Clinical Nutrition 38 (2019) 2389–2398

Contents lists available at ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Original article

Prevalence of malnutrition using harmonized definitions in older adults from different settings – A MaNuEL study

Maike Wolters [a, *], Dorothee Volkert [b], Melanie Streicher [b], Eva Kiesswetter [b], Gabriel Torbahn [b], Eibhlís M. O'Connor [c], Mary O'Keeffe [c], Mary Kelly [c], Eileen O'Herlihy [d], Paul W. O'Toole [d], Suzanne Timmons [e], Emma O'Shea [e], Patricia Kearney [f], Judith van Zwienen-Pot [g], Marjolein Visser [h], Isabelle Maitre [i], Virginie Van Wymelbeke [j, k], Claire Sulmont-Rossé [k], Gabriele Nagel [l], Marion Flechtner-Mors [m], Sabine Goisser [b, n], Ruth Teh [o], Antje Hebestreit [a], on behalf of the MaNuEL consortium

[a] Leibniz Institute for Prevention Research and Epidemiology – BIPS, Achterstr. 30, 28359 Bremen, Germany
[b] Institute for Biomedicine of Aging, Friedrich-Alexander-Universität Erlangen-Nürnberg, Kobergerstr. 60, 90408 Nuremberg, Germany
[c] Dept Biological Sciences, Health Research Institute, University of Limerick, V94 T9PX Limerick, Ireland
[d] School of Microbiology and APC Microbiome Ireland, University College Cork, Cork, T12 Y337, Ireland
[e] Centre for Gerontology and Rehabilitation, School of Medicine, University College Cork, Cork, Ireland
[f] Dept Epidemiology and Public Health, University College Cork, Cork, Ireland
[g] Department of Internal Medicine, Nutrition and Dietetics, VU University Medical Center, de Boelelaan 1117, 1081 HV Amsterdam, the Netherlands
[h] Department of Health Sciences, Faculty Sciences, Vrije Universiteit Amsterdam, Amsterdam Public Health Research Institute, Amsterdam, the Netherlands
[i] USC 1422 GRAPPE, Ecole Supérieure d'Agricultures (ESA), SFR 4207 QUASAV, INRA, 55 Rue Rabelais, F-49007 Angers, France
[j] Centre Hospitalier Universitaire Dijon Bourgogne, Centre Champmaillot, Unité de Recherche Pôle Personnes Âgées, 2 Rue Jules Violle, F-21000 Dijon, France
[k] Centre des Sciences du Goût et de l'Alimentation, AgroSup Dijon, CNRS, INRA, Université Bourgogne Franche-Comté, 9E Boulevard Jeanne d'Arc, F-21000 Dijon, France
[l] Institute of Epidemiology and Medical Biometry, Ulm University, Helmholtzstr. 22, 89081 Ulm, Germany
[m] Medical Center, Division of Sports and Rehabilitation Medicine, University of Ulm, Leimgrubenweg 14, 89075 Ulm, Germany
[n] Network Aging Research, Heidelberg University, Bergheimer Straße 20, 69115 Heidelberg, Germany
[o] General Practice and Primary Health Care, School of Population Health, University of Auckland, Private Bag 92019, Auckland Mail Centre, Auckland 1142, New Zealand

ARTICLE INFO

Article history:
Received 21 June 2018
Accepted 28 October 2018

Keywords:
Malnutrition
Older adults
Prevalence
Older people
Elderly

SUMMARY

Background & aims: Malnutrition is widespread among older people and related to poor outcome. Reported prevalences vary widely, also because of different diagnostic criteria used. This study aimed to describe prevalences in several populations of older persons in different settings using harmonized definitions.

Methods: Available studies within the Joint Programming Initiative (JPI) Knowledge Hub 'Malnutrition in the Elderly' (MaNuEL) were used to calculate and compare prevalences of malnutrition indicators: low BMI (<20 kg/m^2; age-specific BMI <20 if age 65–<70 and <22 kg/m^2 if age ≥70 years), previous weight loss (WL), moderate and severe decrease in food intake, and combined BMI <20 kg/m^2 and/or WL in participants aged ≥65 years.

Results: Fifteen samples with in total 5956 participants (59.3% women) were included: 7 consisting of community-dwelling persons, 2 studies in geriatric day hospitals, 3 studies in hospitalized patients and 3 in nursing homes. Mean age of participants ranged between 67 and 87 years. Up to 4.2% of community-dwelling persons had a BMI <20 kg/m^2, 1.6 and 9% of geriatric day hospital patients, 4.5–9.4% of hospital patients and 3.8–18.2% of nursing home residents. Using age-specific cut-offs doubled these prevalences. WL was reported in 2.3–10.5% of community-dwelling persons, 6% and 12.6% of geriatric day hospital patients, 5–14% of hospitalized patients and 4.5–7.7% of nursing home residents. Severe decrease in food intake was recorded in up to 9.6% of community-dwelling persons, 1.5% and 12% of geriatric day hospital patients, 3.4–34.2% of hospitalized patients and 1.5–8.2% of nursing home residents. The criteria age-

* Corresponding author.
E-mail address: wolters@leibniz-bips.de (M. Wolters).

https://doi.org/10.1016/j.clnu.2018.10.020

specific BMI and WL showed opposing prevalences across all settings. Compared to women, low BMI and moderate decrease in food intake showed low prevalences in men but similar prevalences were observed for weight loss and severe decrease in food intake. In half of the study samples, participants in a younger age group had a higher prevalence of WL compared to those of an older age group. Prevalence of BMI <20 kg/m^2 and WL at the same time did not exceed 2.6% in all samples. The highest prevalences were observed based on combined definitions when only one of the three criteria had to be present.

Conclusions: Prevalences for different criteria vary between and within the settings which might be explained by varying functional status. The criteria used strongly affect prevalence and it may be preferable to look at each criterion separately as each may indicate a nutritional problem.

Abbreviations

ActiFE	Activity and Function in the Elderly Ulm study
BMI	body mass index
CVD	cardiovascular disease
ErnSiPP	Ernährungssituation von Seniorinnen und Senioren mit Pflegebedarf in Privathaushalten (Nutritional situation of seniors with need of care in private households)
ESPEN	European Society for Clinical Nutrition and Metabolism
FFMI	fat-free mass index
GDH	Geriatric Day Hospital
IQCODE	Informant Questionnaire on Cognitive Decline in the Elderly
JPI	Joint Programming Initiative
LASA	Longitudinal Aging Study Amsterdam
LiLACS NZ	Life and Living in Advanced Age: a cohort study in New Zealand
MaNuEL	Malnutrition in the Elderly (JPI knowledge hub title)
MMSE	Mini-Mental State Examination
MNA	Mini Nutritional Assessment
MNA-SF	Mini Nutritional Assessment Short Form
NEADL	Nottingham Extended Activities of Daily Living
ODCACS	Optimal Dementia Care in Acute Care settings
SMMSE	standardized Mini-Mental State Examination
SCREENII	'Seniors in the Community: Risk Evaluation for Eating and Nutrition' Version II
WL	weight loss

1. Introduction

Malnutrition is widespread among older populations and a known risk factor for severe health and functional problems and associated with increased health care costs [1,2]. As numerous studies in older people have shown, malnutrition is associated with a higher risk for morbidity (e.g. infections, pressure ulcers, and hospital readmissions) and mortality [3,4]. Additionally, protein-energy malnutrition is associated with functional impairment that initiates a sequence of negative consequences. These range from a decline in muscle mass and strength, to sarcopenia and frailty at the expense of mobility and independence, which may further aggravate nutritional problems [5–9].

