.64-1.02)
	Q4 (6.0 (6.0 – 6.0))	120	**0.67 (0.49 – 0.92)**	**0.74 (0.54-1.01)**	**0.71 (0.52-0.97)**
Perceived cues	Q1 (3.0 (2.5 – 3.3))	230	Ref	Ref	Ref
	Q2 (4.0 (4.0 – 4.0))	192	1.02 (0.81 – 1.27)	0.98 (0.79-1.22)	1.15 (0.92-1.43)
	Q3 (4.8 (4.5 – 5.0))	187	1.0 (0.80 – 1.26)	0.98 (0.78-1.22)	1.19 (0.94-1.47)
	Q4 (6.0 (5.5 – 6.5))	215	**0.70 (0.54 – 0.90)**	**0.71 (0.55-0.91)**	0.97 (0.74-1.26)
Risk perception	Q1 (4.0 (3.7 – 4.3))	166	Ref	Ref	Ref
	Q2 (5.0 (4.7 – 5.3))	283	0.93 (0.76 – 1.14)	0.99 (0.81-1.21)	1.04 (0.84-1.30)
	Q3 (5.7 (5.7 – 5.7))	99	**0.70 (0.51 – 0.97)**	0.76 (0.55-1.06)	0.89 (0.64-1.25)
	Q4 (6.0 (6.0 – 6.7))	276	**0.67 (0.53 – 0.85)**	**0.71 (0.56-0.89)**	1.00 (0.75-1.33)
Self-efficacy	Q1 (4.0 (3.5 – 4.5))	167	Ref	Ref	Ref

	Q2 (5.5 (5.0 – 5.5))	209	0.93 (0.76 – 1.14)	0.95 (0.77-1.16)	1.06 (0.84-1.35)
	Q3 (6.0 (6.0 – 6.0))	282	**0.63 (0.51 – 0.79)**	**0.65 (0.52-0.81)**	0.85 (0.63-1.15)
	Q4 (7.0 (6.5 – 7.0))	166	**0.51 (0.38 – 0.68)**	**0.53 (0.40-0.71)**	0.64 (0.41-1.01)
Social support	Q1 (2.5 (2.3 – 3.0))	199	Ref	Ref	Ref
	Q2 (4.0 (3.5 – 5.0))	271	0.88 (0.72 – 1.07)	0.88 (0.72-1.06)	0.83 (0.68-1.02)
	Q3 (4.5 (4.5 – 5.0))	180	**0.77 (0.61 – 0.98)**	**0.76 (0.60-0.96)**	0.82 (0.64-1.04)
	Q4 (6.0 (5.5 – 6.0))	174	**0.56 (0.42 – 0.74)**	**0.54 (0.41-0.72)**	**0.71 (0.52-0.96)**

* Adjusted for age (65-74y; 75-84y; >85y), gender (male/female), BMI (<20 kg/m^2; 20 – 27 kg/m^2; >27 kg/m^2), living situation (alone/together) and income (low/high); ** Model included all behavioral determinants (cognizance, knowledge, risk perception, perceived cues, attitude, social support, self-efficacy and intention)

Discussion

This study aimed to explore the chance of a low protein intake regarding eight behavioral determinants of the I-change model among Dutch community-dwelling older adults. In short, almost 40% of respondents had a high chance of a low protein intake (<1 g/kg BW/day). Overall, respondents with lower scores for each of the behavioral determinants had a higher chance of a low protein intake. This effect remained when adjusting for age, gender, BMI, living situation and income. The full model, in which all behavioral determinants were included, showed that *knowledge* and *social support* had an independent association with the chance of a low protein intake.

The corresponding phases in the I-Change model are Awareness for *knowledge* and Motivation for *social support*. Several previous studies have reported associations between nutrition-related knowledge and dietary behavior or nutrition-related knowledge and health status among (older) adults[26-29], although not specifically aimed at protein intake. A study by Jeruszka-Bielak et al. (2018) showed that good nutrition-related knowledge was associated with a lower BMI and higher physical activity in a large European cohort of older adults[26]. Studies by Spronk et al. (2021) and De Vriendt et al. (2009) showed that higher nutrition-related knowledge resulted in better dietary behavior, mostly a higher intake of fruits and vegetables[27,28]. Even though protein intake was not taken into account in these studies and effects of good nutrition-related knowledge often related to a higher intake of fruits and vegetables, these studies and ours, underline the importance of nutrition-related knowledge on eating behavior and lifestyle. Kok et al. (2016) also regarded *knowledge* to be the basis for many other determinants[13]. Similar to the results of our study, they described that most behavioral determinants are not independent of each other. In practice, this may imply that interventions that aim to increase protein intake among Dutch community-dwelling older adults should focus on improvement in knowledge as the basis for multiple behavioral determinants and different stages in the I-Change model. Even though the latter studies were not specifically aimed at increasing protein intake, a recent study by Yung Hung et al. (2019) also addressed different behavioral determinants in relation to protein intake among Dutch older adults[29]. Similar to our study, *knowledge* was low in participants with a high chance of a low protein intake. In addition, difficulties in meal preparation (*self-efficacy*), the ability to engage in physical activities in difficult situations (*self-efficacy*) and a lower readiness to follow dietary advice (*attitude/intention*) were found to be associated with a lower protein intake. Similarities between this study and the current study are that behavioral determinants of the Motivation phase explain a low protein intake among Dutch community-dwelling older adults and that *knowledge* is an important behavioral determinant within the Awareness phase. Differences can be explained by the different methods used to determine the different behavioral determinants.

Previous studies also revealed that *social support* has a large influence on dietary behavior, but again these studies in both young (age 17y-47y) and older adults (>50y) were specifically aimed at fruit and vegetable intake[30-32]. These studies reported either a synergistic or adverse effect between social support and self-efficacy related to action plans (in I-change model: Action phase) or actual behavior. Our study indicates that social support has an independent effect on dietary behavior. This difference may be because other studies focused on the intake of fruit and vegetables, rather than protein intake, and included participants in different age groups. Altogether, future interventions should target behavioral determinants *knowledge* and *social support* to increase protein intake among Dutch community-dwelling older adults.

Strengths and limitations

To our knowledge, this study is one of the first to assess specific behavioral determinants related to protein intake in community dwelling older adults. A large cohort of 824 respondents was recruited via several channels, to include a representative population of Dutch community-dwelling older adults. The mean BMI of our population (25.1 kg/m^2) was lower compared to that in similar studies in community-dwelling older adults (~27 kg/m^2)[11,33]. Also, the proportion of respondents with high education was higher compared to the Dutch population[34]. This may imply that our population already had a healthier diet, as previous studies showed that educational level is positively associated with a healthy lifestyle and a lower BMI[35-38]. Therefore, future research should also include older adults with a low to middle educational level to assess possible differences within this population. Another strength of this study is the fact that the items included in the questionnaire were based on existing, validated questionnaires and that the questionnaire had been pre-piloted among a group of Dutch community-dwelling older adults. A limitation may be that only a few respondents chose the first three categories (totally disagree – disagree a little) of the 7-point Likert scale. Using this type of scale made it impossible to determine the relative outcome per determinant, e.g. whether respondents had a "good" or "bad" attitude towards eating enough protein per day/meal moment. It was also impossible to analyze the outcomes continuously. Therefore, outcomes were divided into quartiles to distinguish between respondents who had higher scores on the 7-point Likert scale.

Implications for Research and Practice

In conclusion, this study shows that behavioral determinants *knowledge* and *social support* are independently associated with the chance of a low protein intake. In practice, this means that interventions should focus on different aspects of behavior and preferably target *knowledge* and *social support* when aiming to increase protein intake of Dutch community-dwelling older adults.

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Appendix

Table 4: Regression coefficients of behavioral determinants with a low Cronbachs

	Quartile (median (IQR))	**N**	**Odds ratio (95% C.I.)**
Cognizance	Q1 (5.0 (4.0 – 5.0))	255	Ref
During the day	Q2 (6.0 (6.0 – 6.0))	428	**0.51 (0.37-0.70)**
	Q3 (7.0 (7.0 – 7.0))	141	**0.36 (0.23-0.57)**
Cognizance	Q1 (3.0 (2.0 – 4.0))	198	Ref
During breakfast	Q2 (5.0 (5.0 – 5.0))	179	0.92 (0.61-1.37)
	Q3 (6.0 (6.0 – 6.0))	315	**0.57 (0.39-0.81)**
	Q4 (7.0 (7.0 – 7.0))	132	**0.47 (0.30-0.75)**
Self-efficacy	Q1 (4.0 (4.0 – 4.0))	257	Ref
During the day	Q2 (5.0 (5.0 – 5.5))	406	**0.51 (0.37-0.71)**
	Q3 (7.0 (6.0 – 7.0))	161	**0.33 (0.22-0.50)**
Self-efficacy	Q1 (4.0 (3.0 – 4.0))	173	Ref
During breakfast	Q2 (5.0 (5.0 – 5.0))	158	1.15 (0.75-1.78)
	Q3 (6.0 (6.0 – 6.0))	333	**0.48 (0.33-0.70)**
	Q4 (7.0 (7.0 – 7.0))	160	**0.24 (0.24-0.59)**

α, per meal moment; outcomes in bold are considered significant

CHAPTER 5

5

The protein gap: increasing protein intake in the diet of community-dwelling older adults – a simulation study

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Objective

Approximately 50% of Dutch community-dwelling older adults does not meet protein recommendations. This study assesses the effect of replacing low protein foods with protein-rich alternatives on protein intake of Dutch community-dwelling older adults.

Design

The Dutch National Food Consumption Survey – Older Adults 2010-2012 was used for scenario modelling. Dietary intake was estimated for 727 adults aged 70+ based on two 24-h recalls. Commonly consumed products were replaced by comparable products rich in protein (scenario 1), foods enriched in protein (scenario 2), and a combination of both (scenario 3). Replacement scenarios were confined to participants whose dietary protein intake was <1.0g/kg BW/day (n=391). Habitual protein intake of all older adults was estimated, adjusting for effects of within-person variation in the 2-days intake data.

Results

Mean protein intake of the total population increased from 1.0 to 1.2 g/kg BW/day (scenarios 1 and 2) and to 1.3 g/kg BW/day (scenario 3). The percentage of participants with intakes of ≥1.0 g/kg BW/day increased from 47.1% to 91.4%, 90.2%, and 94.6% respectively in scenarios 1, 2 and 3. The largest increases in protein intake were due to replacements in food groups *Yoghurt, cream desserts and pudding*, *Potatoes, vegetables and legumes* and *Non-alcoholic beverages and milk* in scenario 1 and *Bread*; *Yoghurt, cream desserts and pudding* and *Soups* in scenario 2.

Conclusions

This simulation model shows that replacing low protein foods with comparable alternatives rich in protein can increase the protein intake of Dutch community-dwelling older adultsa considerably. Results can be used as a basis for nutritional counseling.

Introduction

Vitality and independence are important determinants of healthy ageing. However, the ageing process is naturally associated with loss of muscle mass, reduced strength and physical endurance[1]. A healthy diet in combination with physical exercise can limit age-related muscle decline and help retain optimal muscle function, with a key role for dietary protein[2,3]. The current WHO recommendation for protein is 0.8 grams per kilogram body weight per day (g/kg BW/day), for both men and women[4]. Expert groups recommend a higher intake of 1.0 – 1.2 g/kg BW/day for healthy older adults, and even 1.2 – 1.5 g/kg BW/day for older adults who are malnourished or at risk of malnutrition[5,6].

The Dutch National Food Consumption Survey Older Adults (2010-2012; DNFCS-OA) revealed that 15.4% of older adults did not meet the recommended daily intake of 0.8 g/kg BW/day[7]. Furthermore, approximately 50% of the participants of the DNFCS-OA did not meet the higher protein recommendation of ≥1.0 g/kg BW/day[7]. In accordance, the risk of protein-energy malnutrition (PEM) remains high among community-dwelling older adults: varying from 7-12% among Dutch community-dwelling older adults without home care to 30-40% among older adults receiving home care[8]. PEM may result in reduced functioning of the immune system, impaired muscle function, fatigue, impaired wound healing, and depression[9–11]. PEM, therefore, influences the physical, mental and social well-being of older adults and can pose a threat to independence and quality of life[11,12].

This emphasizes the importance of an adequate intake of dietary protein. Despite the increasing availability of protein-rich and protein-enriched food products, it is still unclear to what extent such products could help to improve protein intakes if chosen instead of regularly consumed products lower in protein. A study by Beelen et al. (2017) revealed that older adults often experience difficulties in adopting and applying changes in their diets, which suggests that staying close to their existing dietary pattern and only making subtle changes, may be most effective in increasing their protein intake[13]. Accordingly, this study aims to assess the potential effect of replacement of commonly consumed foods low in protein content by comparable products high in protein content and/or protein-enriched products on daily protein intake of Dutch community-dwelling older adults.

Methods

2.1 Study population

The sampling frame for DNFCS-OA consisted of the population registers of 15 municipalities in the Netherlands, covering five regions and three region-specific classes of address density. Within each municipality a sex and age-stratified sample was randomly drawn from the population register. This was the sampling base from which a market research organization recruited participants. At first, potential participants received an invitation with information leaflet by mail with an enclosed reply letter. Because response was very low, recruitment changed to face-to-face visiting after sending written information about the study. The DNFCS-OA included 739 community-dwelling older adults living in the Netherlands, and the overall response rate was 25.9%. Mean age was 77.1 (± 5.2 years) and 41.9% were male. The survey was a nationwide cross-sectional study, representative for region, address density and age. Height and weight were measured during a home visit and mean BMI was 27.4 kg/m^2 (± 3.8). The population consisted of 97.0% Dutch participants. Over 50% of the population was married or lived together. Of all participants, 52.9% had a mean protein intake below 1.0 g/kg BW/day (n=391). Almost all participants (96.6%) scored high on the Mini-Mental State Examination (MMSE) score, indicating a low risk of dementia. Furthermore, 95.7% of the participants reported not to have eating and drinking difficulties. Other characteristics and specific details on the recruitment of the participants are described elsewhere[7].

2.2 Dietary intake

Data on dietary intake were collected through two non-consecutive dietary 24h-recalls performed by trained dietitians. Recalls were spread equally over all days of the week and throughout the year and were assisted by food diaries. Participants were asked to record and memorize all foods consumed from the moment of getting up on one day to the moment of getting up the next day. During the 24-hour recalls, participants were asked about the time and place of food consumption occasions. Furthermore, they were asked to describe the type of food consumed using facets and descriptors to specify the foods and to give an indication of the quantity of the food consumed through household measures, units, by weight/volume, or by photo series showing a range of quantities. Detailed information on data collection of the DNFCS-OA can be found elsewhere[7]. Dietitians entered the recall data directly into the computer and products were grouped using EPIC-Soft (IARC©) food group classification[14]. All foods were linked to 1347 food items from the extended version of Dutch Food Composition Database of 2011 (The National Institute for Public Health and the Environment, 2011). Accordingly, total energy, macro –and micronutrient intakes were calculated.

