Prevalence of malnutrition using harmonized definitions in older adults from different settings - A MaNuEL Study

Maike Wolters, Dorothee Volkert, Melanie Streicher, Eva Kiesswetter, Gabriel Torbahn, Eibhlis M. O'Connor, Mary O'Keeffe, Mary Kelly, Eileen O'Herlihy, Paul W. O'Toole, Suzanne Timmons, Emma O'Shea, Patricia Kearney, Judith van Zwienen-Pot, Marjolein Visser, Isabelle Maitre, Virginie Van Wymelbeke, Claire Sulmont-Rossé, Gabriele Nagel, Marion Flechtner-Mors, Sabine Goisser, Ruth Teh, Antje Hebestreit, on behalf of the MaNuEL consortium

1 **Prevalence of malnutrition using harmonized definitions in older adults from different settings**

2 **– a MaNuEL Study**

3

4 Maike Wolters[1*], Dorothee Volkert[2], Melanie Streicher[2], Eva Kiesswetter[2], Gabriel Torbahn[2], Eibhlís M.

5 O'Connor[3], Mary O'Keeffe[3], Mary Kelly[3], Eileen O'Herlihy[4], Paul W. O'Toole[4], Suzanne Timmons[5],

6 Emma O'Shea[5], Patricia Kearney[6], Judith van Zwienen-Pot[7], Marjolein Visser[8], Isabelle Maitre[9],

7 Virginie Van Wymelbeke[10,11], Claire Sulmont-Rossé[11], Gabriele Nagel[12], Marion Flechtner-Mors[13],

8 Sabine Goisser[2,14], Ruth Teh[15], Antje Hebestreit[1], on behalf of the MaNuEL consortium

9

10 [1] Leibniz Institute for Prevention Research and Epidemiology – BIPS, Achterstr. 30, 28359 Bremen,

11 Germany

12 [2] Institute for Biomedicine of Aging, Friedrich-Alexander-Universität Erlangen-Nürnberg, Kobergerstr.

13 60, 90408 Nuremberg, Germany

14 [3] Dept Biological Sciences, and Health Research Institute, University of Limerick, V94 T9PX Limerick,

15 Ireland

16 [4] School of Microbiology and APC Microbiome Ireland, University College Cork, Cork, Ireland T12

17 Y337

18 [5] Centre for Gerontology and Rehabilitation, School of Medicine, University College Cork, Cork, Ireland

19 [6] Dept Epidemiology and Public Health, University College Cork, Cork, Ireland

20 [7] Department of Internal Medicine, Nutrition and Dietetics, VU University Medical Center, Amsterdam,

21 de Boelelaan 1117, 1081 HV Amsterdam, The Netherlands

22 [8] Department of Health Sciences, Faculty Sciences, Vrije Universiteit Amsterdam, Amsterdam Public

23 Health research institute, Amsterdam, The Netherlands

24 [9] USC 1422 GRAPPE, Ecole Supérieure d'Agricultures (ESA), SFR 4207 QUASAV, INRA, 55 rue

25 Rabelais, F-49007 Angers, France

26 [10] Centre Hospitalier Universitaire Dijon Bourgogne, Centre Champmaillot, Unité de Recherche Pôle

27 Personnes Âgées, 2 rue Jules Violle, F-21000 Dijon, France

28 [11] Centre des Sciences du Goût et de l'Alimentation, AgroSup Dijon, CNRS, INRA, Université

29 Bourgogne Franche-Comté, 9[E] Boulevard Jeanne d'Arc, F-21000 Dijon, France

30 [12] Institute of Epidemiology and Medical Biometry, Ulm University, Helmholtzstr. 22, 89081 Ulm,

31 Germany

32   [13] Medical Center, Division of Sports and Rehabilitation Medicine, University of Ulm, Leimgrubenweg

33   14, 89075 Ulm, Germany

34   [14] Network Aging Research, Heidelberg University, Bergheimer Straße 20, 69115 Heidelberg,

35   Germany

36   [15] General Practice and Primary Health Care, School of Population Health, University of Auckland,

37   Private Bag 92019, Auckland Mail Centre, Auckland 1142, New Zealand

38

39

40   Abbreviations: ActiFE, Activity and Function in the Elderly Ulm study; BMI, body mass index; CVD,

41   cardiovascular disease; ErnSiPP, Ernährungssituation von Seniorinnen und Senioren mit Pflegebedarf

42   in Privathaushalten (Nutritional situation of seniors with need of care in private households); ESPEN,

43   European Society for Clinical Nutrition and Metabolism; FFMI, fat-free mass index; GDH, Geriatric Day

44   Hospital; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; JPI, Joint

45   Programming Initiative; LASA, Longitudinal Aging Study Amsterdam; LiLACS NZ, Life and Living in

46   Advanced Age: a cohort study in New Zealand; MaNuEL, Malnutrition in the Elderly (JPI knowledge

47   hub title); MMSE, Mini-Mental State Examination; MNA, Mini Nutritional Assessment; MNA-SF, Mini

48   Nutritional Assessment Short Form; NEADL, Nottingham Extended Activities of Daily Living;

49   ODCACS, Optimal Dementia Care in Acute Care settings; SMMSE, standardized Mini-Mental State

50   Examination; SCREENII, 'Seniors in the Community: Risk Evaluation for Eating and Nutrition' Version

51   II; WL, weight loss.

52

Abstract

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 of combined BMI <20 kg/m^2 and/or WL in participants aged ≥65 years.

Results: Fifteen samples with in total 5,956 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-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.

Key words: malnutrition, older adults, prevalence, older people, elderly

85 **Introduction**

86 Malnutrition is widespread among older populations and a known risk factor for severe health and

87 functional problems and associated with increased health care costs [1,2]. As numerous studies in older

88 people have shown, malnutrition is associated with a higher risk for morbidity (e.g. infections, pressure

89 ulcers, and hospital readmissions) and mortality [3,4]. Additionally, protein-energy malnutrition is

90 associated with functional impairment that initiates a sequence of negative consequences. These

91 range from a decline in muscle mass and strength, to sarcopenia and frailty at the expense of mobility

92 and independence, which may further aggravate nutritional problems [5-9].

93 Reported malnutrition prevalence varies widely between different populations. Malnutrition is generally

94 associated with decreased health and functional status as well as increased dependency and

95 disability. While less than 10% of independently living older persons in the community are affected, the

96 prevalence among nursing home residents, geriatric patients in hospitals and in geriatric rehabilitation

97 is increasing to 50% and more [10-13]. However, the reported prevalences vary not only due to

98 differences in study populations but also depend on which definition was used to evaluate malnutrition.

