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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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ABSTRACT

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

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.

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.

In conclusion, the prevalence of high malnutrition risk in European older adults varies widely between countries and across health-care 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.

1. 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

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

MALNUTRITION SCREENING TOOL abbreviation	MALNUTRITION SCREENING TOOL full name	Setting (validated)[a]
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 Stystem	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

[a] C = community, H = hospital, RC = Residential Care, R = Rehabilitation.

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 individualised 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 study [14].

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 $\geq$ 65 years.

2. 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 $\geq$65 years or subgroups of older adults with a mean/median age $\geq$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, Portugese 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 categorised 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 I^2 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.

3. 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.

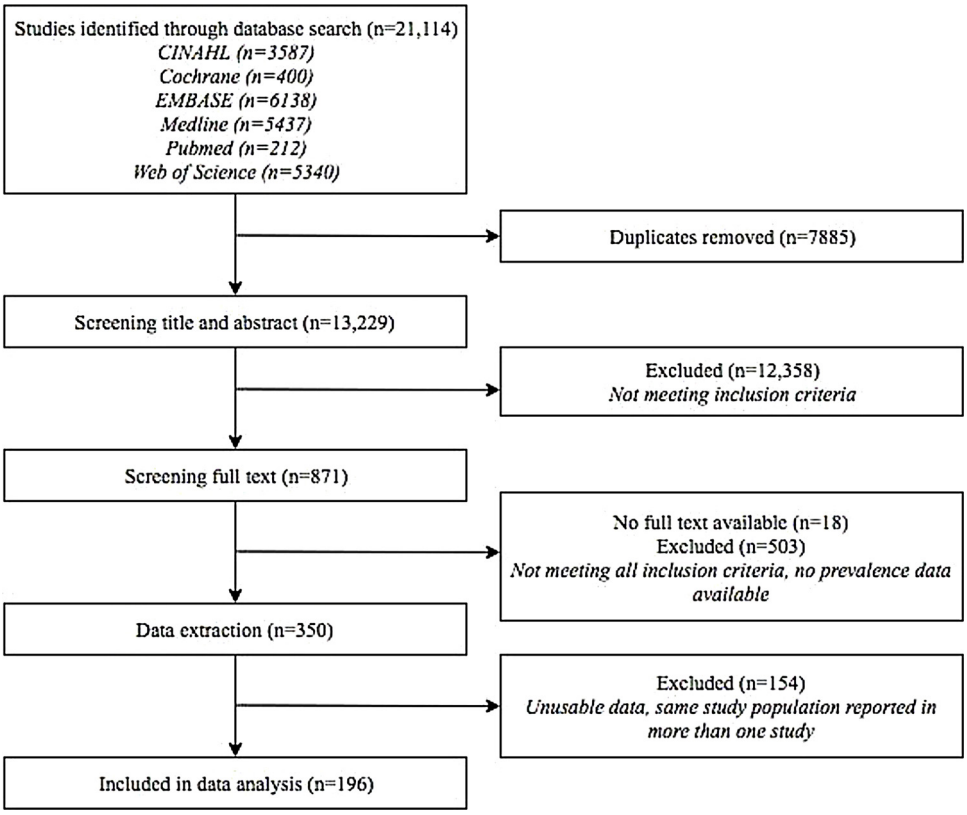

Fig. 1. PRISMA flow-chart of studies screened and reviewed for inclusion in this MaNuEL study.

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).

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.

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.

3.4. 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, I^2 = 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, I^2 = 98%], 17.5% [95%CI: 12.1–23.6, n = 30, ss = 19,735, I^2 = 99%] and 8.5% [95%CI: 5.7–11.7, n = 32, ss = 24,280, I^2 = 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:

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		Heterogeneity 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] prevalences 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		Heterogeneity 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] prevalences estimated if number of study samples was ≥10; insufficient data available from Belgium, Greece, the Netherlands, and Switzerland.