2.3 Data analysis

Participants were excluded in the current data analysis when body weight was unknown (n=12). For each of the remaining 727 participants protein intake per kg BW/day was calculated for each 24-h dietary recall and averaged over the two recalls. Food replacements in all three scenarios were restricted to participants with an average protein intake <1.0 g/kg BW/day (n=391). Participants with a protein intake of ≥1.0 g/kg BW/day were not included in the scenarios. For each of three scenarios, every food item within a specific food group with a protein content below the 75th percentile of the protein contents in that food group was replaced by a high protein alternative product from the same food group. Food groups were included in the different scenarios based on the results of the DNFCS-OA[7] and a study by Hung et al.[15] and their role in the eating pattern in the Netherlands. First a long list of potential food groups, based on either the food groupings in EPIC-Soft or in NEVO, was prepared. Food groups were included when intakes of that food group contributed at least 10% to total food consumption during a specific meal moment[7], or when they contributed most to total intake in grams of a specific meal moment[15]. Only food groups that contributed much to protein intake were included in the scenarios since food groups low in protein content (e.g. fruit or fats) or food products from food groups consumed in small quantities (e.g. herbs) would not have a large impact on protein intake. Products were substituted on the basis of weight (g) consumed. The first scenario focused on replacement by high protein foods, the second scenario on protein-enriched foods, and the third scenario on a combination of both.

2.3.1 Scenario 1

In scenario 1, replacements were made in nine different food groups. The alternative food product has a protein content >P75 of protein content in that food group. To design a feasible scenario in daily practice, the alternative food product should be familiar to the target group and therefore alternative food products were commonly consumed food products within the DNFCS-OA. Food groups and their alternative foods of scenario 1 are presented in table 1.

2.3.2 Scenario 2

In scenario 2, replacements were made in six different food groups, based on EPIC-Soft classification. The alternative foods have a protein content >P75 in that food group and foods had to be familiar to older adults, i.e. be similar to the foods they replace. Food groups and their alternative foods of scenario 2 are presented in table 2.

2.3.3 Scenario 3

Replacements were made in six different food groups in scenario 3. Choice of food groups and alternative foods was based on the top 3 food groups of scenarios 1 and 2 for which replacements resulted in the largest increase in protein intake. The top 3 of scenario 1

included the food groups *Yoghurt, cream desserts and pudding*, *Potatoes, vegetables and legumes* and *Non-alcoholic beverages and milk*. However, since the food group *Yoghurt, cream desserts and pudding* was in the top 3 in both scenarios, *Savory spreads, sweet spreads and cheese* was the fourth most contributing food group in scenario 1 and was chosen as an alternative. Besides *Yoghurt, cream desserts and pudding* the top 3 of scenario 2 included the food groups *Soups* and *Bread*. Food groups and alternative foods included in scenario 3 are presented in tables 1 and 2, indicated with an γ-sign.

For each scenario, protein intake for each consumption day was determined per particpant. For the whole population of older adults and in all three scenarios, the distribution of the habitual protein intake adjusted for within-person variability was estimated using SPADE software[16], a statistical program to estimate habitual dietary intake. The proportion of older adults with a habitual protein intake below a cut-off value of 1.0 g/kg BW/day was estimated and compared to the original scenario. Also, the impact of the exchange of protein sources on mean intakes of other macro- and micronutrients was assessed. Here average intake over two days was used to calculate the mena intakes. Results were weighed for socio-demographic deviances and deviances in the day of the week and season. Besides the SPADE software, data was analyzed using SAS Software (SAS version 9.4, SAS Institute).

Table 1: Scenario 1: Food groups to be replaced and their protein rich alternatives

Food group	Group classification[1]	Protein P75 (g/100 g)	Scenario 1 Protein rich alternatives	Energy (kcal/100g)	Protein (g/100 g)
Bread	EPIC-Soft	11.0	Bread multigrain, with seeds	261	12.3
Breakfast cereals	EPIC-Soft	11.0	Oatmeal	373	12.8
Cakes + Chocolate + Candy bars	EPIC-Soft	6.9	Muesli bar with chocolate	452	7.7
Dairy: Yoghurt + cream desserts and pudding	EPIC-Soft	4.0	Quark, low fat	58	8.5
Non-alcoholic beverages + Dairy: Milk[γ]	EPIC-Soft	0.9	Yoghurt drink with sweetener (Optimel, FrieslandCampina)	30	3.1
Nuts and seeds + Savory snacks	NEVO	18.5	Peanuts, unsalted	627	25.2
Potatoes, vegetables and legumes[γ]	EPIC-Soft	3.0	Lentils	99	8.8
Soups	EPIC-Soft	4.2	Soup with meat, vegetables and noodels	42	4.4
Spreads: Cheese + Savory spreads + Sweet spreads[γ]	NEVO	25.5	Cheese, 30+	289	30.4

1. Group classification: based on the products that were covered, groups were chosen from NEVO of EPIC-Soft classification. **γ.** Included in scenario 3.

Table 2 Scenario 2: Food groups to be replaced and their protein rich alternatives

Food group	Group classification[1]	P75 (g/100 g)	Scenario 2 Protein enriched alternatives	Energy (kcal/100g)	Protein (g/100 g)
Bread[γ]	EPIC-Soft	11.0	White Bread (Carezzo)	255	27.0
Cakes + Chocolate + Candy bars	EPIC-Soft	6.9	"Bouwsteentje" (De Bakker BV)	352	15.0
Ice cream	EPIC-Soft	4.3	Ice cream, vanilla (Carezzo)	176	11.5
Non-alcoholic beverages	EPIC-Soft	0.4	Apple juice (Carezzo)	79	6.7
Soups[γ]	EPIC-Soft	4.2	Funghi soup (Carezzo)	66	6.9
Yoghurt + cream desserts and pudding[γ]	EPIC-Soft	4.0	BonDuo Breakfast	133	12.0

1. Group classification: based on the products that were covered, groups were chosen from NEVO of EPIC-Soft classification. **γ.** Included in scenario 3.

Results

3.1 Simulation model

The number of replacements in the three different scenarios increased from 2.686 in scenario 2, to 4.135 in scenario 3, and 5.535 in scenario 1 (table 3).

3.2 Effects on mean protein intake

3.2.1 Scenario 1: Protein-rich foods

Replacing foods from nine different food groups in participants with a protein intake <1.0 g/kg BW/day (n=391) with protein-rich alternatives resulted in an increase in mean habitual protein intake in the total population (n=727) from 1.0 to 1.2 g/kg BW/day or 76.5 to 89.7 g/day. Overall, the percentage of participants who met the recommended intake of 1.0 g/kg BW/day increased from 41.1% to 91.4%. Replacements in food groups contributing most to the increase in protein intake were *Yoghurt, cream desserts and pudding*; *Potatoes, vegetables and legumes* and *Non-alcoholic beverages and milk*.

3.2.2 Scenario 2: Protein-enriched foods

In scenario 2, consumed foods in six food groups were replaced with protein-enriched products, resulting in an increase in mean habitual protein intake from 1.0 to 1.2 g/kg BW/day and from 76.5 to 91.8 g/day. In this scenario, 90.2% of the participants reached a mean habitual protein intake ≥ 1.0 g/kg BW/day. The three food groups with the highest impact on increasing protein intake were *Bread*; *Yoghurt, cream desserts and pudding* and *Soups*.

3.2.3 Scenario 3: Top 3's of scenario 1 and 2

Scenario 3 included the top three contributing food groups of scenarios 2, and three other most contributing food groups of scenario 1. This scenario resulted in a mean habitual protein intake of 1.3 g/kg BW/day and 93.9 g/day with 94.6% of the participants achieving a protein intake ≥ 1.0 g/kg BW/day.

3.3 Intake of other macro and micronutrients

Evaluation of differences in intake of other macro and micronutrients was based on the average of the two-day 24h recalls. Mean energy intake (kJ (kcal) ± SD) and mean intake of carbohydrates, total fat, and dietary fiber was similar in all scenarios and amounted to approximately 8375 kJ (2000 kcal) ±1900, 45 En%, 35 En%, and 20-24g respectively. Dietary fiber intake was low in all scenarios compared to the recommendation. Mean intakes of other macronutrients were in line with the recommended intake. Intakes of macronutrients are listed in table 4. Most micronutrients remained comparable to the original scenario (Appendix I). Copper and iodine intakes increased substantially in scenario 1 compared to the original scenario, while iodine intake was much lower in scenarios 2 and 3. Mean selenium intake varied through all scenarios being lowest and lower than recommended

in the original scenario and scenario 2. Calcium intake increased considerably in scenarios 1 and 3. In all scenarios, mean vitamin C intake was higher than the average requirement.

Table 3: Food groups, alternative foods and frequencies of replacement

	Scenario 1			*Scenario 2*			*Scenario 3*	
Food group	**Total replacements (n)**	**Replacements per person* per day (mean n)**	**Food group**	**Total replacements (n)**	**Replacements per person* per day (mean n)**	**Food group**	**Total replacements (n)**	**Replacements per person* per day (mean n)**
Bread	850	2.2	**Bread**	850	2.2	**Bread**	850	2.2
Breakfast cereals	67	0.2	**Cakes**	883	2.3	**Non-alcoholic beverages + Dairy: Milk**	582	1.5
Cakes + Candy bars + Chocolate	1150	2.9	**Ice cream**	29	0.1	**Potatoes + vegetables + legumes**	1429	3.7
Non-alcoholic beverages + Dairy: Milk	582	1.5	**Non-alcoholic beverages**	302	0.8	**Soups**	210	0.5
Nuts and seeds + Savory snacks	183	0.5	**Soups**	210	0.5	**Spreads: Sweet + Savory spreads + Cheese**	652	1.7
Potatoes + vegetables + legumes	1429	3.7	**Yoghurt + Cream desserts and pudding**	412	1.1	**Yoghurt + Cream desserts and pudding**	412	1.1
Soups	210	0.5						
Spreads: Sweet + Savory spreads + Cheese	652	1.7						
Yoghurt + Cream desserts and pudding	412	1.1						
Total	5535	14.2	Total	2686	6.9	Total	4135	10.6

*Number of replacements in respondents with an average intake below 1.0 g/kg BW/day (n=391)

Table 4: Mean intake of other macro and micronutrients (±SD) based on two day intake per scenario (n=727)

Nutrient	Norm intakes[143]	Average intake of 2 days			
		Original scenario	Scenario 1	Scenario 2	Scenario 3
Energy in kJ (kcal)	Men: 2500 Women: 2000	8264 (1974) ± 1948	8545 (2041) ± 1932	8503 (2031) ± 1928	8587 (2051) ± 1878
Total protein(g)	46	76.5 ± 19.5	90.7 ± 18.3	92.6 ± 21.7	95.6 ± 21.4
Total fat (g)	20 - 35 En%	76.4 ± 24.2 (34.8 En%)	78.6 ± 25.0 (34.7 En%)	77.8 ± 23.7 (34.5 En%)	76.7 ± 24.0 (33.7 En%)
Saturated fatty acids (g)	As low as possible	29.6 ± 10.8	29.3 ± 10.8	30.1 ± 10.6	29.6 ± 10.6
Mono-unsaturated fatty acids (g)		25.0 ± 8.9	26.7 ± 10.1	23.8 ± 9.2	24.2 ± 9.2
Poly-unsaturated fatty acids (g)		15.0 ± 6.9	15.9 ± 6.9	14.5 ± 7.0	14.6 ± 7.0
Trans fatty acids (g)	As low as possible	1.4 ± 0.8	1.2 ± 0.7	1.2 ± 0.7	1.3 ± 0.8
Carbohydrates (g)	45-60 En%	213.1 ± 56.0 (43.2 En%)	209.0 ± 55.6 (41.0 En%)	207.4 ± 57.0 (40.8 En%)	211.2 ± 55.3 (41.2 En%)
Dietary fiber (g)	25	20.8 ± 6.5	23.8 ± 6.9	20.9 ± 6.7	23.0 ± 7.1

Discussion

This study assessed the effects of replacing foods low in protein content by commonly consumed protein-rich and/or protein-enriched alternative foods on daily protein intake of Dutch community-dwelling older adults. Outcomes showed that replacing low protein foods within six to nine food groups with similar high protein alternatives for participants with a mean protein intake <1.0g/kg BW/day, the protein intake of Dutch community-dwelling older adults can be increased considerably. The proportion of older adults complying with a protein intake of at least 1.0 g/kg BW/day increased from 47.1% to approximately 90% in all three scenarios of the simulation model.

Although the three different scenarios showed similar results with regard to mean protein intake and proportion of participants with a mean intake ≥1.0 g/kg BW/day, the number of replacements in the protein-enriched scenario (scenario 2; protein-enriched) was much lower in comparison to scenarios 1 (protein-rich) and 3 (combination). Therefore, scenario 2 seemed to be the most efficient scenario of this simulation model. This can be explained by the fact that protein-enriched foods often have a higher protein content compared to regular and natural foods since extra protein is added[17]. Hence, the effect of the scenarios is partly explained by the combination of foods within one scenario, but individual foods may have a considerable contribution to protein intake.

Despite a relevant increase in calculated protein intake, none of the scenarios achieved that 100% of the participants had a mean protein intake of ≥1.0 g/kg BW/day. One explanation may be a very low protein intake in a small subgroup of participants. For this subgroup the simulation model may increase the protein intake, but not sufficiently to meet a protein intake of 1.0 g/kg BW/day. Another explanation might be that some people consume little to no foods from the food groups that were included in the simulation model. In that case, no or few replacements were made.

Several intervention studies have been performed in the past showed that protein intake increased remarkably when protein-enriched foods were offered, varying from 14g to 42g of extra protein per day[18–22]. This implies that shifting from regular foods to protein-enriched alternatives might be an effective way to increase protein intake among older adults. However, three of these studies included hospitalized older adults and older adults residing in a rehabilitation ward[18–20]. A study by Ziylan et al.[21] among community-dwelling older adults showed that protein intake increased by 14.6g after replacing bread with protein-enriched bread and hot meals with protein-enriched readymade hot meals compared to the control group who received regular equivalents. A study by Borkent et al.[22] showed that protein intake increased by 13.6g in participants who received readymade protein-rich hot meals and protein-rich dairy products compared to the control group

who received standard readymade hot meals and drinks. Remarkably, participants in the control group decreased their protein intake compared to pre-study intake. Therefore, the authors concluded that switching from self-prepared meals to readymade meals could be a risk for a decreasing protein intake when readymade meals are not protein-enriched. In both studies[18,22], changes were mainly made within the foods from the main meals (breakfast – lunch – dinner), but not in-between meals (snacks). Our simulation model included both foods consumed during main meals, as well as foods consumed in-between meals. This could explain the larger effect on protein intake in our study. However, since our simulation model is a theoretical framework, feasibility should be tested in practice.