Reported malnutrition prevalence varies widely between different populations. Malnutrition is generally associated with decreased health and functional status as well as increased dependency and disability. While less than 10% of independently living older persons in the community are affected, the prevalence among nursing home residents, geriatric patients in hospitals and in geriatric rehabilitation is increasing to 50% and more [10–13]. However, the reported prevalences vary not only due to differences in study populations but also depend on which definition was used to evaluate malnutrition. In a consensus statement of the European Society for Clinical Nutrition and Metabolism (ESPEN), diagnostic criteria for malnutrition were suggested based on body mass index (BMI), or combined determination of unintentional weight loss together with a reduced age-specific BMI or a low fat-free mass index (FFMI) using sex-specific cut-offs [14]. However, the use of these diagnostic criteria in practice has revealed limitations because 20% of different populations showing both a low BMI and low FFMI were not classified as malnourished as they had not reported unintentional weight loss and also diagnostic concordance of the ESPEN criteria with bioelectrical impedance vector analysis was poor [10,15].

Thus, a harmonized malnutrition definition is required to provide more accuracy to reliably comparing prevalences between studies, which was one of the primary objectives of the Joint Programming Initiative (JPI) Malnutrition in the Elderly (MaNuEL) Knowledge Hub. The establishment of the MaNuEL Knowledge Hub, 2016–2018, initiated by the 'Healthy Diet for a Healthy Life' European Joint Programming Initiative comprised a consortium of 22 research groups from 7 countries (Austria, France, Germany, Ireland, Spain, The Netherlands and New Zealand) [16].

The present work provides prevalences according to several harmonized malnutrition criteria in older adults from the age of 65 years. Our study describes and compares the prevalences according to (combinations of) low BMI, previous weight loss and reduced food intake in several large samples of older persons in different settings across Europe and New Zealand. By using single criteria as well as different combinations of the three criteria, our study is able to identify differences between the applied definitions. Another reason to use these malnutrition definitions was that the assessment is easily possible in various settings in order to enable a wide use of the diagnostic criteria of malnutrition.

2. Materials and methods

2.1. Study design and included studies

The present study comprises secondary data analyses from 11 national and cross-country European studies (Austria, Belgium, Czech, France, Germany, Italy, Ireland, The Netherlands, Poland, Switzerland) and from New Zealand (for comparability with the other studies only the non-Māori population was included). Prevalences of malnutrition were calculated by the respective local data analysts represented in the MaNuEL consortium. Five cross-sectional studies [17–21] and six longitudinal studies [22–27] providing data for cross-sectional analyses were included.

Data collection for our analysis samples was performed between 2008 and 2016. The number of included participants per study in our analysis ranged from 114 to 1226. Participants were recruited from different settings: Community-dwelling [22,23,26], community-dwelling with home care [17], community including day hospital [27,28] or nursing home [21], one primary care center [19], only nursing homes [18] and long term institutionalized care hospitals [27,28], one geriatric day hospital [20] and acute hospitals [24,25]. The following studies were included: The Longitudinal Aging Study Amsterdam (LASA) investigates the impact of selected determinants on measures of physical, cognitive, emotional and social functioning in a representative sample of Dutch persons aged 55 years and above [22]. The Activity and Function in the Elderly Ulm study (ActiFE) investigated associations between objectively measured physical activity and particular health-related endpoints, such as disability, falls and cognitive function [23]. The Cork and Kerry Diabetes and Heart Disease Study was a large population-based observational study. The cohort study aimed to investigate the prevalence of key risk factors for cardiovascular disease (CVD) in middle-aged people (50–69 years in 1998) in Ireland [19]. The Life and Living in Advanced Age: a cohort study in New Zealand (LiLACS NZ) investigated the health, social, cultural and environmental status of octogenarians (indigenous Māori and non-Māori population) in order to identify predictors of successful aging [26]. In the cross-sectional study, Geriatric Day Hospital (GDH) in Germany, the prevalence of malnutrition was assessed using the Mini Nutritional Assessment Short Form (MNA-SF) and the complete MNA, and the relationship between nutritional and functional status was determined [20]. The ErnSiPP (*Ernährungssituation von Seniorinnen und Senioren mit Pflegebedarf in Privathaushalten*, Nutritional situation of seniors with need of care in private households) project was aimed at describing the nutritional and health situation of community-dwelling older adults receiving home care in Germany [17]. The ELDERMET study was conducted in Ireland and investigated longitudinal associations between faecal microbiota composition, data on food consumption frequency and markers of frailty, co-morbidity and nutritional status in 178 older people [27,28]. In order to combat malnutrition and increase appetite, the French project AUPALESENS (for improving pleasure of elderly people for better aging and for fighting against malnutrition) has tested the effectiveness of strategies regarding sensory perception [21]. The Optimal Dementia Care in Acute Care settings (ODCACS) project aimed at investigating the prevalence of dementia among older people admitted to acute hospitals in Cork, Ireland [25]. A longitudinal study (2011/2012) in Germany (Hip Fracture) investigated the association between nutritional status and the functional and clinical course up to 6 months after discharge from hospital in geriatric patients with hip fracture [24]. Data from European countries were included from the nutritionDay in nursing homes which is an international 1-day cross-sectional study to increase awareness of malnutrition [18]. While most studies were restricted to one setting (or reported only the data of the predominant setting), AUPALESENS [21] and ELDERMET [27] involved older people from different settings. Table 1 provides an overview of the studies included indicating the year(s) of data collection, the setting(s) as well as the number and main characteristics (age, sex, cognitive impairment, mobility limitations, and dependence in activities of daily living) of the participants included in our analyses.

Written informed consent from the participants and ethical approval from the local competent Institutional Review Boards were obtained prior to the start of each study.

2.2. Inclusion and exclusion criteria

Participants aged 65 years and over were included in the analyses. Individuals with missing data on age, sex or BMI were excluded. Participants with self-reported height and/or weight were also excluded if this information was available while participants with measurement by qualified personnel such as nurses, care facility staff or physicians and those with height estimated from knee height or arm length were included. For the latter, the percentage of participants with estimated values was indicated. In studies with previous weight loss assessment, participants with missing weight loss data were excluded.

2.3. Definition criteria for malnutrition

Each study reported the prevalence of BMI <18.5, <20 and < 22 kg/m^2 as well as age-specific prevalence for BMI <20 kg/m^2 in participants aged ≥65 to <70 years and BMI <22 kg/m^2 in participants ≥70 years. These different BMI cut-offs were applied as they refer to or are part of common definitions of malnutrition, e.g. according to the WHO (<18.5) and current ESPEN consensus definition [14]. Additionally, if available, prevalence of previous weight loss (>3 kg in the past 3 months), prevalence of moderate decrease in food intake and prevalence of severe decrease in food intake in the past 3 months as reported in the Mini Nutritional Assessment (MNA) [29–32] were calculated in all studies. Information collected with the MNA was self-reported either by participants or proxies. If other weight loss definitions were used, these data were reported instead (>5 kg in the past 6 months). Some studies (LASA, ErnSiPP and GDH) also assessed whether weight loss was intended. Here we restrict weight loss prevalence in these studies to participants with unintended weight loss and report number of participants with intended weight loss in the footnote of the respective tables.

In order to gain insight into the prevalence of different combinations, low BMI defined as <20 kg/m^2, weight loss (as described above) and severe (not moderate) decrease in food intake were combined and the prevalence of each of these combinations were calculated as follows: a) low BMI and weight loss, b) low BMI and weight loss and severe decrease in food intake, c) low BMI or weight loss, d) low BMI or weight loss or severe decrease in food intake.