99 In a consensus statement of the European Society for Clinical Nutrition and Metabolism (ESPEN),

100 diagnostic criteria for malnutrition were suggested based on body mass index (BMI), or combined

101 determination of unintentional weight loss together with a reduced age-specific BMI or a low fat-free

102 mass index (FFMI) using sex-specific cut-offs [14]. However, the use of these diagnostic criteria in

103 practice has revealed limitations because 20% of different populations showing both a low BMI and

104 low FFMI were not classified as malnourished as they had not reported unintentional weight loss and

105 also diagnostic concordance of the ESPEN criteria with bioelectrical impedance vector analysis was

106 poor [10,15].

107 Thus, a harmonized malnutrition definition is required to provide more accuracy to reliably comparing

108 prevalences between studies, which was one of the primary objectives of the Joint Programming

109 Initiative (JPI) Malnutrition in the Elderly (MaNuEL) Knowledge Hub. The establishment of the

110 MaNuEL Knowledge Hub, 2016-2018, initiated by the 'Healthy Diet for a Healthy Life' European Joint

111 Programming Initiative comprised a consortium of 22 research groups from 7 countries (Austria,

112 France, Germany, Ireland, Spain, The Netherlands and New Zealand) [16].

113 The present work provides prevalences according to several harmonized malnutrition criteria in older

114 adults from the age of 65 years. Our study describes and compares the prevalences according to

115 (combinations of) low BMI, previous weight loss and reduced food intake in several large samples of

116 older persons in different settings across Europe and New Zealand. By using single criteria as well as

117 different combinations of the three criteria, our study is able to identify differences between the applied

118 definitions. Another reason to use these malnutrition definitions was that the assessment is easily

119 possible in various settings in order to enable a wide use of the diagnostic criteria of malnutrition.

120

121 **Materials and Methods**

122 *Study design and included studies*

123 The present study comprises secondary data analyses from 11 national and cross-country European

124 studies (Austria, Belgium, Czech, France, Germany, Italy, Ireland, The Netherlands, Poland,

125 Switzerland) and from New Zealand (for comparability with the other studies only the non-Māori

126 population was included). Prevalences of malnutrition were calculated by the respective local data

127 analysts represented in the MaNuEL consortium. Five cross-sectional studies [17-21] and six longitudinal

128 studies [22-27] providing data for cross-sectional analyses were included.

129 Data collection for our analysis samples was performed between 2008 and 2016. The number of

130 included participants per study in our analysis ranged from 114 to 1226. Participants were recruited

131 from different settings: Community-dwelling [22,23,26], community-dwelling with home care [17], community

132 including day hospital [27,28] or nursing home [21], one primary care center [19], only nursing homes [18] and

133 long term institutionalized care hospitals [27,28], one geriatric day hospital [20] and acute hospitals [24,25].

134 The following studies were included: The **Longitudinal Aging Study Amsterdam (LASA)**

135 investigates the impact of selected determinants on measures of physical, cognitive, emotional and

136 social functioning in a representative sample of Dutch persons aged 55 years and above [22]. The

137 **Activity and Function in the Elderly Ulm study** (**ActiFE**) investigated associations between

138 objectively measured physical activity and particular health-related endpoints, such as disability, falls

139 and cognitive function [23]. The **Cork and Kerry Diabetes and Heart Disease Study** was a large

140 population-based observational study. The cohort study aimed to investigate the prevalence of key risk

141 factors for cardiovascular disease (CVD) in middle-aged people (50-69 years in 1998) in Ireland [19].

142 The **Life and Living in Advanced Age: a cohort study in New Zealand (LiLACS NZ)** investigated

143 the health, social, cultural and environmental status of octogenarians (indigenous Māori and non-Māori

144 population) in order to identify predictors of successful ageing [26]. In the cross-sectional study,

145 **Geriatric Day Hospital (GDH)** in Germany, the prevalence of malnutrition was assessed using the

146 Mini Nutritional Assessment Short Form (MNA-SF) and the complete MNA, and the relationship

147 between nutritional and functional status was determined [20]. The **ErnSiPP** (*Ernährungssituation von*

148 *Seniorinnen und Senioren mit Pflegebedarf in Privathaushalten*, Nutritional situation of seniors with

149 need of care in private households) project was aimed at describing the nutritional and health situation

150 of community-dwelling older adults receiving home care in Germany [17]. The **ELDERMET** study was

151 conducted in Ireland and investigated longitudinal associations between faecal microbiota

152 composition, data on food consumption frequency and markers of frailty, co-morbidity and nutritional

153 status in 178 older people [27,28]. In order to combat malnutrition and increase appetite, the French

154 project **AUPALESENS** (for improving pleasure of elderly people for better aging and for fighting

155 against malnutrition) has tested the effectiveness of strategies regarding sensory perception [21]. The

156 **Optimal Dementia Care in Acute Care settings (ODCACS)** project aimed at investigating the

157 prevalence of dementia among older people admitted to acute hospitals in Cork, Ireland [25]. A

158 longitudinal study (2011/2012) in Germany (**Hip Fracture**) investigated the association between

159 nutritional status and the functional and clinical course up to 6 months after discharge from hospital in

160 geriatric patients with hip fracture [24]. Data from European countries were included from the

161 **nutritionDay in nursing homes** which is an international 1-day cross-sectional study to increase

162 awareness of malnutrition [18]. While most studies were restricted to one setting (or reported only the

163 data of the predominant setting), AUPALESENS [21] and ELDERMET [27] involved older people from

164 different settings. Table 1 provides an overview of the studies included indicating the year(s) of data

165 collection, the setting(s) as well as the number and main characteristics (age, sex, cognitive

166 impairment, mobility limitations, and dependence in activities of daily living) of the participants included

167 in our analyses.

168 Written informed consent from the participants and ethical approval from the local competent

169 Institutional Review Boards were obtained prior to the start of each study.

170 *Inclusion and exclusion criteria*

171 Participants aged 65 years and over were included in the analyses. Individuals with missing data on

172 age, sex or BMI were excluded. Participants with self-reported height and/or weight were also

173 excluded if this information was available while participants with measurement by qualified personnel

174 such as nurses, care facility staff or physicians and those with height estimated from knee height or

175 arm length were included. For the latter, the percentage of participants with estimated values was

176 indicated. In studies with previous weight loss assessment, participants with missing weight loss data

177 were excluded.