The intervention studies that have been performed in community-dwelling older adults showed a smaller effect on protein intake compared to studies in hospitalized older adults. This may have several reasons. Research has shown that Dutch older adults tend to have low interest and willingness to purchase protein-enriched foods and the price of protein-enriched foods is pointed out as a barrier to purchase those foods[23,24]. When offered (free of costs) at a hospital or rehabilitation center, older adults might be more inclined to consume protein-enriched foods than when they have to purchase the foods at home. Additionally, older adults tend to be more skeptical towards protein-enriched foods and prefer consuming conventional foods that are naturally rich in protein[23]. However, our simulation model has shown that, to increase protein intake with foods that are naturally rich in protein, more replacements are needed compared to protein-enriched foods. All in all, more research is needed to evaluate the efficacy of intervention studies including protein-rich and protein-enriched foods and to identify all barriers and facilitators towards purchasing and consuming protein-rich and protein-enriched foods in the community setting.

The main goal of this study was to study the effects of a simulation model on protein intake. However, changing food patterns can alter the intake of energy and other macro- and micronutrients as well. Therefore, the impact of the replacements on intakes of energy and other macro- and micronutrients was also verified (Appendix I). Results show that energy increased moderately in all three scenarios, varying from 59-66 kcal per day. In practice, this could result in minor weight gain[25]. However, people may also compensate for the surplus of energy[26]. This, and the feasibility of the replacements within this simulation model should be tested through an intervention study. Contrarily, most macro- and micronutrients remained similar to the original scenario, with a few exceptions for the micronutrients copper, iodine, selenium, calcium and vitamin C. However, in the scenarios used in the simulation model the majority of foods from one food group were replaced by just one specific alternative that may be rich or low in other macro- and micronutrients. This might have had a large effect on the total intake of that specific macro or micronutrient. In practice, it is unlikely that older adults will replace all foods in a food group with one

specific alternative. All foods consumed in DNFCS with a protein content >P75 of the food group are shown in appendix II. These findings can be used in dietary advice and/or in the development of new or existing foods.

Strengths and limitations

To our knowledge, this study is one of the first studies to investigate possible strategies to improve protein intake in community-dwelling older adults through a simulation model. In this simulation model the effect of hypothetical changes in the diet of Dutch community-dwelling older adults based on a priori decisions has been identified, keeping several practical issues in mind. A strength of this study is that the choice of the alternative foods was based on familiarity: foods that were already consumed by the target group and were high in protein content were chosen as alternative foods. Furthermore, the choice of the alternative foods was based on similarity: the alternative foods had to be similar to the foods they replaced (i.e. yoghurt and other desserts were replaced by quark, juices were replaced by yoghurt drink with a fruity flavor). Consequently, the alternative foods did not differ much from the products they replaced. Since the choice of the alternative foods was based on familiarity and similarity, the chance of adopting the changes into their current diet is enhanced. Another strength of this study was that foods were replaced within a food group by alternative foods in grams originally consumed instead of replacing foods with alternatives in portions. Thus, in practice participants do not have to increase the portion size to increase protein intake. Recent studies have shown that enrichment of regular products does not affect satiety and has no impact on the consumption of other foods[18,19,21]. Consequently, it is assumed that participants eat similar amounts of food, even though food is protein-enriched. In this way, practical application is again more attainable. Lastly, a strength of this study was the estimation of habitual protein intake in the last step of the simulation model. In this way, within-person variation between the two-day intake was removed, which led to a more accurate estimation of habitual intake of the original scenario and the protein-rich and protein-enriched scenarios.

Yet, this study also has some limitations. The dataset of the DNFCS-OA was the best data set available to include in this simulation model. However, the data originates from 2010-2012. Therefore, the data might not be representative of the current diet of Dutch older adults, as shown in previous research. Hulshof et al. (2003) found that intake of some foods and nutrients in Dutch subjects has changed significantly over 10 years[27]. On the other hand, it is known that older adults tend to keep a very stable food pattern over time[28]. The scenarios in this simulation model included replacements in six to nine food groups. Even though the actual intake of specific food groups might differ in the current population of Dutch older adults, the effects of the different scenarios might be similar, whereby the differences in intakes between the different food groups might compensate for the outcome. Furthermore, within the DNFCS-OA there is an overrepresentation of

relatively healthy older adults[7]. Healthy older adults might have a higher protein intake compared to less healthy older adults[29], while also the type of foods consumed may be different between healthy and less healthy older adults. Moreover, data of the DNFCS-OA are based on self-reported food intake. An error that often occurs in self-reported dietary intake is underreporting[30]. Therefore, actual protein intake might be higher than shown in the data of the DNFCS-OA.

Conclusion

This study has revealed successful strategies to increase protein intake in the diet of community-dwelling older adults by replacing currently consumed foods low in protein with protein-rich and protein-enriched alternatives. Foods that have been used as a replacement of foods within a specific food group can be used in the formulation of dietary advice. However, other foods with a protein content above the P75 within that food group can also be used as a substitution. It is highly recommended to test the feasibility of the theoretical models used in this study in practice.

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Ethical Standards Disclosure

The Ethics Committee of the University Medical Centre Utrecht approved the study protocol of the DNFCS-OA[107]. For the current study the General Data Protection Regulations have been maintained.

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Appendices

Appendix I: Mean micronutrient intake ± SD in the original scenario and in scenario 1, 2 and 3

Nutrient	Norm intakes[157–162]	Average intake of 2 days			
		Original scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**
Calcium (mg)*	1200	966.6 ± 324.3	1069.2 ± 328.1	893.0 ± 358.2	990.4 ± 343.9
Copper (mg)**	0.7	1.1 ± 0.4	1.5 ± 0.5	1.0 ± 0.5	1.3 ± 0.5
Iron (mg)**	6	10.4 ± 3.5	10.4 ± 3.5	10.4 ± 3.5	10.4 ± 3.5
Iodine (µg)*	150	159.0 ± 52.8	169.3 ± 51.5	133.8 ± 66.1	137.1 ± 64.4
Magnesium (mg)*	Men: 350 Women: 300	322.3 ± 83.8	365.9 ± 86.4	295.9 ± 98.0	315.6 ± 90.3
Sodium (mg)***	2400	2329.4 ± 804.7	2320.3 ± 783.6	1996.7 ± 923.0	2038.0 ± 896.9
Phosphorus (mg)*	550	1406.9 ± 357.7	1628.5 ± 334.7	1297.9 ± 429.3	1451.7 ± 368.2
Potassium (mg)*	3500	3268.4 ± 756.5	3689.6 ± 801.1	3073.2 ± 849.0	3423.7 ± 808.2
Selenium (µg)*	70	44.7 ± 17.6	76.0 ± 36.9	42.5 ± 18.6	71.6 ± 34.7
Zinc (mg)**	Men: 6.4 Women: 5.7	10.1 ± 3.2	11.8 ± 3.0	9.5 ± 3.5	10.7 ± 3.2
Retinol activity equivalents (µg)*	Men: 615 Women: 525	1026.1 ± 1592.8	927.4 ± 1590.9	996.9 ± 1595.0	927.9 ± 1591.1
Folate equivalents (µg)**	200	330.8 ± 143.6	336.1 ± 141.0	314.1 ± 148.5	311.0 ± 146.9
Vitamin B1 (mg)**	0.85	1.1 ± 0.5	1.2 ± 0.44	1.0 ± 0.5	1.1 ± 0.5
Vitamin B2 (mg)**	Men: 1.5 Women: 1.1	1.4 ± 0.5	1.6 ± 0.5	1.3 ± 0.5	1.4 ± 0.5
Vitamin B6 (mg)**	Men: 1.3 Women: 1.1	1.8 ± 0.7	1.8 ± 0.6	1.7 ± 0.7	1.8 ± 0.6
Vitamin C (mg)**	Men: 60 Women 50	104.4 ± 56.6	83.6 ± 51.2	101.3 ± 56.4	81.5 ± 52.0
Vitamin D (µg)*	61 – 70y: 10 >70y: 15	4.1 ± 2.8	4.0 ± 2.8	4.0 ± 2.9	4.1 ± 2.8
Vitamin E (mg)*	Men: 13 Women: 11	12.9 ± 5.7	12.1 ± 5.7	12.3 ± 5.7	12.2 ± 5.7

* = Adequate intake; ** = Estimated Average Requirement; *** Maximum recommended intake

Appendix II: Foods with a protein content > p75, per food group with corresponding NEVO code

Food group	Foods with protein intake >p75	NEVO code
Savoury snacks	Almonds blanched unsalted/unsalted	198/2887
	Cashew nuts unsalted/salted	199/2886
	Peanuts unsalted/salted/dry roasted	204/876/2048
	Nuts mixed unsalted/salted	207/1935
	Sesame seeds	838
	Linseeds	867
	Pistachio nuts salted	1896
	Pine nuts	2176
	Wrap shoarma roll prep wo fat	2550
	Pumpin seeds	2806
Breakfast cereals	Oatmeal	213
	Breakfast cereal Brinta	225
	Breakfast cereal All-Bran Plus Kellog's	591
	Breakfast product Special K Original	2005
	Breakfast product Albona 7-cereals-energy	2361
Milk and milk products	Yoghurt low fat	301
	Pudding vanilla	736
	Mousse chocolate	767
	Pudding chipolata	786
	Yoghurt full fat with fruit	863
	Yoghurt Bulgarian low fat	916
	Fromage frais half fat w fruit	917
	Blancmange vanilla w strawberry sauce	940
	Yoghurt half fat	1502
	Fromage frais low fat w fruit w sw	2246
	Fromage frais yoghurt w fruit	2247
	Tiramisu	2371
	Yoghurt Greek full fat	2503
	Pudding airy average	2520
	Porridge milk w flour Lammetjespap	2521
	Yoghurt & custard Campina	2536
	Yoghurt 0% fat w fruit Activia	2655
	Porridge oatmeal w semi-skimmed milk	3050
	Milk raw	270
	Milk chocolate-flavoured full fat	272
	Milk chocolate-flavoured low fat	273
	Milk whole	279
	Milk full fat condensed w sugar tinned	281
	Milk semi-skimmed	286
	Buttermilk	289
	Milk skimmed	294
	Milk skimmed dried	295
	Milk whole dried	296
	Buttermilk with fruit	479

Appendix II: Continued

Milk and milk products	Yoghurt drink	657
	Milk chocolate-flavoured semi-skimmed	1464
	Milk semi-skimmed enriched w calcium	1719
	Milk chocolate-flavoured Chocomel light	1970
	Milk goats- full fat	2240
	Yoghurt drink with sweeteners	2254
	Coconut milk	2290
	Drinking chocolate w s-sk milk	2495
	Dairy drink Campina fruitmilk	2496
	Drinking chocolate w s-sk milk +Nesquik	2500
	Milkdrink skimmed milk Becel pro-activ	2725
	Hot chocolate from vending machine	2760
	Coffee iced	2835
	Dairy drink Milk&Fruit mango	2917
	Milk chocolate-flavoured w sw Optimel	3004
Soups	Soup clear with meat	758
	Soup clear with meat and noodles	760
	Soup clear with meat and vegetables	761
	Soup clear with meat vegetables and noodles	762
	Soup main course with legumes and meat	766
	Stock powder low sodium	1883
Vegetables and legumes	Kale curly boiled	16
	Mushrooms chanterelle boiled	18
	Mushrooms boiled	20
	Lettuce head boiled	47
	Swiss chard leaf boiled	48
	Spinach raw	51
	Bean sprouts raw	58
	Bean sprouts boiled	59
	Peas garden medium fine tinned	134
	Peas garden super fine tinned	135
	Peas and carrots tinned	136
	Spinach tinned	140
	Tomato puree concentrated tinned	141
	Beans broad tinned	142
	Peas marrowfat legumes tinned	196
	Beans baked in tomato sauce tinned	197
	Swiss chard leaf raw	563
	Spinach creamed frozen boiled	651
	Beans brown tinned	660
	Garlic fresh	830
	Broccoli boiled	920
	Peas frozen boiled	953
	Beans broad boiled	962
	Peas fresh boiled	963
	Beans white/brown boiled	968
	Lentils boiled	970
	Peas green boiled	972
	Dandelion leaves raw	1087

Appendix II: Continued

Vegetables and legumes	Peas chick boiled	1095
	Peas and carrots frozen unprepared	1139
	Vegetable mixed Mexico frozen unprepared	1141
	Beans runner frozen unprepared	1143
	Beans broad frozen unprepared	1148
	Onions deep-fried sachet	1484
	Tomatoes dried in oil tin/glass	2377
	Tomato sun-dried	2378
	Rocket raw	2736
	Sweetcorn tinned	2900
	Beans white tinned	3049
Cheese	Cheese Swiss dried	304
	Cheese Edam 40+	511
	Cheese 20+ Leidse w cumin/Fries clove	514
	Cheese Parmesan	718
	Cheese Gruyere	722
	Cheese Emmentaler	724
	Cheese Cheddar	725
	Cheese Amsterdam 48+	883
	Cheese raw milk 48+	1112
	Cheese sodium reduced 48+	1113
	Cheese 30+	1382
	Cheese 20+	1723
	Cheese Leerdammer/Maasdammer 45+	1725
	Cheese 40+ Leiden w cumin/Fries clove	1726
	Cheese 45+	1809
	Cheese 30+ low salt	2824
Pastry and biscuits	Biscuit fortified Liga Tweede Stap	234
	Almond filled pastry	250
	Biscuit sweet	252
	Cake wo butter	253
	Cake sponge Dutch Eierkoek	254
	Biscuit sponge fingers	260
	Biscuit brown/wholemeal	263
	Doughnut Dutch style	474
	Biscuit oatmeal	837
	Biscuit spiced Speculaas w almond paste	855
	Biscuit chocolate	1471
	Biscuits sugar free	1477
	Biscuit fortified Liga Milkbreak	1965
	Cake made with butter	1969
	Cake Dutch spices ontbijtkoek w nuts	2397
	Wafer galette	2425
	Wafer w milk & hazelnts Knoppers	2428
	Cake with nuts	2432
	Biscuit fortified LU Time Out	2556
	Cake with "bitterkoekjes"	2571
	Biscuit Bridge ommetjes	2719
	Sponge cake wholemeal	2933

Appendix II: Continued

Sugar, sweets, sweet spreads and sweet sauces	Cocoa powder	430
	Chocolate milk	431
	Candybar Snickers	528
	Cocoa product powder Ovomaltine	595
	M&M's chocolate with peanuts	621
	Chocolate bar milk with nuts	717
	Almond paste with egg	790
	Chocolate plain with nuts	2375
	Chocolate milk w puffed rice	2376
	Cocoa product sweetened Nesquik Hot Choc	2415
Bread	Bread wholemeal average	246
	Bread wholemeal w pumpkin seeds	2348
	Break linseed	2349
	Bread multigrain average w seeds	2350
	Bread wholemeal w nuts	2354
	Bread wholemeal w sunflower seeds	2357
	Bread wholemeal w seeds	2703
	Bread brown w seeds	2704
	Bread corn w sunflower seeds	2707
	Roll brown hard	2796
	Roll brown soft	2797
	Rolle wholemeal soft	2798
	Roll multigrain hard	2799
	Roll multigrain soft	2800
	Bread brown w pumpkin seeds	2821
	Croissant chocolate-	2400
	Almond paste filled tarts w butter	2761
	Croissant prepared w butter	2801
	Croissant average	2818
	Bread brioche	2876
Non-alcoholic drinks	Juice tomato/vegetable Appelsientje	1933
	Juice tomato Appelsientje Zontomaat	1934

CHAPTER 6

6

The effect of food odor exposure on appetite and nutritional intake of older adults with dementia

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Objective

Dementia can lead to decreased appetite and nutritional intake. Food odor exposure has been shown to increase appetite and nutritional intake in young healthy adults. This study investigates the effect of food odor exposure on appetite, nutritional intake and body weight of Dutch nursing home residents with dementia.