2.4. Data analyses and presentation of results

The local data analysts prepared the dataset according to the provided study protocol and calculated the number and percentage of participants fulfilling the different malnutrition criteria. The prevalences (%) of the harmonized criteria for malnutrition are presented stratified by study sample and by setting, and additionally stratified by setting and sex and by setting and age group.

3. Results

In total 5956 participants (59.3% women) from 11 studies were included. The mean age of participants ranged between 67 and 87 years. The results cover 3507 community-dwelling older adults (including primary care and day hospitals), 333 home care receivers, 648 hospitalized individuals including rehabilitation and 1468 residents of nursing home or institutionalized care homes. The LASA and nutritionDay studies were the largest studies in their respective setting. Participants of Cork and Kerry, ActiFE and LASA were the youngest with a mean age below 75 years. The average age of participants in all other studies was over 75 years of age, with nutritionDay, LiLACS NZ and Hip Fracture including the oldest participants (Table 1). ActiFE participants were in relatively good physical condition as they had no mobility limitations or dependencies. Nursing home residents (nutritionDay, ELDERMET) and home care receivers (ErnSiPP) exhibited the most often severe cognitive impairment and mobility limitations were most frequent

Table 1
Overview of the included studies and characteristics of the included participants of the respective analysis sample.

Study (year of data collection)	Setting	Country	N	Female N (%)	Age group, %, All: mean (SD), years	Cognitive impairment, % assessment instrument	Mobility limitations, % assessment instrument	Dependencies, %	BMI, mean (SD), kg/m^2	Assessment of weight loss (WL), instrument, N with intended WL
LASA (2011/12)	Community	The Netherlands	1087	592 (54.5)	65–<75: 56.2 75–<85: 33.6 ≥85: 10.2 All: 74.9 (7.19)	5.4 MMSE ≤23	Difficulties walking: Some/much: 13.3 Only with help/unable: 5.0 Missing: 0.1	7 items questionnaire: 4–6 wo diff: 40.4 1–3 wo diff: 14.8 All with diff: 3.5 Missing: 1.2	27.5 (4.28)	>5 kg in the past 6 months, Two questions on WL for calculation, intended WL: N = 7
ActiFE (2009–2013)	Community	Germany	791	325 (41.1)	65–<75: 63.1 75–<85: 32.1 ≥85: 4.8 All: 74.1 (5.90)	1.3 Missing: 8.0 MMSE ≤23	0 Persons with mobility limitations were excluded	0 Persons with dependencies were excluded	27.6 (3.95)	>3 kg in the past 3 months, MNA, intended WL: unknown
LiLACS NZ (2010)	Community	New Zealand	360, only non-Māori	187 (51.9)	65–<75: none 75–<85: 41.9 ≥85: 58.1 All: 84.6 (0.58)	6.9 Don't know: 0.5 MMSE ≤23	5.3[a] NEADL	Not available	26.8 (4.00)	>5 kg in the past 6 months, SCREENII
Cork and Kerry (Mitchelstown cohort) (2010/11)	Primary Care Centre	Ireland	386	193 (50.0)	65–<75: 100 All: 67.1 (1.63)	Not available	7.5 Questions on difficulties in walking, climbing stairs, stooping etc.	2.8[b]	28.6 (4.54)	Not available
GDH (2012)	Geriatric Day Hospital	Germany	191	138 (72.3)	65–<75: 24.6 75–<85: 53.9 ≥85: 21.5 All: 79.4 (6.3)	Moderate: 10.5 Severe: 1.0 Missing: 0 MMSE 17 −24 = moderate, 0 −16 = severe	Bed or chair bound: 0 Homebound: 11 Missing 0 MNA	31.4[c]	28.9 (5.6)	>3 kg in the past 3 months, MNA, intended WL: N = 3
ErnSiPP (2010)	Community with home care	Germany	333	212 (63.7)	65–<75: 21.3 75–<85: 42.3 ≥85: 36.3 All: 81.0 (7.70)	Moderate: 20.1 Severe: 20.7 Don't know: 1.5 MMSE 17 −24 = moderate, 0 −16 = severe	Bed or chair bound: 14.4 Homebound: 18.0 Missing: 0 MNA	94.6[c]	28.1 (6.16)	>3 kg in the past 3 months, MNA, intended WL: N = 6
ELDERMET (2008)	All settings	Ireland	438	254 (57.9)	65–<75: 32.8 75–<85: 44.5 ≥85: 22.6 All: 78.3 (7.63)	Moderate: 11.6 Severe: 11.6 Don't know: 8.7 MMSE 18 −23 = moderate, 0 −17 = severe	Bed or chair bound: 23.1 Homebound: 8.44 Missing: 0.23 MNA	44.9[c]	26.5 (5.45)	>3 kg in the past 3 months, MNA, intended WL: N = 0
	Only community	Ireland	198	108 (54.5)	65–<75: 55.1 75–<85: 36.4 ≥85: 8.60 All: 74.2 (6.38)	Moderate:5.5 Severe:1.5 Don't know: 0 MMSE 18 −23 = moderate, 0 −17 = severe	Bed or chair bound: 0 Homebound: 0.5 Missing: 0 MNA	8.08	27.6 (4.75)	>3 kg in the past 3 months, MNA, intended WL: N = 0
	Only day hospital	Ireland	67	32 (47.8)	65–<75: 16.4 75–<85: 59.7 ≥85: 23.9 All: 80.0 (5.84)	Moderate:11.9 Severe:1.5 Don't know: 4.5 MMSE 18 −23 = moderate, 0 −17 = severe	Bed or chair bound: 0 Homebound: 7.5 Missing: 1.5 MNA	26.9	27.4 (6.06)	>3 kg in the past 3 months, MNA, intended WL: N = 0
	Only rehabilitation	Ireland	63	33 (52.4)	65–<75: 11.1 75–<85: 60.3 ≥85: 28.6 All: 80.7 (6.20)	Moderate:15.8 Severe 15.8 Don't know: 3.2 MMSE 18 −23 = moderate, 0 −17 = severe	Bed or chair bound: 14.3 Homebound: 27.0 Missing: 0 MNA	84.1	26.5 (5.88)	>3 kg in the past 3 months, MNA, intended WL: N = 0