178 *Definition criteria for malnutrition*

179 Each study reported the prevalence of BMI <18.5, <20 and <22 kg/m^2 as well as age-specific

180 prevalence for BMI <20 kg/m^2 in participants aged ≥65 to <70 years and BMI <22 kg/m^2 in participants

181 ≥70 years. These different BMI cut-offs were applied as they refer to or are part of common definitions

182 of malnutrition, e.g. according to the WHO (<18.5) and current ESPEN consensus definition [14].

183 Additionally, if available, prevalence of previous weight loss (>3 kg in the past 3 months), prevalence

184 of moderate decrease in food intake and prevalence of severe decrease in food intake in the past 3

185 months as reported in the Mini Nutritional Assessment (MNA) [29-32] were calculated in all studies.

186 Information collected with the MNA was self-reported either by participants or proxies. If other weight

187 loss definitions were used, these data were reported instead (>5 kg in the past 6 months). Some

188 studies (LASA, ErnSiPP and GDH) also assessed whether weight loss was intended. Here we restrict

189 weight loss prevalence in these studies to participants with unintended weight loss and report number

190 of participants with intended weight loss in the footnote of the respective tables.

191 In order to gain insight into the prevalence of different combinations, low BMI defined as <20 kg/m^2,

192 weight loss (as described above) and severe (not moderate) decrease in food intake were combined

193 and the prevalence of each of these combinations were calculated as follows: a) low BMI and weight

194 loss, b) low BMI and weight loss and severe decrease in food intake, c) low BMI or weight loss, d) low

195 BMI or weight loss or severe decrease in food intake.

196 *Data analyses and presentation of results*

197 The local data analysts prepared the dataset according to the provided study protocol and calculated

198 the number and percentage of participants fulfilling the different malnutrition criteria. The prevalences

199 (%) of the harmonized criteria for malnutrition are presented stratified by study sample and by setting,

200 and additionally stratified by setting and sex and by setting and age group.

201

202 **Results**

203 In total 5,956 participants (59.3% women) from 11 studies were included. The mean age of

204 participants ranged between 67 and 87 years. The results cover 3,507 community-dwelling older

205 adults (including primary care and day hospitals), 333 home care receivers, 648 hospitalized

206 individuals including rehabilitation and 1,468 residents of nursing home or institutionalized care

207 homes. The LASA and nutritionDay studies were the largest studies in their respective setting.

208 Participants of Cork and Kerry, ActiFE and LASA were the youngest with a mean age below 75 years.

209 The average age of participants in all other studies was over 75 years of age, with nutritionDay,

210 LiLACS NZ and Hip Fracture including the oldest participants (Table 1). ActiFE participants were in

211 relatively good physical condition as they had no mobility limitations or dependencies. Nursing home

212 residents (nutritionDay, ELDERMET) and home care receivers (ErnSiPP) exhibited the most often

213 severe cognitive impairment and mobility limitations were most frequent among long-term

214 institutionalized care home residents of the ELDERMET study and among Hip Fracture participants.

215 Figure 1 and Supplementary Table 1 present the prevalences of the harmonized **malnutrition criteria**

216 **by setting**. In terms of low BMI, the prevalences were lowest among community-dwellers including

217 those recruited in a primary care center and day care hospital. In contrast, the highest prevalences

218 were observed in nursing homes and long-term institutionalized care homes (with the exception of

219 AUPALESENS). Older people in the home care setting had similar prevalences of low BMI as older

220 people in acute hospitals and rehabilitation. The prevalences of the weight loss criterion varied across

221 all settings without a marked trend showing the highest prevalences in an acute hospital study (Hip

222 Fracture), one day hospital study (GDH) and in home-care receivers (ErnSiPP). With few exceptions,

223 the highest prevalences of the criterion *severe decrease in food intake* were recorded in the hospitals.

224 Prevalence of severe decrease in food intake was much lower than that of moderate decrease in food

225 intake (by a mean factor of 7, range 1.5-29).

226 When the combined criteria were applied, i.e. a BMI <20 kg/m^2 and weight loss (and severe decrease

227 in food intake) being present at the same time, prevalences did not exceed 2.6% in any of the studies

228 or settings. The highest prevalences were found when participants with at least one of the criteria were

229 included. For example, the highest prevalences were observed in nursing homes (>20%) and in one

230 acute hospital (39.5% in Hip Fracture).

231 Figure 2 and Supplementary Table 2 show the prevalences of the harmonized malnutrition criteria **by**

232 **setting and sex**. Women were more likely to be categorized as malnourished in terms of a low BMI

233 compared to men as 12 of 15 studies showed a higher prevalence of a low age-specific BMI in

234 women. In contrast, half of the studies showed prevalences of weight loss higher in men than in

235 women. Accordingly, compared to BMI <20 kg/m^2 the combination of low BMI or weight loss increased

236 the prevalences in men to the double or more. While a severe decrease in men's food intake was

237 more prevalent in five study samples across all settings compared to eight studies in women, a higher

238 prevalence of a moderate decrease in men's food intake was only seen in a single study (Hip

239 Fracture).

240   Figure 3 and Supplementary Table 3 provide an overview of the prevalences of the harmonized

241   malnutrition criteria **by setting and age group**. Prevalences varied within the same age groups

242   across different samples of the same setting. In terms of a low BMI, we observed a trend of increased

243   prevalences with increasing age, e.g. the prevalence of age-specific BMI from the lowest to the

244   highest age group increased by a factor of 2 to 6 in most studies. A BMI <22 kg/m^2 was particularly

245   common among those in the highest age groups with about a quarter of the participants in community-

246   dwellers of ELDERMET and AUPALESENS, as well as hospital and rehabilitation attenders of Hip

247   Fracture and ELDERMET. Among the nursing home residents 31.8% and 39.6% of the participants of

248   nutritionDay and ELDERMET, respectively, had a BMI <22 kg/m^2. Applying the combined definitions

249   showed that adding severe decrease in food intake to the combination of low BMI or weight loss does

250   not strongly increase prevalences except for Hip Fracture hospital patients.