Design

This was a one-armed, non-randomized, non-blinded intervention study consisting of a four-week control period followed by a twelve-week intervention period.

Setting

Four nursing homes in the Netherlands.

Participants

Forty-five nursing home residents with dementia.

Intervention

During the intervention period, odors were dispersed prior to the main meals.

Measurements

General and specific appetite for sweet and savory foods was measured weekly. Nutritional intake was measured once during the control period and three times during the intervention period through a 3-day food record. Body weight was assessed at the start and end of the control period and at the start, end and halfway the intervention period. Data were analyzed with linear mixed models.

Results

Small changes in general and specific appetite were observed after odor exposure. Overall energy intake did not change during the first four intervention weeks, but increased during the second and third (+118kcal/d, p=0.003 and +122kcal/d, p=0.004). Protein intake and body weight did not significantly change during the study.

Conclusion

In this study, no clinically relevant changes in appetite, nutritional intake and body weight were observed after food odor exposure. Future studies should assess the effect of natural food odors and/or meal-tailored odors on nutritional intake of older adults with dementia.

Introduction

Over the past centuries, life expectancy of our world population has grown steadily. Although we can enjoy life for a longer period of time, aging is often accompanied by physical and/or mental decline[1–4]. As a result of this age-related mental decline dementia may develop. Appetite of a patient with dementia often changes over the course of time[5,6], and due to the decline in mental functioning, patients often forget to eat and drink[7]. Consequently, malnutrition is frequently present among older adults with dementia[8].

Sensory cues, such as food odors, can increase appetite and influence food choice[9–11]. An example from everyday life: when you walk past a bakery and smell their freshly baked bread, it triggers your appetite for it. Accordingly, studies among healthy adults showed that exposure to food odors enhances appetite for congruent foods, but not for other foods[9–13]. For example, exposure to banana odor increased appetite for banana and other sweet foods, and likewise, participants who were exposed to a pear odor were more likely to choose fruity desserts compared to participants in the control condition[11,12]. Although appetite for specific foods is shown to increase after exposure to similar food odors, effects on subsequent dietary intake are inconsistent[10,11,14,15]. e.g., participants exposed to a chocolate odor more often chose and consumed sweet, high-energy foods compared to the control condition[13,15]. However, other studies showed no impact of food odor exposure on congruent preferences or intake [14,16].

Previous studies investigating the effect of odor exposure on appetite and nutritional intake were mainly conducted in healthy younger adults[9–13]. Thus far, only one study by Sulmont-Rossé et al. (2018) investigated the effect of (repeated) exposure to a meat odor prior to lunches on subsequent food intake in nursing home residents with dementia[17]. After the first odor exposure, interest towards the meal enhanced and meat and vegetable intake increased with 25%. However, no effects on interest towards the meal nor effects on food intake were shown after the second odor exposure.

Altogether, results from previous studies appear promising and dispersing odors through vaporizers would be a relatively simple way to increase appetite and nutritional intake in an older population that is at risk of malnutrition. Yet, most studies focused on short-term effects only, while long-term effects are more relevant for real-life application. Therefore, the aim of this study is to investigate the effect of a twelve-week food odor exposure on appetite, nutritional intake and body weight of older adults with dementia.

Methods

2.1 Participants

Participants were recruited from psychogeriatric wards of four different nursing homes in the Netherlands, all part of the health care organization Amaris. Exclusion criteria were: aged <65 years, BMI>35 kg/m^2, residing at a somatic or short-stay ward, in a terminal or vegetative stage, using (par)enteral nutrition or not being able to communicate about their appetite.

2.2 Design

This was a one-armed, non-randomized, non-blinded intervention study, consisting of a four week control period, followed by a twelve week intervention period in which odors were dispersed prior to breakfast, lunch and dinner. The twelve week intervention period consisted of three consecutive blocks of four weeks: I1; I2 and I3. Nutritional intake and appetite were measured during the four week control period and the three intervention blocks. Body weight was measured at the start of the control period (BW1) and at the end of the control/beginning of the intervention period (BW2) and halfway (BW3) and at the end (BW4) of the intervention period.

The set-up of the study including all measurements that have been performed is depicted in figure 1.

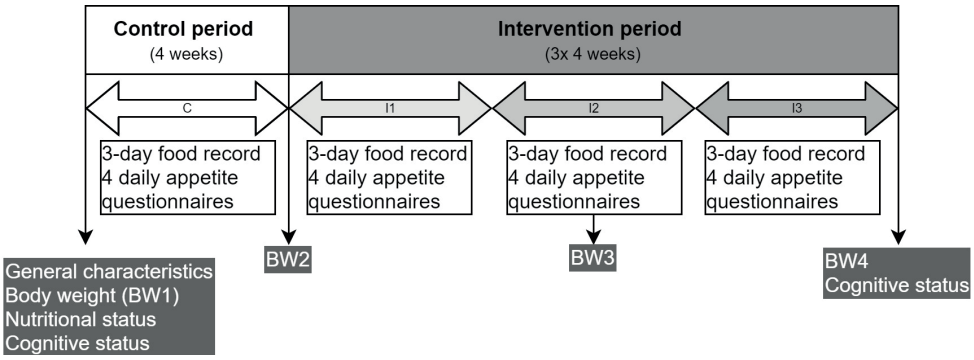

Figure 1: Set-up of the study (C=control period (4 weeks); I1 = First intervention block (4 weeks); I2 = second intervention block (4 weeks); I3 = third intervention block (4 weeks))

2.3 Odors

During the twelve week-intervention period odors were dispersed in the communal living rooms or private rooms of the participants, depending on where participants resided during the day. Odors were dispersed three times a day during a period of 30 minutes prior to meal consumption: a bread odor, a vegetable stock odor and a beef stew odor to match breakfast, lunch and dinner respectively. All odors were designed and produced by Iscent (Zeewolde, the Netherlands). Odors were dispersed using *Iscent 400* vaporizers from the same company. The intensity of the odors was set to be just noticeable by the participants.

2.4 Measurements

Most measurements were performed on or by the participants themselves. If this was not possible due to memory loss as a result of dementia, e.g. in the case of general characteristics, legal representatives or registered nurses were asked for assistance.

2.4.1 General characteristics

Before the start of the study, participant characteristics were recorded. The Dutch version of the Mini Nutritional Assessment Short-Form (MNA-SF)[18] and the Simplified Nutritional Appetite Questionnaire (SNAQ)[19] were administered to assess nutritional status and the risk of losing weight respectively. MNA-SF scores vary from 0 – 14: 0 – 7 indicates undernutrition, 8-11 indicates a risk of undernutrition and scores >11 indicate a normal nutritional status. Outcomes of the SNAQ vary from 0 – 20: outcomes <14 indicates a significant risk of ≥5% body weight loss during the past 6 months. The Severe Impairment Battery (SIB-8)[20] was completed to give insight into participants' cognitive status. The SIB-8 is a non-invasive short questionnaire covering different domains of cognitive functioning. The higher the score on the SIB-8, the better the cognitive status, and vice versa. SIB-8 was measured before the start and at the end of the study.

2.4.2 Appetite

General and specific appetite was measured once a week right before breakfast, lunch and dinner during both control and intervention period. In total, appetite was measured four days during the control period and twelve days during the intervention period. Through a 5-point Likert scale (1 = not at all; 2 = not really; 3 = neutral; 4 = a bit; 5 = very) participants were asked to indicate whether they were hungry (general appetite) and to what extent they would like to eat something sweet or something savory (specific appetite: sweet and savory). During the intervention period, the appetite questionnaire was completed after an odor exposure of at least 20 minutes. Data from these appetite ratings were aggregated into one mean per time block, calculated as a mean before breakfast, lunch and dinner, both for general and specific appetite for sweet and savory foods.

2.4.3 Nutritional intake

During the study, nutritional intake was monitored through four 3-day food records in total: one 3-day food record during each block of four weeks (control, I1, I2, I3). Research assistants completed the food records on three subsequent weekdays with the help of caregivers. Food records were entered into Compl-Eat, a program that calculates nutritional intake based on the NEVO-database on food composition (RIVM, 2016). Portion sizes of foods and drinks consumed during breakfast, lunch and in-between meals were entered into the food records by means of household measures and standardized portions. Soup, hot meals and desserts were weighed before serving. Possible leftovers were weighed and subtracted from the portion served. Data from the 3-day food records were aggregated into one mean per time block, calculated as a daily total for energy intake (kcal) and protein intake (g).

2.4.4 Body weight

Body weight was measured in kilogram (kg) at one decimal accuracy, without shoes or heavy clothing. Wheelchair scales with handrails were used that were available in the nursing homes. In order to calculate body weight, the weight of the wheelchair or walking aid was subtracted from the total weight.

2.5 Data analysis

2.5.1 Sample size calculation

Based on the appetite results of a study by Ramaekers et al. (2013) a sample size calculation was performed[9]. Using a power of 80% and a two-sided significance level (α) of 0.05 the total required sample size would be 34 research subjects. Anticipating a drop-out rate of »20% 40 research subjects in total would be needed to have sufficient research subjects for the primary outcome measures appetite and nutritional intake.

2.5.2 Analyses

Descriptive statistics were performed and general characteristics are reported as means and standard deviations for continuous data and frequencies and percentages for categorical data. Linear mixed models (intention-to-treat) were performed to test for differences in appetite ratings (general, sweet and savory; before breakfast, before lunch and before dinner), energy intake, protein intake, and body weight between control period and the three intervention blocks (I1, I2, I3). For all variables, a two-level structure was used to correct for clustering within the four measurements (Control, I1, I2, I3). Therefore, a random intercept was created at participant level. Time (control/I1/I2/I3) was used as fixed-effect term. Covariates were added to the model when they were significantly correlated with the outcome variable. For energy and protein intake, *Age* and *Height* were added to the models as covariates. For body weight, *Height* was added to the model as a covariate. The outcome of *the MNA-SF* was added as a covariate in the models of savory appetite before

breakfast, before dinner and to the daily total. For sweet and savory appetite before lunch, *SIB-score* was added to the model as a covariate. *Post hoc* comparisons (Least Significance Difference) were performed to compare main effects between the different time blocks (control/I1/I2/I3) for appetite ratings, energy intake, protein intake and body weight. Statistical analyses were performed using IBM SPSS Statistics version 25.0 (IBMCorp., Armonk, NY, USA) and a P-value below 0.05 was considered significant.

Results

3.1. Participants

Forty-five participants living in psychogeriatric wards of four nursing homes were recruited between March 2018 and September 2020. Participants were aged 72 – 98 years (88 ± 6.2), 38 participants were female, and BMI ranged from 17.1 – 34.8 kg/m^2 (24.4 ± 4.4 kg/m^2). General characteristics of all participants are depicted in table 1. There were no differences is general characteristics between residents of the four different nursing homes.

Table 1: General characteristics of participants in frequencies and percentages; mean values and standard deviations

		Total
Participants (n)		45
Age		
	Mean (SD)	88.2 (6.2)
	Range	72-98
Gender		
	Male	7 (15.6%)
	Female	38 (84.4%)
BMI		
	Mean (SD)	24.4 (4.4)
	Range	17.1-34.8
Diagnosis		
	Alzheimer's disease	20 (44.4%)
	Vascular dementia	9 (20.0%
	Parkinson's disease related dementia	3 (6.7%)
	Combination of types	6 (13.3%)
	Undiagnosed	7 (15.6)
MNA-SF		
	Mean (SD)	9.4 (2.3)
	Normal nutritional status (12-14p)	7 (15.6%)
	Risk on malnutrition (8-11p)	30 (66.7%)
	Malnourished (0-7p)	8 (17.8%)
SNAQ		
	Mean (SD)	15.4 (2.1)
	No risk	29 (64.4%)
	Risk on 5% weight loss within 6 months (<15p)	16 (35.6%)
SIB score		
	Mean (SD)	13.4 (8.9)
	Range	0-32

Thirty-two participants completed the study: two participants deceased, two participants were not able to finish the study due to physical deterioration and one participant moved to another nursing home during the study. Due to a renovation of the living rooms in one of the nursing homes, data of four participants were collected during fourteen weeks in total (ten weeks of intervention) and data of four other participants were collected during twelve weeks in total (eight weeks of intervention).

3.3 Appetite

3.3.1 General appetite

Mean general appetite scores ranged from 3.7 – 4.0 before breakfast, indicating a (little) bit hungry, and decreased significantly in I1 compared to the control period (p=0.037). However, general appetite before breakfast returned to baseline level of the control period in I3 (p=0.028). Mean general appetite scores before lunch ranged from 3.3 – 3.6 and from 3.5 – 3.6 before dinner. No significant differences were found for general appetite before lunch and dinner between control and intervention period. Mean appetite scores (±SE) are shown in figure 2a.

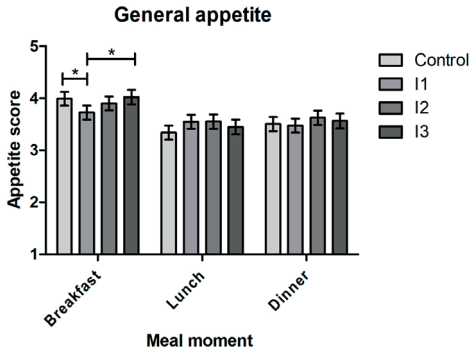

Figure 2a: General appetite scores before breakfast, lunch and dinner in control versus intervention blocks. * indicates significant differences (p<0.05)

3.3.2 Appetite for sweet foods

Appetite for sweet foods before breakfast ranged from 3.4 – 3.7 and increased significantly between the first and second intervention block (p=0.042). Appetite for sweet foods before lunch and dinner ranged from 2.8 – 3.0 and 3.2 – 3.3 respectively, but did not change significantly during the intervention period compared to the control period. Mean appetite scores (±SE) are shown in figure 2b.