	Only long-term institution-alized care	Ireland	110	81 (73.6)	65−<75: 15.5 75−<85: 40.9 ≥85: 43.6 All: 83.2 (7.60)	Moderate: 20.9 Severe: 33.6 Don't know: 29.1 MMSE 18 −23 = moderate, 0 −17 = severe	Bed or chair bound: 83.6 Homebound: 12.7, Missing: 0; MNA	100	24.0 (5.17)	>3 kg in the past 3 months, MNA, intended WL: N = 0
AUPALESENS (2011)	All settings	France	559	387 (63.2)	65−<75: 33.4 75−<85: 38.5 ≥85: 28.1 All: 79.0 (8.10)	Severe: 0 Only participants with MMSE ≥20 included MNA	Bed or chair bound: 4.7 Homebound: 15.6 Missing: 0 MNA	48.3[d]	27.8 (4.94)	>3 kg in the past 3 months, MNA, intended WL: unknown
	Only community	France	427	287 (67.2)	65−<75: 42.4 75−<85: 41.7 ≥85: 15.9 All: 76.7 (7.20)	Severe: 0 Only participants with MMSE ≥20 included MNA	Bed or chair bound: 2.1 Homebound: 7.0 Missing: 0 MNA	32.3[d]	27.7 (4.95)	>3 kg in the past 3 months, MNA, intended WL: unknown
	Only nursing home	France	132	100 (75.8)	65−<75: 4.5 75−<85: 28.0 ≥85: 67.4 All: 86.6 (6.30)	Severe: 0 Only participants with MMSE ≥20 included MNA	Bed or chair bound: 12.9 Homebound: 43.2 Missing: 0 MNA	100[d]	28.1 (4.89)	>3 kg in the past 3 months, MNA, intended WL: unknown
ODCACS (2012, 2013)	Acute Hospital	Ireland	471	246 (52.2)	65−<75: 27.8 75−<85: 49.7 ≥85: 22.5 All: 79.4 (6.48)	Moderate: 17.6 Severe: 11.9 Don't know: 6 MMSE 18 −23 = moderate, 0 −17 = severe	Bed or chair bound: 8.3 Homebound: 20.8 Not homebound: 70.7 Missing: 0.2 MNA	40.8, Missing: 4.2[c]	28.1 (5.22)	>3 kg in the past 3 months, MNA, intended WL: unknown
Hip Fracture (2011−2012)	Geriatric patients with hip fracture	Germany	114	87 (76.3)	65−<75: 0 75−<85: 50.9 ≥85: 79.1 All: 84.1 (5.40)	Moderate: 26.3 Severe: 10.5 Missing: 25.4 MMSE 17 −24 = moderate, 0 −16 = severe	Bed or chair bound: 92.1 Homebound: 7.9 Missing: 0 MNA	100[c]	26.5 (4.70)	>3 kg in the past 3 months, MNA, intended WL: unknown
nutritionDay (2016)	Nursing home	Austria, Belgium, Switzerland, Czech Republic, Germany, Italy, Poland	1226	910 (74.2)	65−<75: 8.8 75−<85: 24.1 ≥85: 67.1 All: 86.7 (7.67)	Moderate: 40.4 Severe: 29.0 Don't know: 0.1 MNA	Bed or chair bound: 40.5 Homebound: 34.3 Missing: 0.6 MNA	96.4[e]	24.9 (5.33)	>3 kg in the past 3 months, MNA, intended WL: unknown

IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; MMSE, Mini-Mental State Examination; MNA, Mini Nutritional Assessment; NEADL, Nottingham Extended Activities of Daily Living; wo diff, items without difficulties; SMMSE standardized Mini-Mental State Examination, SCREENII, 'Seniors in the Community: Risk Evaluation for Eating and Nutrition' Version II.

[a] At least one of the following activities needing help: a. Do you walk around outside? b. Do you climb stairs? c. Do you get in and out of the car? d. Do you walk over uneven ground? e. Do you cross roads? f. Do you travel on public transport? − based on NEADL questions on mobility.

[b] Dependent in at least one of the following activities: getting dressed, crossing a room, taking a bath or shower, eating, getting in/out of bed, using the toilet.

[c] Dependent in at least one activity of daily living (Barthel Index).

[d] People need help for meal or get prepared meal at least once per week for community and help for all meals for nursing home.

[e] Require at least 45 min of basic care every day.

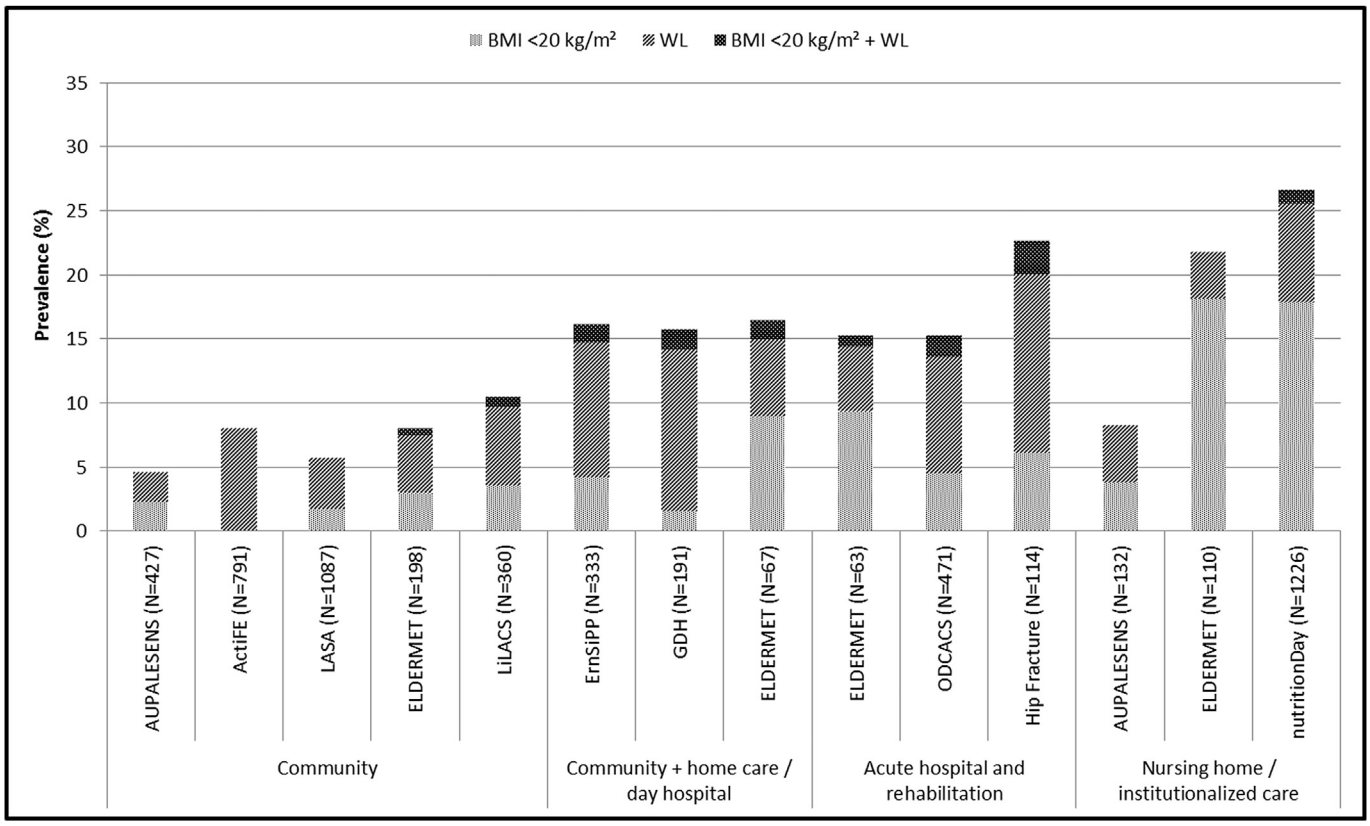

Fig. 1. Prevalences of malnutrition criteria based on low BMI, weight loss (WL) or both in older adults in different study samples by setting.

among long-term institutionalized care home residents of the ELDERMET study and among Hip Fracture participants.

Figure 1 and Supplementary Table 1 present the prevalences of the harmonized malnutrition criteria by setting. In terms of low BMI, the prevalences were lowest among community-dwellers including those recruited in a primary care center and day care hospital. In contrast, the highest prevalences were observed in nursing homes and long-term institutionalized care homes (with the exception of AUPALESENS). Older people in the home care setting had similar prevalences of low BMI as older people in acute hospitals and rehabilitation. The prevalences of the weight loss criterion varied across all settings without a marked trend showing the highest prevalences in an acute hospital study (Hip Fracture), one day hospital study (GDH) and in home-care receivers (ErnSiPP). With few exceptions, the highest prevalences of the criterion *severe decrease in food intake* were recorded in the hospitals. Prevalence of severe decrease in food intake was much lower than that of moderate decrease in food intake (by a mean factor of 7, range 1.5–29).