251

252 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 Nether-lands	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	Ger-many	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	Community	New	360, only	187	65-<75: none	6.9	5.3[1]	Not available	26.8 (4.00)	>5 kg in the past

(2010)		Zealand	non-Māori	(51.9)	75-<85: 41.9 ≥85: 58.1 All: 84.6 (0.58)	Don't know: 0.5 MMSE ≤23	NEADL			6 months, SCREENII
Cork and Kerry (Mitchels-town 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[2]	28.6 (4.54)	Not available
GDH (2012)	Geriatric Day Hospital	Ger-many	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[3]	28.9 (5.6)	>3 kg in the past 3 months, MNA, intended WL: N=3
ErnSiPP (2010)	Community with home care	Ger-many	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,	Bed or chair bound: 14.4 Homebound: 18.0 Missing: 0	94.6[3]	28.1 (6.16)	>3 kg in the past 3 months, MNA, intended WL: N=6

						0-16= severe	MNA			
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[3]	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	Bed or chair bound: 4.7 Homebound: 15.6 Missing: 0 MNA	48.3[4]	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	Severe: 0 Only participants	Bed or chair bound: 2.1	32.3[4]	27.7 (4.95)	>3 kg in the past 3 months, MNA,

					75-<85: 41.7 ≥85: 15.9 All: 76.7 (7.20)	with MMSE ≥20 included	Homebound: 7.0 Missing: 0 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	Bed or chair bound: 12.9 Homebound: 43.2 Missing: 0 MNA	100[4]	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[3]	28.1 (5.22)	>3 kg in the past 3 months, MNA, intended WL: unknown
Hip Fracture (2011-2012)	Geriatric patients with hip	Germany	114	87 (76.3)	65-<75: 0 75-<85: 50.9	Moderate: 26.3 Severe: 10.5	Bed or chair bound: 92.1 Homebound: 7.9	100[3]	26.5 (4.70)	>3 kg in the past 3 months, MNA,

	fracture				≥85: 79.1 All: 84.1 (5.40)	Missing: 25.4 MMSE 17-24= moderate, 0-16= severe	Missing: 0 MNA			intended WL: unknown
nutritionDay (2016)	Nursing home	Austria, Belgium, Switzer-land, Czech Repub-lic, Ger-many, 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[5]	24.9 (5.33)	>3 kg in the past 3 months, MNA, intended WL: unknown

253   [1] 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

254   roads? f. Do you travel on public transport? – based on NEADL questions on mobility

255   [2] 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

256   [3] Dependent in at least one activity of daily living (Barthel Index)

257   [4] People need help for meal or get prepared meal at least once per week for community and help for all meals for nursing home

258   [5] Require at least 45 min of basic care every day

259   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;

260   wo diff, items without difficulties; SMMSE standardized Mini-Mental State Examination, SCREENII, 'Seniors in the Community: Risk Evaluation for Eating and Nutrition' Version II
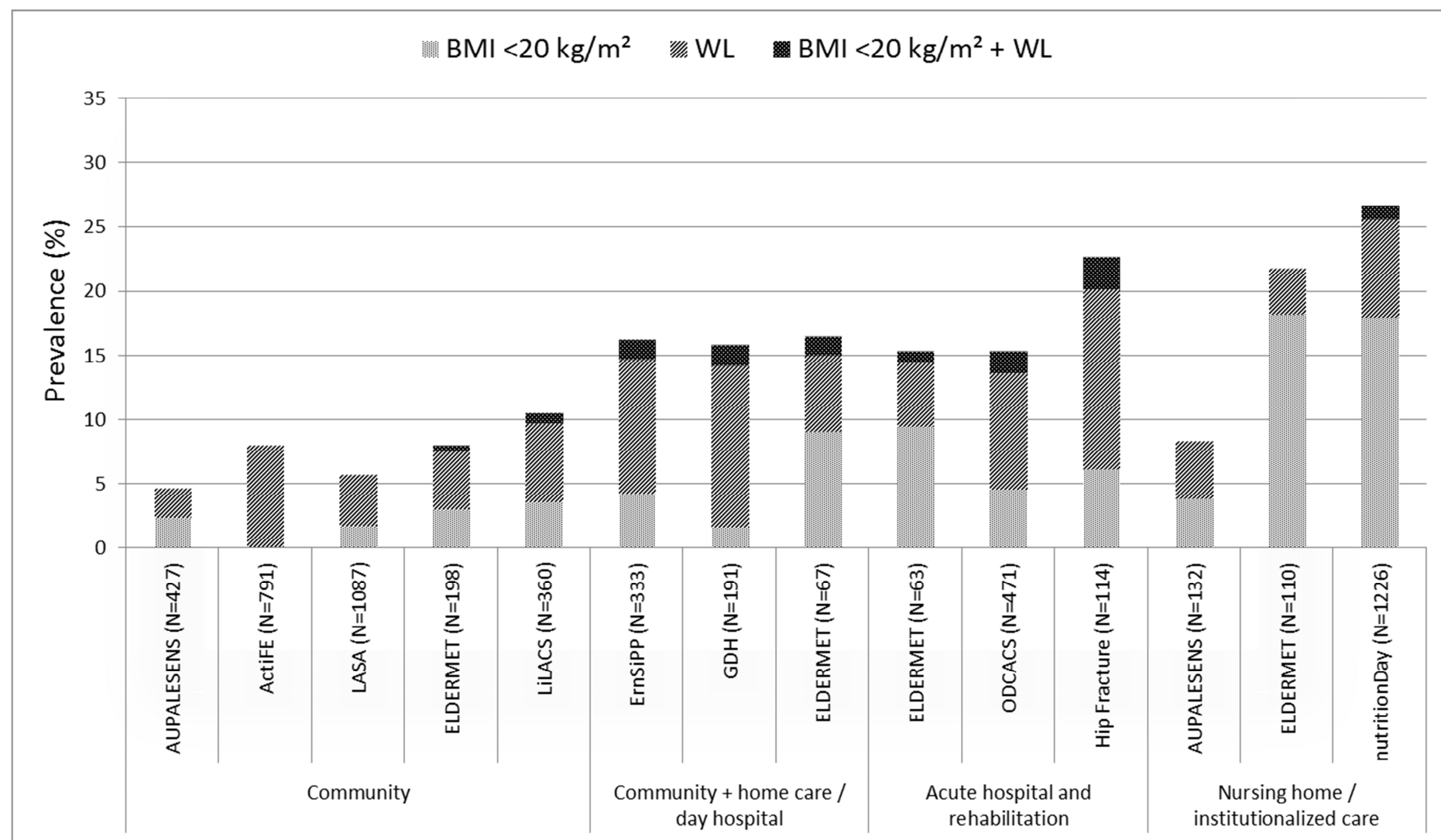
261