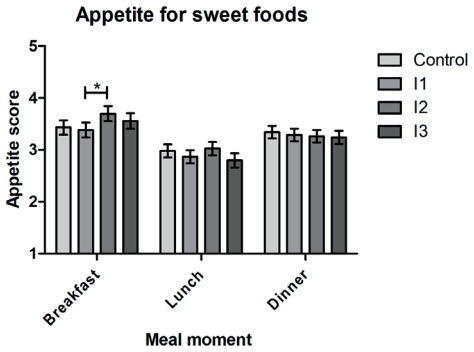

Figure 2b: Appetite for sweet foods before breakfast, lunch and dinner in control versus intervention blocks. * indicates significant differences (p<0.05)

3.3.3 Appetite for savory foods

Mean appetite for savory foods before breakfast and lunch ranged from 3.1 – 3.2 and 3.5 – 3.8 respectively, but did not significantly change during the intervention period compared to the control period. Appetite for savory foods before dinner ranged from 3.5 – 3.9 and increased significantly between the control period and the second (p=0.004) and third intervention block (p=0.001). Mean appetite scores (±SE) are shown in figure 2c.

Figure 2c: Appetite for savory foods before breakfast, lunch and dinner in control versus intervention blocks. * indicates significant differences (p<0.05)

3.4 Nutritional intake

Mean energy intake ranged from 1362 kcal to 1484 kcal per day and mean protein intake ranged from 45.1 and 47.9g/d during the study. As shown in figure 3a, energy intake increased significantly during the second (p=0.003) and third intervention block (p=0.004) compared to the first intervention block. The absolute difference in energy intake was approximately 118 kcal/d between I1 and I2 and 122 kcal/d between I1 and I3. In figure 3b, protein intake throughout the study is shown. There were no significant differences between control period and intervention period, nor between intervention blocks.

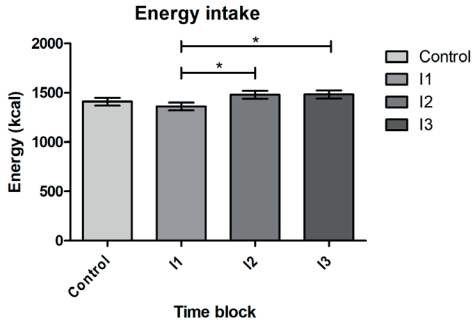

Figure 3a: Daily energy intake in kcal during control period and intervention blocks. * indicates significant differences (p<0.05)

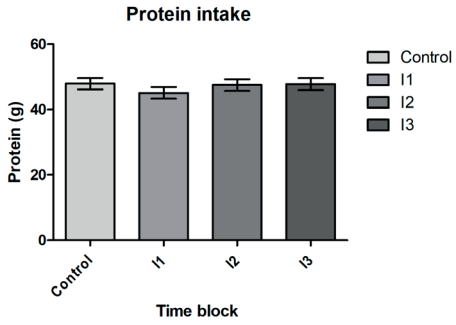

Figure 3b: Daily protein intake in grams during control and intervention blocks

3.5 Body weight

Mean body weight (kg) ranged from 65.6 – 66.7kg but did not significantly change during the intervention period compared to the control period (figure 4). However, during the last six weeks of the intervention (I2), mean body weight tended to decrease with 1.1kg (p=0.058).

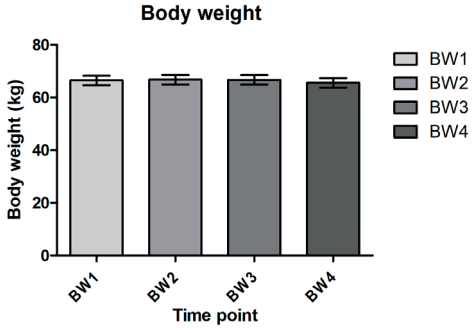

Figure 4: Body weight at the start of the study (C1), after the control period/at the start of the intervention period (C2), halfway the intervention (I1) and at the end of the intervention (I2)

Mean appetite ratings, energy and protein intake and body weight (±SEs) are presented in the Appendix.

Discussion

The aim of this study was to investigate the effect of food odor exposure on appetite, nutritional intake and body weight of nursing home residents with dementia. The results of the present study show relatively small effects on general and specific appetite. Energy intake increased significantly during the second and third intervention block compared to the first intervention block, but not compared to the control condition. Protein intake and body weight were not significantly affected during the study.

Based on previous studies, we hypothesized that general appetite would increase after food odor exposure. Proserpio et al. (2017) showed an increase in general appetite scores after exposure to different food odors compared to the control condition in a population of young women[13]. Similarly, general appetite was increased after exposure to different food odors in 21 young women[9]. The results of our study reveal opposite results: general appetite before breakfast declined in I1 but returned to baseline in the I3, while general appetite before lunch and dinner was not affected during the odor intervention. Previous studies that investigated olfactory function in older adults found that olfactory function is generally impaired at a higher age[21,22] and in patients with different types of dementia[23]. Consequently, the effect size of the intervention may have increased when the intensity of the odors was adjusted to the individual participants instead of the general intensity maintained in the current study. However, odor identification is often impaired in patients with dementia [24]. Altogether, an impaired olfactory function and odor identification may explain the fact that no relevant differences were found in general appetite after exposure to food odors.

With regard to appetite for specific foods, a study by Zoon et al. (2016) showed that odors signaling a sweet or savory taste led to an increased appetite for congruent foods in healthy young women. Ramaekers et al. (2016) showed that bread odor increased general appetite women aged 18-45 years[25]. Therefore, we hypothesized that general appetite would increase after exposure to bread odor and appetite for savory foods would increase after exposure to vegetable stock odor and beef stew odor. However, exposure to the bread odor only increased appetite for sweet foods before breakfast in I1. Furthermore, only appetite for savory foods before dinner increased in I2 and I3, but not in I1. Appetite for sweet foods was not affected before lunch or dinner, only before breakfast in I2. These particular changes in specific appetite may be explained by the fact that specific appetite for both sweet and savory products are often meal-specific. Appetite for sweet foods is higher before breakfast, while appetite for savory products is generally higher before lunch and dinner. The relatively small effect of odor exposure on specific appetite might also be caused by the impaired odor identification among patients with dementia, as stated above.

Our second hypothesis was that energy and protein intake would increase after odor exposure. Namely, Proserpio et al. (2017) found that odor exposure increased subsequent food intake in a population of normal-weight young women. A study by Gaillet-Torrent et al. (2014) showed that exposure to a sweet-fatty odor guided participants (18-50y) to choosing desserts with high energy density. Similarly, an increase in Sulmont-Rossé et al (2018) of 25% in meat and vegetable consumption during lunch was shown after odor exposure in a population of older adults with dementia[17]. Remarkably, the results of the present study show that energy intake did not change significantly in I1 compared to the control period, but increased significantly in I2 and I3 compared to I1 (but not compared to the control condition). It was also hypothesized that an increased appetite for savory foods would increase subsequent protein intake, as savory odors often signal foods with a high protein content[26]. Even though specific appetite for savory products increased before dinner, protein intake did not change during the study. This indicates that the exposure to food odors did not affect protein intake in this population. Even though these findings are contradictory to our hypotheses, they are in line with other previous studies reporting an increased appetite, but no effect on subsequent food intake. A study by Morquecho-Campos et al. (2020) shows that even though appetite for congruent foods was increased after odor exposure, food intake did not change in a group of healthy young females. In the study among older adults with dementia by Sulmont-Rossé et al. (2018) effects on nutritional intake were no longer present when the odor exposure was repeated two weeks later[17]. This may indicate that there is no direct relationship between appetite and subsequent food intake, which is in contradiction with previous studies in controlled clinical settings reporting positive associations between appetite and food intake[27,28]. However, in free-living situations effects were slightly smaller[29–31].

The third hypothesis of this study was that body weight would be positively affected as a result of an increased appetite and food intake due to the food odor exposure. However, no significant differences in body weight were found during the study which is consistent with the results regarding appetite and nutritional intake. Contrarily to our hypothesis, body weight decreased (but not significantly) during the last 6 weeks of the intervention (-1.1kg, p=0.058). This might have been the result of the decrease in energy intake after odor exposure.

Three standard food odors were dispersed before breakfast, lunch and dinner. As previous research showed that general appetite and specific appetite for congruent food increases[10,13,14,25], a pilot study among nine older adults was conducted in which the choice of the odors used in the current study was determined. The participants were asked which odors were most pleasant, but also which odors would suit best prior to breakfast, lunch and dinner. However, as meals were precooked and the menu varied throughout the year it is unlikely that the standard odors used in this study were congruent with all meals

consumed subsequent to the odor exposure. In order to optimize the possible effect of food odor exposure on appetite and nutritional intake, future research should match odors with the meal that is consumed subsequently. Additionally, it would be interesting to study the effect of natural food odors by preparing meal on site.

Strengths and limitations

One of the strengths of this study is the 12-week intervention period that allowed to obtain a conclusion about the long-term effect of food odor exposure on appetite, nutritional intake and body weight of older adults with dementia. Another strength of this study is the fact that the study was performed in a real-life setting. This enhances the external validity of the results. Also, nutritional intake was measured through 3-day food records where nutritional intake was measured through observations and by weighing soup, the hot meal and desserts. This is shown to be a reliable method in measuring intake in a population of institutionalized older adults[32] and provides more insights into the effects of food odor exposure on the diet compared to a single meal. However, mean energy intake during the control period (1410 kcal/day) was considerably lower compared to other studies observing nutritional intake in a population of nursing home residents diagnosed with dementia. Previous studies among nursing home residents with mild to severe dementia report an intake of 1650-1789 kcal per day, measured through (weighed) food records[33,34] This may indicate that energy intake in our population was lower compared to similar populations. Furthermore, the impaired cognitive status of older adults with dementia may have caused difficulties in expressing their needs[35,36], i.e. whether they were hungry or had a specific appetite for sweet or savory products and whether they felt satiated or not. Therefore, the method used to assess appetite might be a limitation of this study as this may have affected the validity of the appetite ratings and consequently the association between appetite and subsequent energy intake. Therefore, future research is needed to further investigate validity and feasibility of appetite ratings in older adults with dementia. Also, the method of assessing appetite was different in the study by Sulmont-Rossé et al. (2018)[17], i.e. through observations by the experimenters, therefore making it impossible to compare results.

Conclusion

In conclusion, the results of this study show no clinically relevant effects of food odor exposure on appetite, nutritional intake and body weight of nursing home residents with dementia.. Future research should focus on optimizing odors and to validate appetite measurements in this specific population. In this way, further evidence will show whether food odor exposure increases appetite and nutritional intake in older adults with dementia.

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Ethical Standards Disclosure
Most residents were incapacitated and therefore legal representatives approved participation in the study by signing informed consent. The study was conducted according to the principles of the Declaration of Helsinki (version 2013) and in accordance with the Medical Research Involving Human Participants Act (WMO). This study was approved by the Medical Ethical Committee of Wageningen University (NL64189.081.18).

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Appendix

Table 2: Food intake (energy and protein intake), appetite ratings and body weight during the control and intervention period (I1, I2, I3).

	Control		I1		I2		I3	
	Mean[a]	**S.E.**	**Mean**	**S.E.**	**Mean**	**S.E.**	**Mean**	**S.E.**
General appetite								
Before breakfast	4.0	0.1	3.7*[b]	0.1	3.9	0.1	4.0	0.1
Before lunch	3.3	0.1	3.5	0.1	3.6	0.1	3.4	0.1
Before dinner	3.5	0.1	3.5	0.1	3.6	0.1	3.6	0.1
Appetite for sweet foods								
Before breakfast	3.4	0.1	3.4	0.1	3.7	0.1	3.6	0.2
Before lunch	3.0	0.1	2.9	0.1	3.0	0.1	2.8	0.1
Before dinner	3.3	0.1	3.3	0.1	3.3	0.1	3.2	0.1
Appetite for savory foods								
Before breakfast	3.2	0.2	3.1	0.2	3.1	0.2	3.2	0.2
Before lunch	3.5	0.1	3.5	0.1	3.8	0.1	3.6	0.1
Before dinner	3.5*	0.1	3.7	0.1	3.8	0.1	3.9	0.1
Energy (kcal)	1410	38.7	1362*	38.9	1480	39.4	1484	40.8
Protein (g)	47.9	1.7	45.1	1.8	47.5	1.8	47.8	1.9
	BW1		BW2		BW3		BW4	
	Mean	**S.E.**	**Mean**	**S.E.**	**Mean**	**S.E.**	**Mean**	**S.E.**
Body weight (kg)	66.5	1.8	66.7	1.8	66.7	1.8	65.6	1.8

Abbreviations: I1, Intervention block 1; I2, Intervention Block 2; I3, Intervention block 3; BW1, before start of control period; BW2, end of control period/start of the intervention, BW3, halfway intervention; BW4, end of intervention period

a. Mean values with their standard errors;

b. * = significantly different from I3 ($p<0.05$)

CHAPTER 7

7

General discussion

General discussion

The overall aim of this thesis was to address the magnitude of the malnutrition problem among older adults, current practices in nutritional care and possible nutritional solutions to tackle malnutrition later in life. Figure 1 summarizes the main findings of this thesis. These findings will be discussed throughout this chapter. Furthermore, this chapter includes methodological considerations and elaborates on practical implications and perspectives for future research.

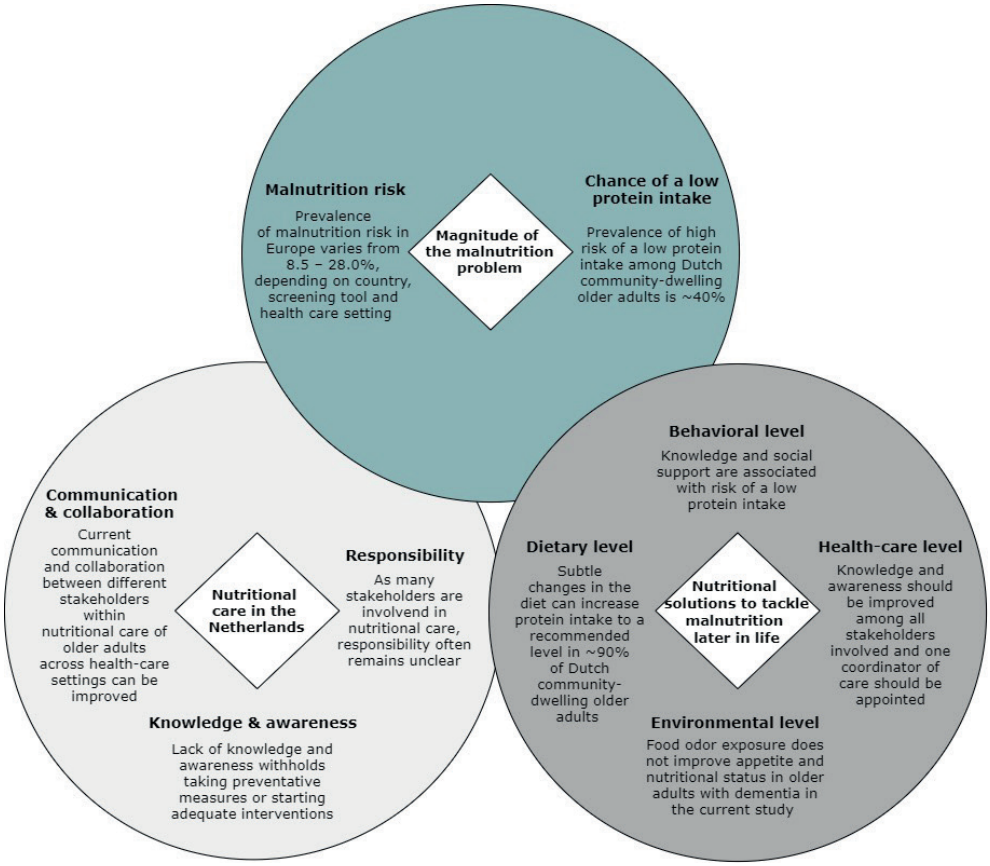

Figure 6: Main findings of this thesis

What is the magnitude of the malnutrition problem among older adults?