When the combined criteria were applied, i.e. a BMI <20 kg/m^2 and weight loss (and severe decrease in food intake) being present at the same time, prevalences did not exceed 2.6% in any of the studies or settings. The highest prevalences were found when participants with at least one of the criteria were included. For example, the highest prevalences were observed in nursing homes (>20%) and in one acute hospital (39.5% in Hip Fracture).

Figure 2 and Supplementary Table 2 show the prevalences of the harmonized malnutrition criteria by setting and sex. Women were more likely to be categorized as malnourished in terms of a low BMI compared to men as 12 of 15 studies showed a higher prevalence of a low age-specific BMI in women. In contrast, half of the studies showed prevalences of weight loss higher in men than in women. Accordingly, compared to BMI <20 kg/m^2 the combination of low BMI or weight loss increased the prevalences in men to the double or more. While a severe decrease in men's food intake was more prevalent in five study samples across all settings compared to eight studies in women, a higher prevalence of a moderate decrease in men's food intake was only seen in a single study (Hip Fracture).

Figure 3 and Supplementary Table 3 provide an overview of the prevalences of the harmonized malnutrition criteria by setting and age group. Prevalences varied within the same age groups across different samples of the same setting. In terms of a low BMI, we observed a trend of increased prevalences with increasing age, e.g. the prevalence of age-specific BMI from the lowest to the highest age group increased by a factor of 2–6 in most studies. A BMI <22 kg/m^2 was particularly common among those in the highest age groups with about a quarter of the participants in community-dwellers of ELDERMET and AUPALESENS, as well as hospital and rehabilitation attenders of Hip Fracture and ELDERMET. Among the nursing home residents 31.8% and 39.6% of the participants of nutritionDay and ELDERMET, respectively, had a BMI <22 kg/m^2. Applying the combined definitions showed that adding severe decrease in food intake to the combination of low BMI or weight loss does not strongly increase prevalences except for Hip Fracture hospital patients.

4. Discussion

In this study we applied widely accepted and harmonized criteria to estimate the prevalences of malnutrition in almost 6000 older adults in different settings from 11 studies across 10 countries in Europe and New Zealand. To our knowledge this is the first study to compare prevalences of malnutrition according to several harmonized definition criteria across different study samples and across different strata of setting, sex, and age group. Previous large,

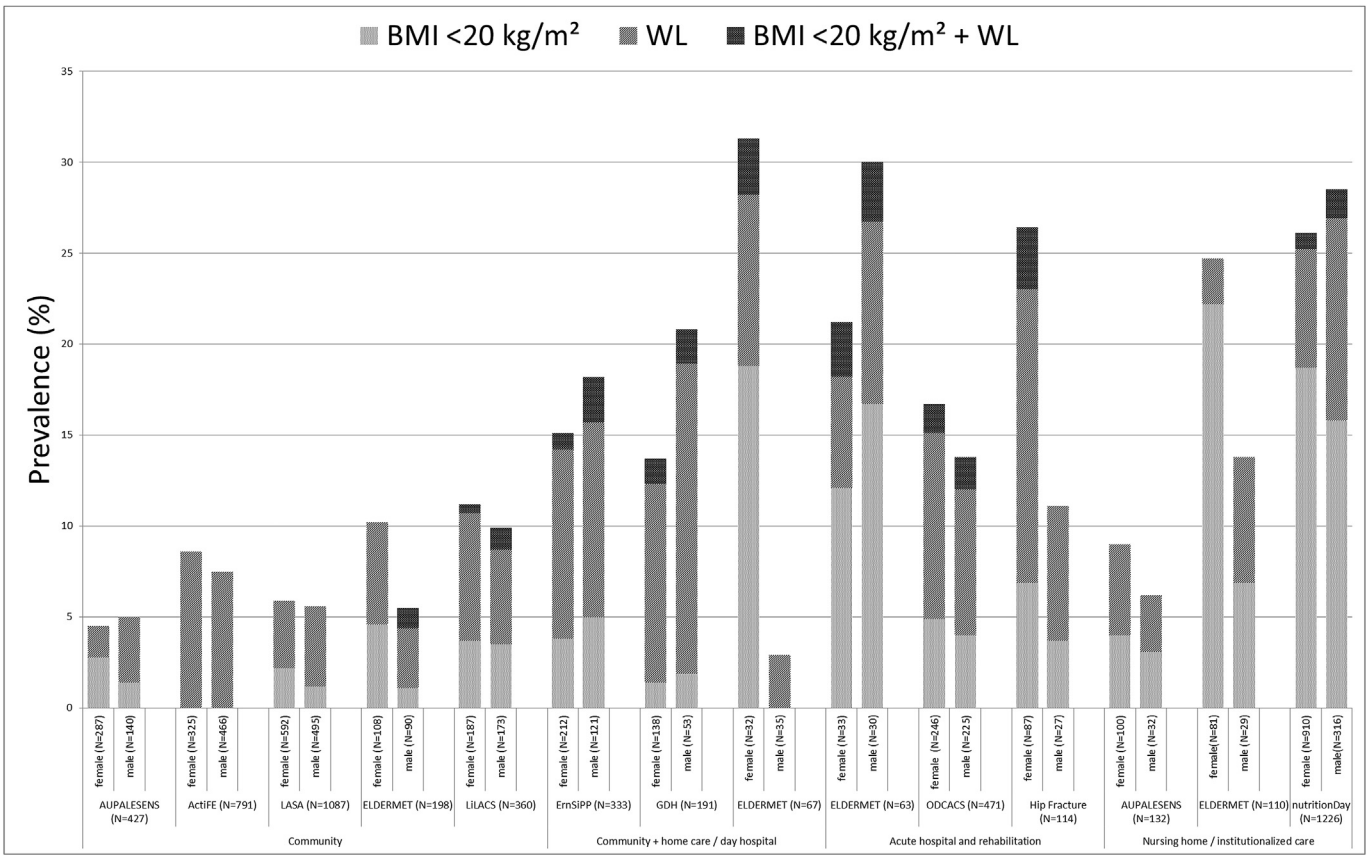

Fig. 2. Prevalences of malnutrition criteria based on low BMI, weight loss (WL) or both in older adults in different study samples and settings by sex.

international analyses reported prevalences of malnutrition risk based on only one single criterion applying the MNA [11,33].

The combined definition of low BMI and weight loss strongly reduced the prevalence of malnutrition in our study as for most study participants only one of the two criteria applied. A further slight reduction was observed if severe decrease in food intake was added to the definition. Accordingly, the highest prevalences were observed when only one of the criteria from the combined definitions had to be present. Adding 'or severe decrease in food intake' to the combined low BMI or weight loss criteria resulted in increases of prevalences by a factor of 1.1–1.3 in most settings showing that these additional participants only suffer from severe decrease in food intake which may have not yet resulted in weight loss or low BMI. Only in Hip Fracture patients prevalences more than doubled indicating that the disease had a strong effect on food intake in many patients.

A strong effect on prevalences was observed applying age-specific BMI cut-offs of <20 kg/m^2 if <70 years and <22 kg/m^2 if ≥70 years versus simply using <18.5 or <20 kg/m^2 as a standard cut-off: This even doubled the malnutrition prevalences in our samples. Rojer et al. [10] reported prevalences from different European studies of age-specific BMI in healthy older people of 13% and in geriatric outpatients of 21% which were similar or slightly higher than the respective prevalences observed in our older community-dwellers and in our hospital attenders. In contrast, much lower prevalences of 1% and 7%, respectively, were reported in the same samples applying the ESPEN definition [10]. One of the results of the latter study was a lower prevalence of unintended weight loss compared to low BMI in geriatric outpatients prompting the authors to suggest the investigation of the importance of the relative contribution of unintentional weight loss versus low BMI based on the new ESPEN consensus definition of malnutrition. Our study confirms that the combined use of BMI <20 kg/m^2 and weight loss results in a much lower prevalence of <1% in community-dwellers although we used absolute but not relative weight loss data. We do not know the true proportion of malnourished participants in our study, however, our results together with those of Rojer et al. may suggest that there could be at least a risk of underestimation when the ESPEN definition of malnutrition is applied. This assumption is supported by a) the observation of the opposite trend of low BMI and weight loss and b) the observation that in several studies a significant weight loss in the past 3–6 months was least prevalent in the oldest age group, the group with the highest prevalence of a low BMI.