262

263

264   Figure 1: Prevalences of malnutrition criteria based on low BMI, weight loss (WL) or both in older adults in different study samples by setting
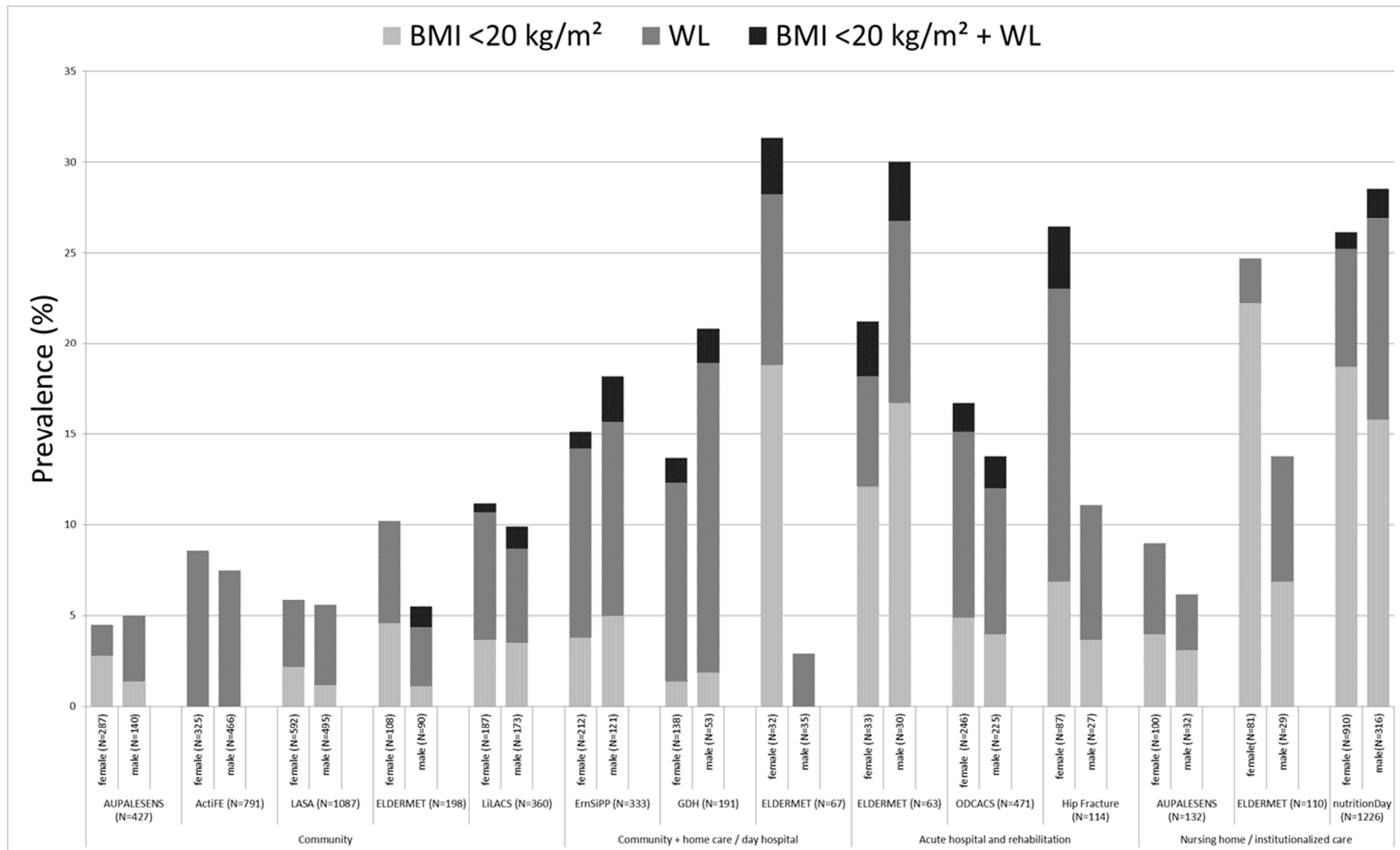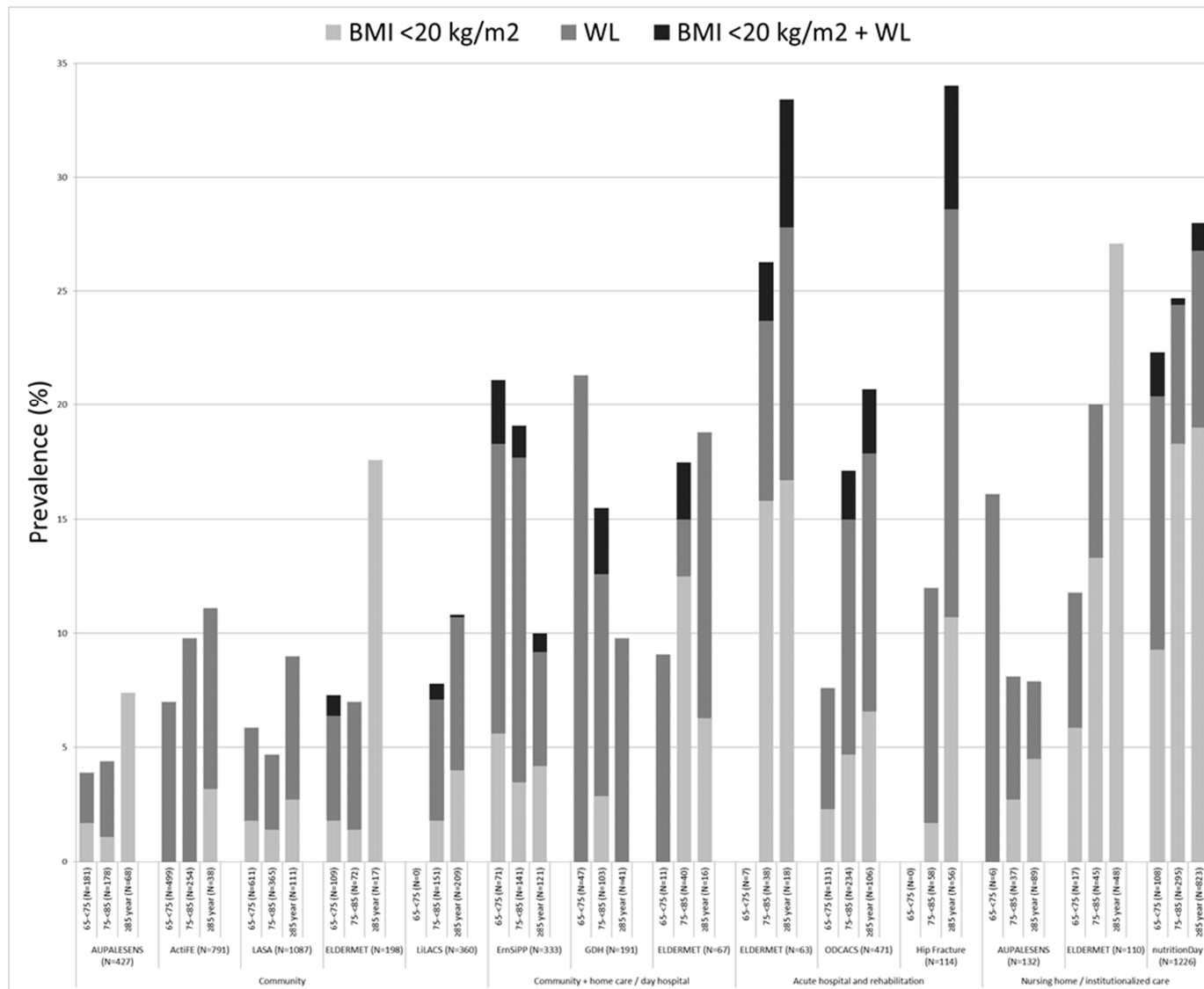
Figure 2: Prevalences of malnutrition criteria based on low BMI, weight loss (WL) or both in older adults in different study samples and settings by sex