The European prevalence of malnutrition risk varies from 8.5% to 28.0%, depending on healthcare setting and screening tool. Between European countries, the prevalence varies widely: the mean prevalence across all healthcare settings is lowest in Spain (15.2%) and highest in Switzerland (37.7%). High risk of a low protein intake (<1.0 g/kg BW/day) is present in 39.4% of Dutch community-dwelling older adults.

The European prevalence of malnutrition risk varies from 8.5% to 28.0%, depending on healthcare setting and screening tool. Between European countries, the prevalence varies widely: the mean prevalence across all healthcare settings is lowest in Spain (15.2%) and highest in Switzerland (37.7%). High risk of a low protein intake (<1.0 g/kg BW/day) is present in 39.4% of Dutch community-dwelling older adults.

Malnutrition in older adults is associated with weight loss, a decrease in muscle mass and muscle function and other impairments[1]. Malnutrition is frequently present among older adults[2], partly due to age-related loss of appetite[3]. The prevalence of malnutrition (risk) in different healthcare settings has been reported in many previous studies. However, these are often limited to specific health care settings or specific research populations. Therefore, we performed a systematic review and meta-analysis of recent studies that reported malnutrition risk (*Chapter 2*), combining these into a European prevalence rate, with specifications to European country, healthcare setting and screening tool through univariate analyses. Studies were included when malnutrition risk was evaluated using validated screening tools for the specific setting[4]. The meta-analyses showed that 23% of European older adults is at high risk of malnutrition. Studies showed large differences between different healthcare settings, varying from 8.5% among community-dwelling older adults to 28.0% in the hospital setting. Also large differences between European countries were shown. The lowest prevalence of malnutrition risk was found in Spain (15.2%) and the highest in Switzerland (37.7%). Lastly, the results of our study indicate large differences in prevalence rates between different screening tools used to assess malnutrition risk. The latter underlines the importance of unambiguous screening and the identification of clear diagnostic criteria. Therefore, the Global Leadership Initiative on Malnutrition (GLIM) developed a consensus for malnutrition diagnosis[5]. Herewith, GLIM aims to facilitate the identification of the prevalence of malnutrition in the future.

Even though we found a difference in prevalence rates between European countries and between screening tools, caution is advised in interpreting these results. The meta-regressions included univariate analyses with no correction for confounding. Therefore,

these differences may be caused by other variables that are not accounted for in the analyses. Namely, the studies included in the analyses per country differed considerably regarding the study design, e.g. the screening tool that was used and the study population included in the studies. Even though studies were only included when they used screening tools validated for that specific healthcare setting, different screening tools may provide differences in outcomes, as also shown in the meta-analyses. Furthermore, study populations of the included studies were too small to stratify according to type of disease. Consequently, for some countries we may have included more populations with a disease associated with a higher malnutrition risk, such as cancer patients[6,7]. Furthermore, a random effects model was used for the pooled prevalence. A fixed effect was not considered appropriate as the studies included in the meta-analysis were not comparable with each other. However, in the random effects model more weight is given to studies that report higher between-group variance while less weight is given to the size of the study population. In this case, more weight might have been given to smaller studies included in the analyses. Contrarily, less weight is given to larger studies that account for a large proportion of the total study population, while larger populations are often more representative of the total population. Altogether, the current prevalence assessed in our systematic review gives an overview of malnutrition risk prevalence based on the current included studies and gives directions for future research on the prevalence of malnutrition risk. In order to establish a prevalence rate which is representative for each country and screening tool, future studies should pool original data and correct for confounding factors such as disease. Our systematic review also underlines the importance of unambiguous screening and the importance of continued assessment of malnutrition (risk).

Secondly, in our study focusing on the association between risk of a low protein and several behavioral determinants among Dutch community-dwelling older adults (*Chapter 4*) we found that, based on the Protein Screener 55+[8], nearly 40% of all respondents had a high risk of a low protein intake with no significant differences in socio-demographic characteristics. This tool has been developed based on a protein requirement of 1.0 g/kg/BW/day. Previous studies showed that dietary protein in combination with physical exercise may play an important role in retaining muscle mass and function [9–12]. However, the recommended protein intake of older adults is still a matter of debate. Expert groups, such as the PROT-AGE study group and the European Society for Clinical Nutrition and Metabolism (ESPEN), recommend a protein intake of at least 1.0 g/kg BW/day for adults aged 65 years and older[13,14] to maintain muscle mass and function. Also the recommendations setting body for Germany, Austria and Switzerland (D-A-CH) and the Nordic Nutrition Recommendations advocate a protein intake of at least 1.0g/kg BW/day[15,16]. However, the World Health Organization recommends a protein intake of 0.8g/kg BW/day for all adults[17], but this recommendation dates from 2007. A recent report by the Dutch Health Council also concludes that a protein intake of 0.83 g/kg BW/day

would be sufficient for healthy older adults (>60 years) with a normal body weight and they conclude that higher intakes are not directly associated with a higher fat-free mass[18]. The conclusion of the Dutch Health Council is based on a systematic review including 18 randomized controlled trials (RCTs) with a total of 1284 participants, the majority of them being healthy older adults. Only studies that reported protein intake in g/kg BW/day were included; studies that reported protein doses solely were excluded[19]. As only RCTs can provide evidence for a causal relationship between variables and prospective studies cannot, prospective observational studies were excluded. Despite a well-founded rationale for applying these exclusion criteria, this resulted in the exclusion of many well-designed studies investigating the effect of protein intake on muscle mass and/or fat free mass. Also, the recommendation applies to healthy older adults only. The recommendation does not apply to older adults with underlying diseases, while over 50% of Dutch older adults (65+) suffer from one or more chronic diseases[20]. Therefore, it is debatable whether more evidence should have been taken into account while compiling this recommendation. A clear position on an adequate level of protein intake for older adults is still needed to identify the exact size of the malnutrition problem among older adults. Additionally, protein requirements for frail older adults should be considered.

Lastly, within our study that investigated the effect of food odor exposure on nutritional status of older adults (*Chapter 6*), we assessed nutritional status at baseline using the Mini Nutritional Assessment Short-Form (MNA-SF)[21]. In this study, 45 older adults with dementia residing at a psychogeriatric ward in four different nursing homes were included. In total, 66.7% of the 45 participants were at risk of malnutrition, and 17.8% were undernourished. This high prevalence of malnutrition (risk) is in line with previous studies among nursing home residents with dementia[22,23]. The findings of these and our study indicate that nursing home residents with dementia are at high risk of malnutrition.

How is nutritional care organized in the Netherlands?

Many stakeholders are involved in nutritional care for malnourished older adults over the continuum of healthcare settings. Knowledge and awareness about (mal)nutrition is often lacking among healthcare professionals and older adults themselves. Also, it is often unclear who is responsible for the nutritional status and taking the appropriate action in case of malnutrition.

The risk of having one or more chronic diseases, also known as multimorbidity, increases during aging[24]. Multimorbidity is associated with an increased occurrence of hospitalization[25,26]. A healthy lifestyle and diet can increase our general health while malnutrition is associated with an impaired physical function and may delay recovery from disease[27]. Therefore, nutrition can play an important role for the ones who are in transition of care, e.g. from hospital or rehabilitation center to home. As a consequence, information can get lost within the transition of care and this requires extra attention for nutritional care. We investigated current practices and recommendations regarding the communication and collaboration in nutritional care across the continuum of healthcare settings (*Chapter 3*). In this study, focus group interviews were held with healthcare professionals, older adults and caretakers. The results of this study revealed that many stakeholders are involved in the nutritional care of older adults across the continuum of healthcare settings in the Netherlands. In theory, this may sound promising, as many stakeholders can diagnose malnutrition and take appropriate actions. In practice, this is unfortunately not always the case yet. Similar to a study by Ziylan et al. (2015), our study shows that knowledge and awareness about malnutrition is lacking[28], withholding the various stakeholders from taking preventative measures or starting adequate interventions. A study focusing on nutritional education within nursing schools showed that a large share of European nursing schools does not include courses on nutrition in their curricula or address the topic of malnutrition in older adults[29]. Additionally, a Dutch study found that only 0.4% of the curricula of Dutch nursing schools consists of nutrition[30]. Also other disciplines, such as general practitioners, stress that they lack expertise to monitor malnutrition[28].

Secondly, our study found that, even when malnutrition is correctly recognized, there still is room for improvement regarding the communication and collaboration between different healthcare professionals and with older adults. When looking at the curricula of nursing schools, the majority of nursing schools do not pay any attention to interdisciplinary collaboration regarding nutritional care[29]. A possible solution to improve interdisciplinary collaboration could therefore be to include this topic in curricula of different healthcare professionals, e.g. nurses, general practitioners, physiotherapists etcetera. This may

improve interdisciplinary communication between future healthcare professionals, yet another solution is needed for current healthcare professionals, for example in terms of trainings, seminars or workshops. Another problem that was identified in our study hindering communication and collaboration across different healthcare settings has a more technical nature. Namely, different hospitals, nursing homes and home care organizations have different electronic programs in which patient data are stored. Until this day, these programs can often not be linked due to technical impossibilities and/or privacy issues. Therefore, extra actions are required to transfer nutrition-related information from one healthcare setting to another. However, within the different healthcare settings workload is often already high[31,32] resulting in little time for extra tasks besides the current range of tasks. Consequently, information about for instance nutritional care can get lost over the continuum of healthcare settings. One of the solutions could therefore lie in facilitating an easy and accessible communication system between different healthcare settings. One of the interventions that has been developed based on the results of our study aiming to facilitate communication is "the Nutrition Passport": a guide that can be used to improve continuity in nutritional care for older adults[33]. However, the problem of connecting the different electronic programs persists.

Similar to the results of a study by Ziylan et al. (2015), our study found that there is no clarity about who is responsible for monitoring the nutritional status of older adults and taking action when problems arise[28]. During the focus group interviews it was suggested to appoint one coordinator of care and it was even suggested that older adults themselves should take the lead role in this matter. The latter is in line with the aim of many self-management programs that have been developed to help older adults manage their chronic condition(s). However, a study by Warner et al. (2019) denotes that increasing older adults' ability to approach relevant resources, i.e. healthcarea dietitian, is an important strategy to live well with a chronic disease but is often not addressed in self-management programs[34]. This underlines the importance of communication between healthcare professionals, older adults and their caretakers and the suggestion to appoint one coordinator of care. In that way, the coordinator of nutritional care can appoint the appropriate healthcare professional and approaching the relevant resource is made easy for the older adult. Similar to Ziylan et al. (2015), the general practitioner, the nurse practitioner and the home care nurse were suggested as coordinator of nutritional care, as dietitians are not always involved with every client. It would be the responsibility of the coordinator to involve a dietitian when nutritional status is at harm. However, as mentioned above, all three disciplines suggested as coordinator of nutritional care already have many responsibilities and it is questionable whether this would fit in their current schedule.

What are possible solutions to tackle malnutrition later in life?

Healthcare level (Chapter 3) – Improving knowledge and awareness regarding (the causes) of undernutrition and appointing one coordinator of nutritional care are aspects that might improve nutritional care.

Behavioral level (Chapter 4) – Knowledge and social support might have an independent association with the chance of a low protein intake. This may indicate that future interventions that aim to improve protein intake among community-dwelling older adults should target these specific behavioral determinants.

Dietary level (Chapter 5) – Subtle changes in the diet can increase protein intake to ≥1.0 g/kg BW/day in approximately 90% of Dutch community-dwelling older adults. Replacing foods low in protein by protein-enriched alternatives results in the least number of replacements compared to protein-rich alternatives.

External level (Chapter 6) - In contrast to the results of other studies in healthy younger adults, the results of our study suggest that food odor exposure has no clinically relevant effect on appetite, nutritional intake or body weight in older adults with dementia living in a nursing home.

To tackle malnutrition later in life, we investigated possible solutions at four different levels: healthcare level, behavioral level, dietary level, and external level.

Possible solutions to improve nutritional care across the continuum of healthcare settings are to increase knowledge and awareness through nutritional education and to appoint one coordinator of nutritional care who consults the appropriate healthcare professional and monitors health goals in co-operation with the older adult. Additionally, including nutritional information systematically in transfer reports, connecting the different programs used to store patients' information among different healthcare settings and including older adults in the communication about their own health were suggested as possible solutions. A "nutrition passport" was suggested to improve communication between all stakeholders, including older adults themselves. However, also in this matter, a coordinator of nutritional care should be made responsible for keeping the passport up to date.

In *Chapter 4* we focused on the behavioral levels of older adults. In this study, we investigated the association between the chance of a low protein intake and eight different behavioral determinants through an online survey among 824 respondents. The

behavioral determinants were based on two different stages within the I-change model[35]: Awareness and Motivation. The corresponding behavioral determinants were cognizance, knowledge, risk perception, perceived cues, attitude, social support, self-efficacy and intention. We found that knowledge and social support were independently associated with the chance of a low protein intake. Increasing knowledge to influence behavior is a common and often effective strategy in behavior change[36–38]. Kok et al. (2016) even consider knowledge as the basis for many other determinants[39]. Together with the findings in *Chapter 3* regarding the lack of knowledge about (the causes) of malnutrition, focusing on increasing knowledge concerning the importance of dietary protein among older adults can be an effective strategy to change behavior. Similar to the findings by Croezen et al (2012), showing that socials support influences lifestyle factors such as fruit and vegetable intake, smoking, alcohol consumption and physical activity[40], the findings of our study indicate that social support might also be an important behavioral determinant to focus on in interventions that aim to increase protein intake among Dutch community-dwelling older adults. Several previous studies that aimed to increase social support by building networks to encourage a person to do a specific behavior, e.g. increase their physical activity level, have shown to be effective[41,42]. In addition, a study by Hess and Davis (2020) focusing on increasing physical activity recommends to also focus on community-level social support[43]. In this way, next to focusing on the individual adherence to guidelines, the environment of older adults will additionally support individuals to change behavior. Concerning increasing protein intake among older adults this may suggest that interventions should not only focus on the social environment of older adults, such as family members, friends or other close relatives, but also on environmental level in order to stimulate healthy eating behavior.