With regard to the setting-specific differences, we observed a high heterogeneity in the prevalence depending on the respective criteria and characteristics of the study population. In general, there was a positive trend between age (and also functional status) and increase of the prevalence of low BMI. This positive trend cannot be confirmed for weight loss as LASA and ActiFE showed similar or even higher prevalences compared to studies with averagely older and more dependent participants. It becomes evident that studies with the lowest weight loss rates showed the highest prevalence of low age-specific BMI and vice-versa. In this regard, community-dwellers of AUPALESENS showed the lowest weight loss prevalence but the highest prevalence of low age-specific BMI among all community-based studies. Using exclusively the BMI criterion or a combination of a low BMI and weight loss does not identify older

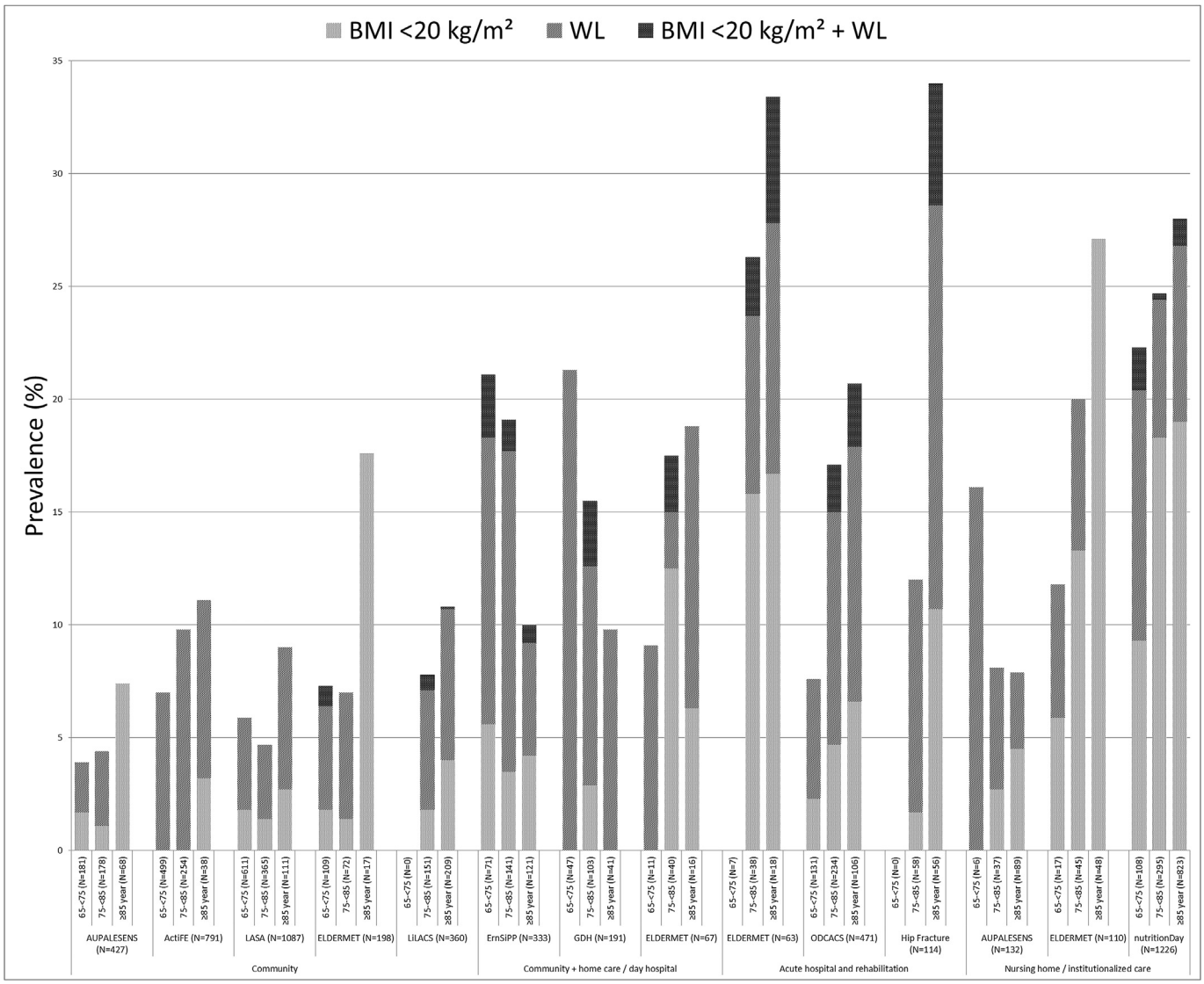

Fig. 3. Prevalences of malnutrition criteria based on low BMI, weight loss (WL) or both in older adults in different study samples and settings by age group.

adults (who had a higher former BMI) with a significant weight loss who are at risk of malnutrition.

Our study confirms other findings based on malnutrition risk assessment [12,34] indicating that residents in long term institutionalized care/nursing homes have high prevalences of low BMI except for the AUPALESENS study sample in which only those without severe cognitive impairment (MMSE≥20) were included. A comparison of Dutch, Austrian and German nursing home residents revealed that the prevalence of malnutrition differs according to sex, age and care dependency [35] as also indicated by our study.

The highest percentage of older adults with weight loss was noted in hospitals and rehabilitation units suggesting that the underlying disease of the patients may have been a cause for their weight loss. In one acute hospital study (Hip Fracture) the highest prevalence of almost 40% was observed for the combined definition of malnutrition including all participants with any of the three single criteria. Among the acute hospital/rehabilitation attenders, ODCACS participants had a lower prevalence of low BMI possibly due to the lower percentage of participants with reduced mobility and cognitive impairment compared to ELDERMET and Hip Fracture participants.

The sex-dependent differences observed in our analyses suggest that malnutrition among men may be underestimated by the BMI criterion: Based on the same definition of a low BMI for both sexes, men will be classified less often as malnourished as women. Also the criterion of a moderate decrease in food intake was less frequent among men than among women. However, given that a severe decrease in food intake was more prevalent in males than in females in five of the study samples across all settings, this may indicate a risk of underestimation when not considering this item. Furthermore, the higher prevalence of weight loss and of the combined low BMI and weight loss definition in men compared to women in half of the study samples indicates that taking into account BMI only can increase the risk of not being diagnosed as malnourished in men. Thus, in terms of weight loss and severe decrease in food intake men seem to be as vulnerable for malnutrition as women. In contrast, BMI may be less informative for assessing nutritional status in men as it is mostly higher in men than in women because of their physical build and higher muscle mass [36]. Thus, focusing on BMI or on moderate decrease in food intake men seem to be affected less often from malnutrition. Male community-dwellers, particularly when living alone, may have an

increased risk for malnutrition as the quality of their diet is often less nutritious compared to that of women [37,38].