267

Figure 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

Discussion

In this study we applied widely accepted and harmonized criteria to estimate the prevalences of malnutrition in almost 6,000 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, 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 to 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

300 by a) the observation of the opposite trend of low BMI and weight loss and b) the observation that in

301 several studies a significant weight loss in the past 3-6 months was least prevalent in the oldest age

302 group, the group with the highest prevalence of a low BMI.

303 With regard to the **setting-specific differences,** we observed a high heterogeneity in the prevalence

304 depending on the respective criteria and characteristics of the study population. In general, there was

305 a positive trend between age (and also functional status) and increase of the prevalence of low BMI.

306 This positive trend cannot be confirmed for weight loss as LASA and ActiFE showed similar or even

307 higher prevalences compared to studies with averagely older and more dependent participants. It

308 becomes evident that studies with the lowest weight loss rates showed the highest prevalence of low

309 age-specific BMI and vice-versa. In this regard, community-dwellers of AUPALESENS showed the

310 lowest weight loss prevalence but the highest prevalence of low age-specific BMI among all

311 community-based studies. Using exclusively the BMI criterion or a combination of a low BMI and

312 weight loss does not identify older adults (who had a higher former BMI) with a significant weight loss

313 who are at risk of malnutrition.

314 Our study confirms other findings based on malnutrition risk assessment [12,34] indicating that **residents**

315 in **long term institutionalized care/ nursing homes** have high prevalences of low BMI except for the

316 AUPALESENS study sample in which only those without severe cognitive impairment (MMSE≥20)

317 were included. A comparison of Dutch, Austrian and German nursing home residents revealed that the

318 prevalence of malnutrition differs according to sex, age and care dependency [35] as also indicated by

319 our study.

320 The highest percentage of older adults with weight loss was noted in **hospitals and rehabilitation**

321 **units** suggesting that the underlying disease of the patients may have been a cause for their weight

322 loss. In one acute hospital study (Hip Fracture) the highest prevalence of almost 40% was observed

323 for the combined definition of malnutrition including all participants with any of the three single criteria.

324 Among the acute hospital/ rehabilitation attenders, ODCACS participants had a lower prevalence of

325 low BMI possibly due to the lower percentage of participants with reduced mobility and cognitive

326 impairment compared to ELDERMET and Hip Fracture participants.

327 The **sex-dependent** differences observed in our analyses suggest that malnutrition among men may

328 be underestimated by the BMI criterion: Based on the same definition of a low BMI for both sexes,

329 men will be classified less often as malnourished as women. Also the criterion of a moderate decrease

330 in food intake was less frequent among men than among women. However, given that a severe

331 decrease in food intake was more prevalent in males than in females in five of the study samples

332 across all settings, this may indicate a risk of underestimation when not considering this item.

333 Furthermore, the higher prevalence of weight loss and of the combined low BMI and weight loss

334 definition in men compared to women in half of the study samples indicates that taking into account

335 BMI only can increase the risk of not being diagnosed as malnourished in men. Thus, in terms of

336 weight loss and severe decrease in food intake men seem to be as vulnerable for malnutrition as

337 women. In contrast, BMI may be less informative for assessing nutritional status in men as it is mostly

338 higher in men than in women because of their physical build and higher muscle mass [36]. Thus,

339 focusing on BMI or on moderate decrease in food intake men seem to be affected less often from

340 malnutrition. Male community-dwellers, particularly when living alone, may have an increased risk for

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

342 Our study results which are based on **age-dependent** differences emphasize that older age is not

343 automatically associated with any of the included malnutrition criteria but that further aspects as

344 dependency or illness need to be considered. In half of the study samples, participants in a younger

345 age group had a higher prevalence of weight loss compared to those of an older age group.

346 Additionally, in five study samples the lowest prevalence of weight loss was observed in the oldest age

347 group, indicating that pace of weight loss may decelerate with increasing age. This was seen in

348 ErnSiPP and in the community-dwelling and institutionalized participants of AUPALESENS and

349 ELDERMET. In the three community-dwelling samples of AUPALESENS, ELDERMET and ErnSiPP, a

350 high proportion of participants of 22.1, 29.4 and 18.2%, respectively, had a low age-specific BMI and

351 12.8% of ELDERMET participants had a BMI <18.5 kg/m^2 in the highest age group. Among the

352 institutionalized participants a high prevalence of low age-specific BMI (39.6%) was seen in the

353 highest age group in ELDERMET. This might indicate that weight loss may have already occurred in

354 younger age which is reflected by a low BMI in older age. Additionally, participants of AUPALESENS

355 from all settings and community-dwelling participants of ELDERMET had mostly no or only mild

356 cognitive impairment which may also have contributed to avoid weight loss in the highest age group as

357 in other studies dementia may have occurred particularly in this group and may have increased the

358 weight loss risk. Thus, weight loss may play a greater role in younger age groups. There is also no

359 clear trend towards increasing rates from the lowest to the highest age group for the prevalence of

360 moderate and severe decrease in food intake.