In order to investigate nutritional strategies to tackle malnutrition focused on dietary level, we developed a simulation model (*Chapter* 5) based on the Dutch National Food Consumption Survey – Older Adults 2010-2012 (DNFCS-OA). The simulation model included three different scenarios in which foods low in protein were replaced by:

1. Foods that are naturally rich in protein;
2. Protein-enriched foods;
3. A combination of foods that are naturally rich in protein and protein-enriched foods.

All scenarios resulted in an increase in mean protein intake from 1.0 to 1.2 or 1.3 g/kg BW/day. The percentage of participants with a mean protein intake of ≥1.0 g/kg BW/day increased from 47% to approximately 90% in all three scenarios. However, the number of replacements in the protein-enriched scenario was considerably lower compared to the other two scenarios. This indicates that replacing foods low in protein by protein-enriched alternatives requires the least amount of changes in the diet of Dutch community-dwelling

older adults. This can be explained by the fact that protein-enriched foods often have a higher protein content compared to comparable foods naturally high in protein. This results in a larger effect on protein intake per replacement. The choice of both protein-rich and protein-enriched alternatives in this study was based on familiarity and similarity, meaning that the alternative foods were already familiar to older adults and were similar to the foods they replaced. When looking at the protein sources of the alternatives in all scenarios, many come from animal sources (either dairy or meat), similar to previous studies that investigated the effect of protein-enriched foods on protein intake of older adults[44–48]. With the current focus on sustainability within our diet[49,50], it is important to look for strategies to improve protein intake with environmentally sustainable protein sources. However, whether an adequate intake of nutritional protein can be achieved, especially in frail older adults, and whether older adults are receptive to these changes in their diet must be investigated in future studies.

Our fourth study that focused on possible solutions to malnutrition later in life investigated the effect of food odor exposure on the nutritional status of older adults with dementia (*Chapter 6*). Even though we hypothesized that food odor exposure would improve the nutritional status of older adults with dementia, our study did not show a clear positive effect of the food odors on appetite, nutritional intake or body weight (*Chapter 6*). Only specific appetite for sweet foods before breakfast and specific appetite for savory foods before dinner increased significantly during the intervention. General appetite even decreased in the first four weeks of the intervention, but returned to baseline level in the second and third intervention block. Nutritional intake did not increase and body weight was not affected during the intervention. A study by Morquecho-Campos et al. (2020) also found that protein-related odor exposure increased appetite for congruent foods, but food intake was not affected. Morquecho-Campos et al. (2020) proposed that taste quality of the food that is represented by the odor is the main driver for sensory-specific appetite, while macronutrient content does not influence sensory-specific appetite. This might explain the results of our study: even though specific appetite for savory foods was increased after exposure to beef odor, it did not affect subsequent food intake. Thus, this study does not show clinically relevant improvement in appetite and nutritional status in older adults with dementia. However, as odors were dispersed through machines, it is yet unclear what the effect of natural odors coming from freshly cooked foods would be.

Methodological considerations

Chapter 3

Besides the populations included in the systematic review (*Chapter 2*) and in the DNFCS-OA (*Chapter 5*), three study populations were included in this thesis. The aim of *Chapter 3* was to assess the current nutritional care communication and collaboration through focus groups. We included healthcare professionals, older adults and caregivers from three different regions in the Netherlands. In this way, we aimed to include a population whose results are representative of the Netherlands. Only small differences were observed within these regions. We therefore do not expect major differences within other regions in the Netherlands. Based on the results of our study, a blueprint of "the Nutrition Passport" has been designed. In the future, this blueprint can be used throughout all regions in the Netherlands and can be adapted to possible regional differences and needs[33].

Chapter 4

In *Chapter 4* we included 824 Dutch community-dwelling older adults. Recruitment took place over a period of 13 months and via different channels. In this way, we were able to recruit older adults living throughout the Netherlands. However, the population of our study was slightly higher educated and mean age was lower in our study population (72.9) compared to that of older adults in the Netherlands in general (76.6y). A higher educational level is associated with a higher protein intake, while a higher age is associated with a lower protein intake[51]. Also, previous studies show that persons with a healthy lifestyle and diet are more prone to participating in nutritional studies compared to persons with a worse nutritional status[52]. Consequently, the chance of a low protein intake is expected to be even higher in the total population of Dutch community-dwelling older adults. On the other hand, other behavioral determinants could play a role in the risk of a low protein intake[51].

Chapter 6

In *Chapter 6* we performed a one-armed, cross-over intervention study. One of the disadvantages of a cross-over design is that a "carry-over effect" can emerge[53], where the residual effect of one intervention could continue in the period that follows. As we started the study with a four-week control period, this "carry-over effect" was prevented. Also, in this way a "wash-out" period was not needed, as there was no intervention in the control period. Another disadvantage of a cross-over design is that there is often an increased drop-out rate: the duration of the study is often prolonged as participants complete both a control and intervention period. To prevent this, we limited the control period to four weeks. Consequently, the duration of the intervention period could be prolonged as long as possible, keeping ethical aspects in mind. An advantage of this design was that a smaller sample size was required, as participants served as their own control. Also, it

would be unethical to offer no intervention to half of the group, while promising results were expected. All in all, we consider the design of this study most suitable in answering the research question while keeping research integrity and ethical aspects in mind.

However, there is a point of criticism that should be addressed regarding the inclusion of participants. Despite our recruitment efforts, five of the 45 participants were not able to communicate well about their appetite or needs due to the advanced state of dementia. Consequently, we did not collect appetite data of these participants. Also, these participants were not always able to communicate whether they would want an extra portion of the food that was offered while they might have had an increased appetite. These impaired communication skills may have prevented these participants from increasing their nutritional intake even though they had wanted to as a result of the food odor exposure. However, as an impaired communication ability is a common feature in patients with dementia[54], and ~90% of the participants were able to communicate their needs. Even though it cannot be ruled out that the appetite and nutritional intake of the participants who were unable to communicate their needs did increase due to the odor exposure but was not shown in the current study, a good impression of the effect of food odor exposure on appetite and nutritional intake in this specific population was obtained.

The appetite of the participants in *Chapter 6* was measured using a 5-point Likert scale. Initially, the aim was to measure the general appetite using a pictorial scale designed for children[55]. The different pictures in this scale depict persons with increasing numbers of circles in the abdomen to indicate increasing levels of fullness. For the specific appetite ratings we aimed to make use of a shortened version of the specific appetite score based on a study by Zoon et al. (2016) with smiley faces instead of visual analog scales[56]. These smiley faces are used in pain research in cognitively impaired older adults[57]. In this way, we aimed to rate the general and specific appetite in an accessible and understandable way for older adults with dementia. However, in practice, this was not feasible as participants often got insecure or even emotional. Consequently, we had to adapt the questions to how much people would fancy something to eat in general, and in specific for sweet or savory foods. The answers participants gave were interpreted by the research assistants and classified on the 5-point Likert scale. However, post-hoc analyses showed that the appetite ratings were often not associated with the actual food that was consumed afterwards. This may indicate that the appetite ratings used in this study were not a valid method for measuring appetite, either because the method that was used was not valid or appropriate for this population, or participants suffering from dementia are unable to communicate about their appetite properly. A study by Morquecho-Campos also found no association between sensory-specific appetite and subsequent food intake in healthy younger adults[58]. Thus, it is also questionable whether appetite ratings are predictive for subsequent food intake in general.

Perspectives for future research

Even though the previous Chapters already (partly) answer the various research questions of this thesis, there is a number of issues that require further investigation and/or follow-up in future research.

To our knowledge, our study that determined the prevalence of malnutrition risk in Europe was the first to assess this topic on such a large-scale basis. Also, it is one of the first to make a distinction between the different healthcare settings. However, the studies included in the analysis were predominantly from the hospital setting and few studies including more than one site within one country were included in the analysis. In order to identify up-to-date prevalence rates of malnutrition (risk) that are representative for the whole population of older adults, regular screening for malnutrition (risk) should take place within each healthcare setting. To do so, standardized screening tools should be used per healthcare setting, as suggested by Power et al. (2018) and/or the GLIM criteria for the diagnosis of malnutrition[5,59]. However, GLIM criteria need to be validated and tested for reliability in a variety of healthcare settings and populations, as proposed by GLIM denoted in their guide[60]. Nevertheless, it is advised to implement the GLIM criteria, as using standardized tools will ensure that prevalence of malnutrition (risk) can be regularly identified and trends over time can be determined through future systematic reviews. Therefore, malnutrition (risk) screening should be added to the standard procedure within each healthcare setting. However, as of 2021 screening for malnutrition among geriatric patients admitted to hospital is no longer mandatory according to the New Dutch quality indicators for hospitals and private clinics[61]. Until 2021, quality indicators have shown large differences between hospitals. A report by Naumann et al. (2020) describes outcomes of focus group interviews with different hospital employees in which causes for the large differences in quality indicators were discussed. Responsibility, multidisciplinary collaboration and knowledge and skills of healthcare professionals are examples that were mentioned as possible causes. This is in line with the results of our study in *Chapter 3*. Consequently, to ensure regular malnutrition (risk) screening in every healthcare setting the current knowledge and awareness of healthcare professionals must be improved allowing healthcare professionals to understand the importance of regular screening, interdisciplinary collaboration should be improved and someone should take or should be made responsible in managing nutritional care. As it remains unclear who should be made responsible in this matter, future research should focus on identifying the appropriate coordinator of care: whether this would be a new type of healthcare professional or by expanding the range of duties of a current healthcare professional and how this would impact their daily activities accordingly.

Chapter 4 revealed that the chance of a low protein intake is independently associated with knowledge and social support in our study population. Hence, future studies should develop interventions aiming to increase knowledge and social support and test whether protein intake among community-dwelling older adults increases correspondingly. In *Chapter 4* the risk of a low protein intake was assessed using the Protein Screener 55+ (Pro55+)[8]. The cut-off point of the Pro55+ is 1.0g/kg BW/day, which is in line with protein recommendations of expert groups, D-A-CH and Nordic Nutrition Recommendations[13–16]. With the debate over protein recommendations in mind, future research should determine whether this tool including this cutoff-point is sensitive enough to detect low protein intake. If so, this tool is a quick and simple way to screen the risk of a low protein intake. As the tool has been validated in Dutch adults aged 55 years and older, it would be useful to validate the tool in other countries as well.

The simulation model developed in *Chapter 5* was based on the outcomes of the DNFCS-OA that originates from 2010-2012. Even though we consider this dataset to be the best available option to include in this simulation model, it is known that populations' food intake often changes over time[62]. Although older adults tend to keep a stable food pattern over time, the simulation model can be applied to a more recent food consumption survey among older adults. Also, future research should investigate whether the conclusions drawn from our simulation model are feasible in practice and whether they are in line with the current nutritional intake of Dutch community-dwelling older adults.

The results of our study into the effects of food odor exposure on nutritional status of older adults with dementia residing in a nursing home did not show large positive effects on appetite, nutritional status and body weight (*Chapter 6*). However, spreading food odors through machines would be an easy solution to improve appetite and nutritional status in this population. Our study used three standard odors throughout the whole intervention period. Since other studies showed that food odors increase specific appetite of the diffused food odor, while decreasing appetite for other products[56,63–66], it could be interesting to investigate the effect of meal-tailored food odors on appetite and nutritional status of this population. Additionally, our study did not measure individual olfactory function of our participants, while previous studies have shown that food odor exposure is especially effective in increasing appetite when the odor is just noticeable. Future studies should therefore include measuring olfactory function of individual participants and adjust the concentration of the odors accordingly. Lastly, our results indicate that the method used to assess appetite was not suitable for this population, or that there is no relationship between appetite and consequent food intake in this population. Future research should therefore focus on the validation of appetite measurements in older adults suffering from dementia and presumably target improving nutritional intake instead of improving appetite.

Another point to address in future research is the protein intake recommendation for older adults. Important health advisory boards such as the WHO and the Dutch Health Council recommend a protein intake of 0.8g/kg BW/day for all healthy adults aged ≥18 years[17,18], while expert groups emphasize the fact that even healthy older adults have a higher protein requirement[13,14]. A clear direction in this matter is required, for both scientific research, as towards older adults themselves.

Conclusion

It can be concluded that malnutrition is a large problem among older adults across different healthcare settings. In practice, this may imply that nutritional status of older adults can be improved significantly and may improve physical functioning and wellbeing and decrease healthcare demands and healthcare costs accordingly.

When looking at possible strategies to tackle malnutrition later in life, we first found that optimization of nutritional care communication and collaboration is needed (*Chapter 3*). One way to do so is to appoint a coordinator of care, as clarity about responsibility is often lacking. Another way to do so would be to increase knowledge about malnutrition among older adults themselves, their caregivers and healthcare professionals. Also, increasing knowledge about the importance of dietary protein may be a solution to increase protein intake among older adults (*Chapter 4*). Thirdly, improving social support on the social level but also on the community level might also help to tackle the malnutrition problem. Fourth, the results of *Chapter 5* can be used to make small changes in the diet of Dutch community-dwelling older adults to increase protein intake. Lastly, there is no direct evidence that odor exposure increases appetite and nutritional intake in older adults with dementia (*Chapter 6*), but more research is needed to unravel the potential effect of food odor exposure on nutritional status of older adults with dementia.

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Summary

During the past centuries, life-expectancy of humans improved exceptionally. As a result, the number of older adults has increased significantly. Ageing often goes hand in hand with physical and mental deterioration, with malnutrition as one of the risk factors. With the increasing number of older adults worldwide, it is important to gain more insights into the current diet and to look for nutritional strategies to prevent and treat malnutrition. Therefore, the overall aim of this thesis was to describe the magnitude of the malnutrition problem among older adults, current practices in nutritional care and possible nutritional solutions to tackle malnutrition later in life.

In Chapter 2 we performed systematic searches in six electronic databases to assess the prevalence of malnutrition risk among European older adults. A total of 223 study samples were included in the meta-analysis, accounting for 583.972 older adults from 24 European countries. The results of the meta-analysis revealed a malnutrition risk among European older adults varying from 8.5% to 28.0%, depending on healthcare setting. The prevalence of high malnutrition risk varied widely between countries and differed between the different screening tools that were used to determine malnutrition risk. The latter underlines the importance of unambiguous screening.

Chapter 3 describes current practices in nutritional care across different healthcare settings. Through eleven focus group interviews in three regions across the Netherlands various aspects of collaboration and communication between all stakeholders involved in nutritional care were discussed. From these focus group interviews it can be concluded that it is important that interdisciplinary communication and collaboration improves in the vast future. Knowledge and awareness regarding malnutrition were acknowledged as being insufficient among all involved, which might impair timely recognition and diagnosis. Furthermore, responsibility for nutritional care and its communication to other disciplines was low and stakeholders experienced barriers with regard to communication with other disciplines. Appointing one coordinator of nutritional care could help to improve communication and collaboration.