Our study results which are based on age-dependent differences emphasize that older age is not automatically associated with any of the included malnutrition criteria but that further aspects as dependency or illness need to be considered. In half of the study samples, participants in a younger age group had a higher prevalence of weight loss compared to those of an older age group. Additionally, in five study samples the lowest prevalence of weight loss was observed in the oldest age group, indicating that pace of weight loss may decelerate with increasing age. This was seen in ErnSiPP and in the community-dwelling and institutionalized participants of AUPALESENS and ELDERMET. In the three community-dwelling samples of AUPALESENS, ELDERMET and ErnSiPP, a high proportion of participants of 22.1, 29.4 and 18.2%, respectively, had a low age-specific BMI and 12.8% of ELDERMET participants had a BMI <18.5 kg/m^2 in the highest age group. Among the institutionalized participants a high prevalence of low age-specific BMI (39.6%) was seen in the highest age group in ELDERMET. This might indicate that weight loss may have already occurred in younger age which is reflected by a low BMI in older age. Additionally, participants of AUPALESENS from all settings and community-dwelling participants of ELDERMET had mostly no or only mild cognitive impairment which may also have contributed to avoid weight loss in the highest age group as in other studies dementia may have occurred particularly in this group and may have increased the weight loss risk. Thus, weight loss may play a greater role in younger age groups. There is also no clear trend towards increasing rates from the lowest to the highest age group for the prevalence of moderate and severe decrease in food intake.

In order to enable a comparable standardized diagnosis, it is important to establish a definition based on relatively easily measurable criteria such as BMI, weight loss and decrease in food intake. We applied these factors and their combinations as the BMI and weight loss had proven to be among the most predictive and widely recommended items for malnutrition diagnosis [34]. A decrease in food intake often occurs as a result of loss of appetite or of eating dependency both of which have been revealed to be relevant predictors of malnutrition [39].

As our results show, prevalences vary widely between the different criteria and in some categories there are even conflicting trends such as for low BMI and weight loss among community-dwellers. These variations probably resulted from the different functional status of the included participants in the studies as cognitive impairment, mobility limitations and dependencies may contribute to the development of malnutrition (Table 1). Great proportions of participants with severe cognitive impairment were included in ErnSiPP, ELDERMET rehabilitation and institutions, and nutritionDay. Further, a high proportion of participants were bed- or chair-bound in Hip Fracture and nutritionDay as well as in ELDERMET institutions. Participants of these study samples, i.e. with high proportions of cognitive impairment and/or mobility limitations also showed comparatively high prevalences of malnutrition. Sex-specific differences are evident in our results and should be considered by physicians, nutritionist, nursing staff and staff from other disciplines entrusted with health and nutrition care for older people.

4.1. Limitations and strengths

As we included only cross-sectional data from longitudinal surveys in our analyses, weight loss was not measured but reported by the participants or institutional staff. We were unable to use the relative weight loss data as percentage which may have been more informative as weight loss was assessed via MNA categories in kg in most of the included studies. Also, decrease in food intake was not measured but taken from the MNA and was self-reported either by participants or proxies. The reported prevalences were gathered from longitudinal and cross-sectional studies with respective study aim, hence these estimations are limited by selection bias. For example, some studies excluded participants with severe cognitive impairment which is a known predictor for malnutrition [40]. An important strength of our study is that for the first time we applied several easily measurable harmonized criteria for the diagnosis of malnutrition risk in multinational study samples from different settings, including a total of around 6000 older adults. We also used fixed strata according to e.g. age to investigate whether prevalences differed between these strata.

4.2. Conclusion

Applying harmonized definitions for malnutrition revealed that the prevalences vary considerably between and even within the settings which might be explained by differences in age and functional status of included participants in the studies. Prevalences double when using an age-specific BMI versus a BMI <20 kg/m^2 as a standard cut-off. The criteria age-specific BMI and weight loss showed opposing prevalences across all settings. Because of their physical build, men may not be classified as malnourished based on the BMI alone. Therefore, weight loss or severe decrease in food intake may be considered in a malnutrition definition. However, these latter two criteria may play a greater role in younger than in higher age groups. Our results confirm that prevalences increase from community-dwellers to residents of nursing homes. It should be noted that the criteria used strongly affect prevalence and it may be preferable to look at each criterion separately as each may indicate a nutritional problem.

Funding

The preparation of this paper was supported by the MalNutrition in the ELderly (MaNuEL) knowledge hub. This work is supported by the Joint Programming Initiative ‘A Healthy Diet for a Healthy Life’. The funding agencies supporting this work are (in alphabetical order of participating Member State): France: Agence Nationale de la Recherche (ANR); Germany: German Federal Ministry of Food and Agriculture (BMEL) through the Federal Office for Agriculture and Food (BLE), grant number 2815ERA09E; Ireland: Department of Agriculture, Food and the Marine (DAFM), and the Health Research Board (HRB); Spain: Instituto de Salud Carlos III, and the SENATOR trial (FP7-HEALTH-2012-305930); The Netherlands: The Netherlands Organisation for Health Research and Development (ZonMw).

Conflict of interest

None declared.

Acknowledgements

We would like to thank all associates and collaborators from the underlying studies of this work. We gratefully acknowledge the support of Josephine Kanbach and Christina Princk in reference administration, data aggregation and data presentation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnu.2018.10.020.

References

[1] Abizanda P, Sinclair A, Barcons N, Lizan L, Rodriguez-Manas L. Costs of malnutrition in institutionalized and community-dwelling older adults: a systematic review. J Am Med Dir Assoc 2016;17(1):17–23.

[2] Martinez-Reig M, Aranda-Reneo I, Pena-Longobardo LM, Oliva-Moreno J, Barcons-Vilardell N, Hoogendijk EO, et al. Use of health resources and healthcare costs associated with nutritional risk: the FRADEA study. Clin Nutr 2018;37(4):1299–305.

[3] Sullivan DH, Walls RC. Protein-energy undernutrition and the risk of mortality within six years of hospital discharge. J Am Coll Nutr 1998;17(6):571–8.

[4] McMinn J, Steel C, Bowman A. Investigation and management of unintentional weight loss in older adults. BMJ (Clin Res Ed) 2011;342:d1732.

[5] Artaza-Artabe I, Saez-Lopez P, Sanchez-Hernandez N, Fernandez-Gutierrez N, Malafarina V. The relationship between nutrition and frailty: effects of protein intake, nutritional supplementation, vitamin D and exercise on muscle metabolism in the elderly. A systematic review. Maturitas 2016;93:89–99.

[6] Volkert D. The role of nutrition in the prevention of sarcopenia. Wiener medizinische Wochenschrift (1946) 2011;161(17–18):409–15.

[7] Rolland Y, Dupuy C, Abellan van Kan G, Gillette S, Vellas B. Treatment strategies for sarcopenia and frailty. Med Clin North Am 2011;95(3):427–38. ix.

[8] Kiesswetter E, Pohlhausen S, Uhlig K, Diekmann R, Lesser S, Uter W, et al. Prognostic differences of the Mini Nutritional Assessment short form and long form in relation to 1-year functional decline and mortality in community-dwelling older adults receiving home care. J Am Geriatr Soc 2014;62(3):512–7.

[9] Boulos C, Salameh P, Barberger-Gateau P. Malnutrition and frailty in community dwelling older adults living in a rural setting. Clin Nutr (Edinburgh, Scotland) 2016;35(1):138–43.

[10] Rojer AG, Kruizenga HM, Trappenburg MC, Reijnierse EM, Sipilä S, Narici MV, et al. The prevalence of malnutrition according to the new ESPEN definition in four diverse populations. Clin Nutr (Edinburgh, Scotland) 2016;35(3):758–62.

[11] Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Frequency of malnutrition in older adults: a multinational perspective using the mini nutritional assessment. J Am Geriatr Soc 2010;58(9):1734–8.