361   In order to enable a comparable standardized diagnosis, it is important to establish a definition based

362   on relatively easily measurable criteria such as BMI, weight loss and decrease in food intake. We

363   applied these factors and their combinations as the BMI and weight loss had proven to be among the

364   most predictive and widely recommended items for malnutrition diagnosis [34]. A decrease in food intake

365   often occurs as a result of loss of appetite or of eating dependency both of which have been revealed

366   to be relevant predictors of malnutrition [39].

367   As our results show, prevalences vary widely between the different criteria and in some categories

368   there are even conflicting trends such as for low BMI and weight loss among community-dwellers.

369   These variations probably resulted from the different functional status of the included participants in

370   the studies as cognitive impairment, mobility limitations and dependencies may contribute to the

371   development of malnutrition (Table 1). Great proportions of participants with severe cognitive

372   impairement were included in ErnSiPP, ELDERMET rehabilitation and institutions, and nutritionDay.

373   Further, a high proportion of participants were bed- or chair-bound in Hip Fracture and nutritionDay as

374   well as in ELDERMET institutions. Participants of these study samples, i.e. with high proportions of

375   cognitive impairment and/or mobility limitations also showed comparatively high prevalences of

376   malnutrition. Sex-specific differences are evident in our results and should be considered by

377   physicians, nutritionist, nursing staff and staff from other disciplines entrusted with health and nutrition

378   care for older people.

379   *Limitations and strengths*

380   As we included only cross-sectional data from longitudinal surveys in our analyses, weight loss was

381   not measured but reported by the participants or institutional staff. We were unable to use the relative

382   weight loss data as percentage which may have been more informative as weight loss was assessed

383   via MNA categories in kg in most of the included studies. Also, decrease in food intake was not

384   measured but taken from the MNA and was self-reported either by participants or proxies. The

385   reported prevalences were gathered from longitudinal and cross-sectional studies with respective

386   study aim, hence these estimations are limited by selection bias. For example, some studies excluded

387   participants with severe cognitive impairment which is a known predictor for malnutrition [40]. An

388   important strength of our study is that for the first time we applied several easily measurable

389   harmonized criteria for the diagnosis of malnutrition risk in multinational study samples from different

390   settings, including a total of around 6,000 older adults. We also used fixed strata according to e.g. age

391   to investigate whether prevalences differed between these strata.

392 *Conclusion*

393 Applying harmonized definitions for malnutrition revealed that the prevalences vary considerably

394 between and even within the settings which might be explained by differences in age and functional

395 status of included participants in the studies. Prevalences double when using an age-specific BMI

396 versus a BMI <20 kg/m^2 as a standard cut-off. The criteria age-specific BMI and weight loss showed

397 opposing prevalences across all settings. Because of their physical build, men may not be classified

398 as malnourished based on the BMI alone. Therefore, weight loss or severe decrease in food intake

399 may be considered in a malnutrition definition. However, these latter two criteria may play a greater

400 role in younger than in higher age groups. Our results confirm that prevalences increase from

401 community-dwellers to residents of nursing homes. It should be noted that the criteria used strongly

402 affect prevalence and it may be preferable to look at each criterion separately as each may indicate a

403 nutritional problem.

404

405

421

422

423

424

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. *Journal of the American Medical Directors Association.* 2016;17(1):17-23.

2. Martinez-Reig M, Aranda-Reneo I, Pena-Longobardo LM, et al. Use of health resources and healthcare costs associated with nutritional risk: The FRADEA study. *Clinical nutrition (Edinburgh, Scotland).* 2017.

3. Sullivan DH, Walls RC. Protein-energy undernutrition and the risk of mortality within six years of hospital discharge. *Journal of the American College of Nutrition.* 1998;17(6):571-578.

4. McMinn J, Steel C, Bowman A. Investigation and management of unintentional weight loss in older adults. *BMJ (Clinical research 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):409-415.

7. Rolland Y, Dupuy C, Abellan van Kan G, Gillette S, Vellas B. Treatment strategies for sarcopenia and frailty. *The Medical clinics of North America.* 2011;95(3):427-438, ix.

8. Kiesswetter E, Pohlhausen S, Uhlig K, 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. *Journal of the American Geriatrics Society.* 2014;62(3):512-517.

9. Boulos C, Salameh P, Barberger-Gateau P. Malnutrition and frailty in community dwelling older adults living in a rural setting. *Clinical nutrition (Edinburgh, Scotland).* 2016;35(1):138-143.

10. Rojer AG, Kruizenga HM, Trappenburg MC, et al. The prevalence of malnutrition according to the new ESPEN definition in four diverse populations. *Clinical nutrition (Edinburgh, Scotland).* 2016;35(3):758-762.

11. Kaiser MJ, Bauer JM, Ramsch C, et al. Frequency of malnutrition in older adults: a multinational perspective using the mini nutritional assessment. *Journal of the American Geriatrics Society.* 2010;58(9):1734-1738.

12. van Zwienen-Pot JI, Visser M, Kuijpers M, Grimmerink MFA, Kruizenga HM. Undernutrition in nursing home rehabilitation patients. *Clinical nutrition (Edinburgh, Scotland).* 2017;36(3):755-759.

13. Sanchez-Rodriguez D, Marco E, Ronquillo-Moreno N, et al. ASPEN-AND-ESPEN: A postacute-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. *Clinical nutrition (Edinburgh, Scotland).* 2018.

14. Cederholm T, Bosaeus I, Barazzoni R, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. *Clinical nutrition (Edinburgh, Scotland).* 2015;34(3):335-340.

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. *Clinical nutrition ESPEN.* 2017;18:44-48.

16. Visser M, Volkert D, Corish C, et al. Tackling the increasing problem of malnutrition in older persons: The Malnutrition in the Elderly (MaNuEL) Knowledge Hub. *Nutrition Bulletin.* 2017;42(2):178-186.