Next, in Chapter 4, we used an online survey to explore the chance of a low protein intake in relation to eight behavioral determinants among Dutch community-dwelling older adults. In total, 824 respondents completed the questionnaire. Nearly 40% of all participants had a high chance of a low protein intake (<1.0g/kg BW/day) based on the ProteinScreener55+. Univariate analyses indicated that lower scores for all different behavioral determinants were associated with a higher chance of a low protein intake. However, knowledge and social support were independently associated with chance of a low protein intake. This may indicate that future interventions aiming to increase protein

intake in Dutch community-dwelling older adults should target increasing knowledge and social support.

In Chapter 5 we developed a simulation model based on the results of the Dutch National Food Consumption Survey Older Adults 2010-2012. In this model we included three different scenarios in which commonly consumed foods were replaced by comparable food rich in protein (scenario 1), foods enriched in protein (scenario 2) and a combination of both (scenario 3). Mean protein intake of the total population increased from 1.0 to 1.2-1.3g/kg BW/day and the percentage of participants with intakes of ≥1.0 g/kg BW/day increased from 47.1% to ~90% in all scenarios. Results of this simulation model can be used as a basis for future intervention studies and for nutritional counseling.

Lastly, in Chapter 6, we assessed the effect of food odor exposure on appetite, nutritional intake and body weight among Dutch nursing home residents with dementia. Through odor dispersers food odors were vaporized before breakfast, lunch and dinner. Exposure to food odors in a younger, healthy population has shown to increase specific appetite for the exposed odor. However, in our study we found no clinically relevant changes in appetite, nutritional intake and body weight. This may indicate that this strategy is not effective in a population of older adults with dementia, but future research is needed to assess the effect of natural food odors and/or meal-tailored odors on appetite and nutritional status of older adults with dementia.

In conclusion, malnutrition remains a major health problem among older adults while communication and collaboration between all stakeholders involved in nutritional care often fall short. Possible solutions to tackle malnutrition later in life might include interventions aiming to increase nutrition knowledge among healthcare professionals and older adults, improving social support around the older adult and achieving subtle changes in the diet of older adults. Whether natural and/or meal-tailored food odors can increase appetite and nutritional intake among older adults remains unclear. Future research should focus on the effects of interventions targeting specific behavioral determinants aiming to increase protein intake and on developing and testing methods to improve collaboration and communication between all stakeholders involved in nutritional care.

Samenvatting

Gedurende de afgelopen eeuwen is de levensverwachting van de mens enorm gestegen, waardoor het aantal ouderen significant is toegenomen. Ouder worden gaat vaak gepaard met mentale en fysieke achteruitgang. Ondervoeding is hier een risicofactor van. Door het groeiende aantal ouderen wereldwijd is het belangrijk om inzicht te verkrijgen in het huidige voedingspatroon en het achterhalen van strategieën die gericht zijn op voeding, om ondervoeding te voorkomen en te behandelen. Het doel van dit proefschrift is dan ook: het beschrijven van de magnitude van het ondervoedingsprobleem onder ouderen, huidige gang van zaken in voedingszorg en mogelijke oplossingen om ondervoeding op latere leeftijd te voorkomen.

In hoofdstuk 2 hebben we een systematische review uitgevoerd om de prevalentie van het risico op ondervoeding onder Europese ouderen vast te stellen. Er zijn 223 studiepopulaties uit zes verschillende databases geïncludeerd in de meta-analyse. In totaal hebben we de gegevens meegenomen van 583.972 ouderen uit 24 Europese landen. De meta-analyse wees uit dat het risico op ondervoeding onder Europese ouderen varieerde van 8.5% tot 28.0%, met een zichtbaar verschil per zorgsetting, land en screening tool. Dit laatste onderstreept het belang van eenduidige screening op ondervoeding.

Hoofdstuk 3 beschrijft de huidige voedingszorg binnen en tussen verschillende zorgsettings in Nederland. Door middel van 11 focusgroepen in drie regio's in Nederland, zijn verschillende aspecten van de samenwerking en communicatie tussen alle betrokkenen bij voedingszorg in kaart gebracht. Hieruit kan worden geconcludeerd dat er ruimte is voor verbetering in het geval van interdisciplinaire samenwerking en communicatie binnen voedingszorg. Er werd vaak benoemd dat kennis en bewustzijn rondom ondervoeding onvoldoende is onder de verschillende betrokkenen, wat tijdige herkenning en diagnose van ondervoeding in de weg kan staan. Daarnaast is het vaak onduidelijk wie er verantwoordelijk is voor voedingszorg en de communicatie hiervan naar andere disciplines. Betrokkenen gaven aan barrières te ervaren rondom communicatie met andere disciplines. Het aanstellen van één coördinator van voedingszorg werd genoemd om de samenwerking en communicatie tussen betrokkenen te verbeteren.

In hoofdstuk 4 hebben we door middel van een online vragenlijst de relatie tussen de kans op een lage eiwitinname en acht verschillende gedragsdeterminanten onder Nederlandse thuiswonende ouderen onderzocht. In totaal hebben 824 respondenten de vragenlijst ingevuld. Bijna 40 procent van de respondenten had een hoge kans op een lage eiwitinname (<1.0g/kg lichaamsgewicht/dag), gebaseerd op de ProteinScreener55+. Univariaat analyses lieten zien dat lagere scores op de verschillende gedragsdeterminanten waren geassocieerd met een hogere kans op een lage eiwitinname. Echter, kennis en

sociale steun waren onafhankelijk geassocieerd met de kans op een lage eiwitinname. Dit kan er op duiden dat toekomstige interventies gericht op het verhogen van de eiwitinname van Nederlandse thuiswonende ouderen zich zouden moeten focussen op het verhogen van de kennis en sociale steun.

Hoofdstuk 5 beschrijft een modelleerstudie gebaseerd op de uitkomsten van de Voedselconsumptiepeiling Ouderen 2010-2012. Binnen deze modelleerstudie hebben we gebruik gemaakt van drie verschillende scenario's waarin voedingsmiddelen laag in eiwit werden vervangen door vergelijkbare producten die van nature rijk zijn aan eiwitten (scenario 1), eiwitverrijkte voedingsmiddelen (scenario 2) en een combinatie hiervan (scenario 3). De gemiddelde eiwitinname van de gehele populatie steeg van 1.0 tot 1.2-1.3 g/kg lichaamsgewicht/dag en het percentage van respondenten met een eiwitinname van tenminste 1.0g/kg lichaamsgewicht/dag steeg van 47.1% naar ~90% in alle scenario's. De resultaten van deze studie kunnen worden gebruikt als basis voor toekomstige interventie studies en voor voedingsadvies.

Tenslotte hebben we in hoofdstuk 6 het effect van voedselgeur op de eetlust, voedselinname en lichaamsgewicht van verpleeghuisbewoners met dementie onderzocht. Door middel van geurdispensers werden voedselgeuren verspreid voorafgaand aan het ontbijt, de lunch en het diner. Blootstelling aan voedselgeuren in jongere, gezonde populaties liet een verhoging in specifieke eetlust zien. Echter, in onze studie hebben we geen klinisch relevante veranderingen in eetlust, voedselinname en lichaamsgewicht gevonden. Dit kan erop duiden dat deze strategie niet effectief is in deze specifieke populatie, maar toekomstig onderzoek is nodig om het effect van natuurlijke voedselgeuren en/of voedselgeuren die passen bij de maaltijd die volgt op de eetlust en voedselinname van ouderen met dementie vast te stellen.

Concluderend: ondervoeding blijft een groot gezondheidsprobleem onder ouderen, terwijl de samenwerking en communicatie tussen betrokkenen in voedingszorg vaak onvoldoende blijkt. Mogelijke uitkomsten om ondervoeding te voorkomen kunnen interventies zijn die zich richten op het verhogen van (onder)voedingskennis van zorgmedewerkers en ouderen, het verbeteren van de sociale steun rondom de oudere en het implementeren van subtiele veranderingen in het dieet van ouderen om de eiwitinname te verhogen. Of natuurlijke en/of maaltijdafhankelijke voedselgeuren de eetlust en inname van ouderen met dementie gunstig kunnen beïnvloeden blijft onduidelijk. Toekomstig onderzoek zou zich kunnen richten op de effecten van interventies die zich richten op specifieke gedragsdeterminanten om eiwitinname te verhogen en op het ontwikkelen van methoden om samenwerking en communicatie tussen alle betrokkenen binnen voedingszorg te verbeteren.

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List of Publications

In this thesis

Leij-Halfwerk, S., Verwijs, M.H., van Houdt, S., Borkent, J.W., Guaitoli, P.R., Pelgrim, T., Heymans, M.W., Power, L., Visser, M., Corish, C.A. & de van der Schueren, M.A.E. (2019). 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*, *126*, 80-89.

Verwijs, M.H., Puijk-Hekman, S., van der Heijden, E., Vasse, E., de Groot, L.C.P.G.M., & de van der Schueren, M.A.E. (2020). Interdisciplinary communication and collaboration as key to improved nutritional care of malnourished older adults across health-care settings–A qualitative study. *Health Expectations*, *23*(5), 1096-1107.

Other publications

Verwijs, M.H., Linschooten, J.O., Roodenburg, A.J.C., De van der Schueren, M.A.E. (2019). Whitepaper Project "ConsuBETER": Consumenten BEwusT EiwitRijk

Van Oers, S., Davis-Owusu, K., Romero-Herrera, N., Vastenburg, M., Verwijs, M., van Brakel, L., Beeren, I., Holtkamp, M., Helder, S., Vreugdenhil, A. & De van der Schueren, M. (2019). Foodsampler: de context als onderdeel van voedingsinnameregistratie. *Nederlands Tijdschrift voor Voeding en Diëtetiek, 74*(3), 23-31.

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Submitted for publication

M.H. Verwijs, A. Haveman-Nies, J.W. Borkent, J.O. Linschooten, A.J.C. Roodenburg, L.C.P.G.M. de Groot, M.A.E. de van der Schueren. Protein intake among community-dwelling older adults: the influence of (pre-) motivational determinants.

M.H. Verwijs, O. van de Rest, G.J. van der Putten, L.C.P.G.M. de Groot, S. Boesveldt. The effect of food odor exposure on appetite and nutritional intake of older adults with dementia.
Linschooten, J., 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 4 qualitative studies.

Linschooten, J.O., Verwijs, M.H., De van der Schueren, M.A.E., Roodenburg, A.J.C. Senioren onderschatten het belang van adequate eiwitinname.

Linschooten, J., 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 4 qualitative studies.

Verwijs M.H., de van der Schueren, M.A.E., Ocké, M.C., Ditewig, J., Linschooten, J.O., Roodenburg A.J.C., de Groot, L.C.P.G.M. The protein gap: increasing protein intake in the diet of community-dwelling older adults – A simulation study.

About the author

Marije Verwijs was born on March 16th, 1992 in Ede, the Netherlands. After the completion of secondary school at Marnix College Ede, she started the bachelor study Nutrition and Dietetics at the HAN University of Arnhem and Nijmegen, in Nijmegen (2011). After four interesting and fun years at the HAN and completing the minor "Psychobiology of Eating Behavior" at the Wageningen University (WUR), she continued in 2015 at the WUR with the master Nutrition and Health, specialization "Nutritional Physiology and Health Status". During her minor and master at the WUR, she also had a special interest in "Sensory Science", therefore completing her master thesis under supervision of dr. Sanne Boesveldt. In this project, the effect of olfactory enhancement of appetite and food intake of Dutch older adults residing in a somatic ward of a nursing home was investigated. After completing her thesis, she started her internship at a familiar place: the HAN in Nijmegen. She assisted in doing a large literature review and meta-analysis into the prevalence of malnutrition risk in European older adults under supervision of dr. Susanne Leij-Halfwerk, resulting in her first second author publication (Chapter 2). Little did she know that both her thesis as her internship project would lead to this PhD thesis. Namely, after obtaining her master diploma in 2018, she started working at WUR for the ODE project as a research assistant in February (Chapter 6). In September that same year she was able to combine this project with a project at the HAN in Nijmegen, resulting in her first authorship paper (Chapter 3). Altogether, these projects and future projects were to be combined into a PhD project focusing on the impact of and nutritional solutions to malnutrition later in life. The results of these projects are summarized in this thesis.

Overview of completed training activities

Discipline specific activity	Organizing institute	Year
ESPEN Congress 2018 • *Poster presentation*	ESPEN, Madrid	2018
ConsuBETER consortium meeting	ConsuBETER consortium	2019
ESPEN Congress 2019 • *Presentation in PROMISS booth*	ESPEN, Krakau	2019
Pact voor de Ouderenzorg	Ministerie voor Volksgezondheid, Welzijn en Sport	2019
Pioneering Nutrition Symposium	Wageningen University & Research	2019
ConsuBETER consortium meeting • *Two oral presentations*	ConsuBETER consortium	2020
Symposium Personalized Food for the Future	Amsterdam Green Campus	2020
PROMISS consortium meeting	PROMISS/Vrije Universiteit Amsterdam	2020
ConsuBETER consortium meeting • *Two oral presentations*	ConsuBETER consortium	2020
ESPEN Congress 2020 • *Oral presentation and poster presentation*	ESPEN, online	2020
iXbites: Zelfredzaam en minder eenzaam dankzij een robot	iXperium	2020
Webinar Sorgente • *Oral presentation*	Sorgente	2020
ConsuBETER consortium meeting	ConsuBETER	2021
eICDAM 2021	WUR	2021
Health Valley Event 2021	Health Valley	2021
International Week VIVES Brugge • *Oral presentation/workshop*	VIVES	2021
Webinar Sondevoeding & Transmurale zorg • *Oral presentation*	Sorgente & Nutricia	2021
PROMISS Final Conference • *Oral presentations*	PROMISS/Vrije Universiteit Amsterdam	2021

Course	Organizing institute	Year
Schrijftweedaagse	HAN	2019
SAS Programming 1: Essentials	SAS	2019
The Essentials of Scientific Writing and Presenting	WGS	2019
Searching and Organizing Literature	WGS	2019
Introduction to R	VLAG	2020
Supervising Thesis Students	ESD	2020
Posters and Pitching	WGS	2020
Applied Statistics	VLAG	2020
Career Assessment	WGS	2020
Cursus Methodologie voor Voedselconsumptieonderzoek	Wageningen Academy	2020

Other activities	Organizing institute	Year
VLAG Proposal	WUR	2019
Preparation of research protocol – ConsuBETER WP 2	HAN	2019
Preparation of research protocol – ConsuBETER WP 3	HAN	2019
Preparation of research protocol – GoedZo!	HAN	2020

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