28.0–47.9, n = 15, ss = 11,277, I^2 = 98%]) and the lowest risk in Spain (15.2% [95%CI: 9.2–22.3, n = 36, ss = 19436, I^2 = 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, I^2 = 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, I^2 = 99%], followed by 51.8% [95%CI: 44.4–59.0, n = 38 ss = 23,522, I^2 = 99%] in residential care and 32.7% [95%CI: 27.0–38.7, n = 48, ss = 28,338, I^2 = 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, I^2 = 99%] to 67.4% in Sweden [95%CI: 58.5–75.7, n = 13, ss = 4,239, I^2 = 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, I^2 = 99%], and combined moderate and high malnutrition risk of 48.9 [95%CI: 44.5–51.5, n = 187, ss = 105,234, I^2 = 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, I^2 = 97%] for MNA-SFv1 to 41.5% [95%CI: 34.3–48.9, n = 42, ss = 29,919, I^2 = 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, I^2 = 99%] for MUST to 63.1%[95%CI: 47.8–77.3, n = 16, ss = 7,355, I^2 = 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, I^2 = 98%] and 5.2% [95%CI: 3.1–7.7, n = 19, ss = 13697, I^2 = 97%] respectively.

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 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		Heterogeneity I^2	Health care setting											
						Hospital				Residential care				Community			
	(n)	(n)	(%)	[95%CI]	(%)	Number of study samples (n)	Prevalence of malnutrition risk (%)	[95%CI]	Hetero geneity I^2 (%)	Number of study samples (n)	Prevalence of malnutrition risk (%)	[95%CI]	Hetero geneity I^2 (%)	Number of study samples (n)	Prevalence of malnutrition risk (%)	[95%CI]	Hetero geneity I^2 (%)
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 [44], MNA-SFv1 = Mini Nutritional Assessment Short Form version 1 [45], MUST = malnutrition universal screening tool [46]; NRS-2002 = Nutritional Risk Screening 2002 [39].

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		Heterogeneity I^2	Health care setting									
						Hospital			Residential care			Community			
	(n)	(n)	(%)	[95%CI]	(%)	Number of study samples (n)	Prevalence of malnutrition risk (%)	[95%CI]	Hetero geneity I^2 (%)	Number of study samples (n)	Prevalence of malnutrition risk (%)	[95%CI]	Hetero geneity I^2 (%)	Number of study samples (n)	Prevalence of malnutrition risk (%)	[95%CI]	Hetero geneity I^2 (%)
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 [44], MNA-SFv1 = Mini Nutritional Assessment Short Form version 1 [45], MUST = malnutrition universal screening tool [46]; NRS-2002 = Nutritional Risk Screening 2002 [39].

4. 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

Table 5
Pooled prevalence rates for high malnutrition risk and combined moderate and high malnutrition risk in age and gender groups of European older adults.

Malnutrition risk	High					P-value[a]	Combined moderate and high					P-value[a]
	Number of study samples (n)	Sample size (n)	Prevalence of malnutrition risk (%)	[95%CI]	Heterogeneity I^2 (%)		Number of study samples (n)	Sample size (n)	Prevalence of malnutrition risk (%)	[95%CI]	Hetero geneity I^2 (%)	
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	

[a] Meta-regression analyses of between age-groups or gender.

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 categorised 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.

Conflict of interest

The authors declare that they have no conflict of interest.

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CRediT authorship contribution statement

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editing, Visualization. **Jos W. Borkent:** Methodology, Validation, Software, Data curation, Writing - review & editing, Formal analysis. **P.R. Guaitoli:** Investigation. **Thomas Pelgrim:** Resources, Methodology, Software, Writing - review & editing. **Martijn W. Heymans:** Methodology, Software, Formal analysis, Writing - review & editing. **Lauren Power:** Conceptualization. **Marjolein Visser:** Conceptualization, Funding acquisition, Writing - review & editing. **Clare A. Corish:** Conceptualization, Writing - review & editing. **Marian A.E. de van der Schueren:** Conceptualization, Supervision, Funding acquisition, Writing - original draft, Writing - review & editing, Visualization, Resources.

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Appendix A. Supplementary data

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