[12] van Zwienen-Pot JI, Visser M, Kuijpers M, Grimmerink MFA, Kruizenga HM. Undernutrition in nursing home rehabilitation patients. Clin Nutr (Edinburgh, Scotland) 2017;36(3):755–9.

[13] Sanchez-Rodriguez D, Marco E, Ronquillo-Moreno N, Maciel-Bravo L, Gonzales-Carhuancho A, Duran X, et al. ASPEN-AND-ESPEN: a post-acute-care comparison of the basic definition of malnutrition from the American Society of Parenteral and Enteral Nutrition and Academy of Nutrition and Dietetics with the European Society for Clinical Nutrition and Metabolism definition. Clin Nutr 2019 Feb;38(1):297–302. https://doi.org/10.1016/j.clnu.2018.01.017.

[14] Cederholm T, Bosaeus I, Barazzoni R, Bauer J, van Gossum A, Klek S, et al. Diagnostic criteria for malnutrition - An ESPEN consensus statement. Clin Nutr (Edinburgh, Scotland) 2015;34(3):335–40.

[15] Dehesa-Lopez E, Martinez-Felix JI, Ruiz-Ramos A, Atilano-Carsi X. Discordance between bioelectrical impedance vector analysis and the new ESPEN definition of malnutrition for the diagnosis of hospital malnutrition. Clin Nutr ESPEN 2017;18:44–8.

[16] Visser M, Volkert D, Corish C, Geisler C, De Groot LC, Cruz-Jenthoft AJ, et al. Tackling the increasing problem of malnutrition in older persons: the malnutrition in the elderly (MaNuEL) knowledge hub. Nutr Bull 2017;42(2):178–86.

[17] Pohlhausen S, Uhlig K, Kiesswetter E, Diekmann R, Heseker H, Volkert D, et al. Energy and protein intake, anthropometrics, and disease burden in elderly home-care receivers–a cross-sectional study in Germany (ErnSIPP study). J Nutr Health Aging 2016;20(3):361–8.

[18] Valentini L, Schindler K, Schlaffer R, Bucher H, Mouhieddine M, Steininger K, et al. The first nutrition day in nursing homes: participation may improve malnutrition awareness. Clin Nutr (Edinburgh, Scotland) 2009;28(2):109–16.

[19] Kearney PM, Harrington JM, Mc Carthy VJ, Fitzgerald AP, Perry IJ. Cohort profile: the Cork and Kerry Diabetes and Heart disease study. Int J Epidemiol 2013;42(5):1253–62.

[20] Schrader E, Grosch E, Bertsch T, Sieber CC, Volkert D. Nutritional and functional status in geriatric day hospital patients – MNA short form versus full MNA. J Nutr Health Aging 2016;20(9):918–26.

[21] Maitre I, Van Wymelbeke V, Amand M, Vigneau E, Issanchou S, Sulmont-Rossé C. Food pickiness in the elderly: relationship with dependency and malnutrition. Food Qual Prefer 2014;32(Part B):145–51.

[22] Hoogendijk EO, Deeg DJ, Poppelaars J, van der Horst M, Broese van Groenou MI, Comijs HC, et al. The longitudinal aging study Amsterdam: cohort update 2016 and major findings. Eur J Epidemiol 2016;31(9):927–45.

[23] Denkinger MD, Franke S, Rapp K, Weinmayr G, Duran-Tauleria E, Nikolaus T, et al. Accelerometer-based physical activity in a large observational cohort–study protocol and design of the activity and function of the elderly in Ulm (ActiFE Ulm) study. BMC geriatrics 2010;10:50.

[24] Goisser S, Schrader E, Singler K, Bertsch T, Gefeller O, Biber R, et al. Malnutrition according to mini nutritional assessment is associated with severe functional impairment in geriatric patients before and up to 6 months after hip fracture. J Am Med Dir Assoc 2015;16(8):661–7.

[25] O'Shea E, Trawley S, Manning E, Barrett A, Browne V, Timmons S. Malnutrition in hospitalised older adults: a multicentre observational study of prevalence, associations and outcomes. J Nutr Health Aging 2017;21(7):830–6.

[26] Kerse N, Teh R, Moyes SA, Broad J, Rolleston A, Gott M, et al. Cohort profile: Te Puawaitanga o Nga Tapuwae Kia Ora Tonu, life and living in advanced age: a cohort study in New Zealand (LiLACS NZ). Int J Epidemiol 2015;44(6):1823–32.

[27] Claesson MJ, Jeffery IB, Conde S, Power SE, O'Conner EM, Cusack S, et al. Gut microbiota composition correlates with diet and health in the elderly. Nature 2012;488(7410):178–84.

[28] Jeffery IB, Lynch DB, O'Toole PW. Composition and temporal stability of the gut microbiota in older persons. ISME J 2016;10(1):170–82.

[29] Vellas B, Villars H, Abellan G, Soto ME, Rolland Y, Guigoz Y, et al. Overview of the MNA–Its history and challenges. J Nutr Health Aging 2006;10(6):456–63. discussion 463–455.

[30] Cereda E. Mini nutritional assessment. Curr Opin Clin Nutr Metab Care 2012;15(1):29–41.

[31] Guigoz Y, Vellas B, Garry PJ. Mini Nutritional Assessment (a practical assessment tool for grading the nutritional state of elderly patients). Facts Res Gerontol 1994;4(2):15–59.

[32] Kaiser R, Winning K, Uter W, Lesser S, Stehle P, Sieberer CC, et al. Comparison of two different approaches for the application of the mini nutritional assessment in nursing homes: resident interviews versus assessment by nursing staff. J Nutr Health Aging 2009;13(10):863–9.

[33] Cereda E, Pedrolli C, Klersy C, Bonardi C, Quarleri L, Capello S, et al. Nutritional status in older persons according to healthcare setting: a systematic review and meta-analysis of prevalence data using MNA((R)). Clin Nutr (Edinburgh, Scotland) 2016;35(6):1282–90.

[34] Serrano-Urrea R, Garcia-Meseguer MJ. Malnutrition in an elderly population without cognitive impairment living in nursing homes in Spain: study of prevalence using the Mini Nutritional Assessment test. Gerontology 2013;59(6):490–8.

[35] van Nie-Visser NC, Meijers J, Schols J, Lohrmann C, Bartholomeyczik S, Spreeuwenberg M, et al. Which characteristics of nursing home residents influence differences in malnutrition prevalence? An international comparison of The Netherlands, Germany and Austria. Br J Nutr 2014;111(6):1129–36.

[36] Rothman KJ. BMI-related errors in the measurement of obesity. Int J Obes (Lond) 2008;32(Suppl. 3):S56–9.

[37] Santos DM, Rodrigues SS, de Oliveira BM, Vaz de Almeida MD. Diet quality in elderly Portuguese households. J Nutr Health Aging 2014;18(3):243–50.

[38] Smee D, Pumpa K, Falchi M, Lithander FE. The relationship between diet quality and falls risk, physical function and body composition in older adults. J Nutr Health Aging 2015;19(10):1037–42.

[39] Favaro-Moreira NC, Krausch-Hofmann S, Matthys C, Vereecken C, Vanhauwaert E, Declercq A, et al. Risk factors for malnutrition in older adults: a systematic review of the literature based on longitudinal data. Adv Nutr (Bethesda, Md) 2016;7(3):507–22.

[40] Volkert D, Chourdakis M, Faxen-Irving G, Frühwald T, Landi F, Suominen MH, et al. ESPEN guidelines on nutrition in dementia. Clin Nutr (Edinburgh, Scotland) 2015;34(6):1052–73.