473	17.	Pohlhausen S, Uhlig K, Kiesswetter E, et al. Energy and Protein Intake, Anthropometrics, and
474		Disease Burden in Elderly Home-care Receivers--A Cross-sectional Study in Germany (ErnSIPP
475		Study). *The journal of nutrition, health & aging.* 2016;20(3):361-368.
476	18.	Valentini L, Schindler K, Schlaffer R, et al. The first nutritionDay in nursing homes:
477		participation may improve malnutrition awareness. *Clinical nutrition (Edinburgh, Scotland).*
478		2009;28(2):109-116.
479	19.	Kearney PM, Harrington JM, Mc Carthy VJ, Fitzgerald AP, Perry IJ. Cohort profile: The Cork
480		and Kerry Diabetes and Heart Disease Study. *International journal of epidemiology.*
481		2013;42(5):1253-1262.
482	20.	Schrader E, Grosch E, Bertsch T, Sieber CC, Volkert D. Nutritional and Functional Status in
483		Geriatric Day Hospital Patients - MNA Short Form Versus Full MNA. *The journal of nutrition,*
484		*health & aging.* 2016;20(9):918-926.
485	21.	Maitre I, Van Wymelbeke V, Amand M, Vigneau E, Issanchou S, Sulmont-Rossé C. Food
486		pickiness in the elderly: Relationship with dependency and malnutrition. *Food Quality and*
487		*Preference.* 2014;32(Part B):145-151.
488	22.	Hoogendijk EO, Deeg DJ, Poppelaars J, et al. The Longitudinal Aging Study Amsterdam: cohort
489		update 2016 and major findings. *European journal of epidemiology.* 2016;31(9):927-945.
490	23.	Denkinger MD, Franke S, Rapp K, et al. Accelerometer-based physical activity in a large
491		observational cohort--study protocol and design of the activity and function of the elderly in
492		Ulm (ActiFE Ulm) study. *BMC geriatrics.* 2010;10:50.
493	24.	Goisser S, Schrader E, Singler K, et al. Malnutrition According to Mini Nutritional Assessment
494		Is Associated With Severe Functional Impairment in Geriatric Patients Before and up to 6
495		Months After Hip Fracture. *Journal of the American Medical Directors Association.*
496		2015;16(8):661-667.
497	25.	O'Shea E, Trawley S, Manning E, Barrett A, Browne V, Timmons S. Malnutrition in
498		Hospitalised Older Adults: A Multicentre Observational Study of Prevalence, Associations and
499		Outcomes. *The journal of nutrition, health & aging.* 2017;21(7):830-836.
500	26.	Kerse N, Teh R, Moyes SA, et al. Cohort Profile: Te Puawaitanga o Nga Tapuwae Kia Ora Tonu,
501		Life and Living in Advanced Age: a Cohort Study in New Zealand (LiLACS NZ). *International*
502		*journal of epidemiology.* 2015;44(6):1823-1832.
503	27.	Claesson MJ, Jeffery IB, Conde S, et al. Gut microbiota composition correlates with diet and
504		health in the elderly. *Nature.* 2012;488(7410):178-184.
505	28.	Jeffery IB, Lynch DB, O'Toole PW. Composition and temporal stability of the gut microbiota in
506		older persons. *The ISME journal.* 2016;10(1):170-182.
507	29.	Vellas B, Villars H, Abellan G, et al. Overview of the MNA--Its history and challenges. *The*
508		*journal of nutrition, health & aging.* 2006;10(6):456-463; discussion 463-455.
509	30.	Cereda E. Mini nutritional assessment. *Current opinion in clinical nutrition and metabolic*
510		*care.* 2012;15(1):29-41.
511	31.	Guigoz Y, Vellas B, Garry PJ. Mini Nutritional Assessment (a practical assessment tool for
512		grading the nutritional state of elderly patients). *Facts Res Gerontol.* 1994;4(2):15-59.
513	32.	Kaiser R, Winning K, Uter W, et al. Comparison of two different approaches for the
514		application of the mini nutritional assessment in nursing homes: resident interviews versus
515		assessment by nursing staff. *The journal of nutrition, health & aging.* 2009;13(10):863-869.
516	33.	Cereda E, Pedrolli C, Klersy C, et al. Nutritional status in older persons according to
517		healthcare setting: A systematic review and meta-analysis of prevalence data using
518		MNA((R)). *Clinical nutrition (Edinburgh, Scotland).* 2016;35(6):1282-1290.
519	34.	Serrano-Urrea R, Garcia-Meseguer MJ. Malnutrition in an elderly population without
520		cognitive impairment living in nursing homes in Spain: study of prevalence using the Mini
521		Nutritional Assessment test. *Gerontology.* 2013;59(6):490-498.
522	35.	van Nie-Visser NC, Meijers J, Schols J, et al. Which characteristics of nursing home residents
523		influence differences in malnutrition prevalence? An international comparison of The
524		Netherlands, Germany and Austria. *The British journal of nutrition.* 2014;111(6):1129-1136.

525   36.   Rothman KJ. BMI-related errors in the measurement of obesity. *Int J Obes (Lond).* 2008;32
526   Suppl 3:S56-59.
527   37.   Santos DM, Rodrigues SS, de Oliveira BM, Vaz de Almeida MD. Diet quality in elderly
528   Portuguese households. *The journal of nutrition, health & aging.* 2014;18(3):243-250.
529   38.   Smee D, Pumpa K, Falchi M, Lithander FE. The Relationship between Diet Quality and Falls
530   Risk, Physical Function and Body Composition in Older Adults. *The journal of nutrition, health*
531   *& aging.* 2015;19(10):1037-1042.
532   39.   Favaro-Moreira NC, Krausch-Hofmann S, Matthys C, et al. Risk Factors for Malnutrition in
533   Older Adults: A Systematic Review of the Literature Based on Longitudinal Data. *Advances in*
534   *nutrition (Bethesda, Md).* 2016;7(3):507-522.
535   40.   Volkert D, Chourdakis M, Faxen-Irving G, et al. ESPEN guidelines on nutrition in dementia.
536   *Clinical nutrition (Edinburgh, Scotland).* 2015;34(6):1052-1073.

537

538   Supplementary Table 1: Prevalence (%) of malnutrition based on harmonized criteria by setting

Setting	Study (N of total sample)	BMI <18.5 kg/m^2	BMI <20 kg/m^2	BMI <22 kg/m^2	Age specific BMI of <20 kg/m^2 in participants ≥65 to <70 and <22 in participants ≥70 years	Weight loss >3 kg in the past 3 months unless otherwise stated	Severe decrease in food intake (MNA)	Moderate decrease in food intake (MNA)	BMI <20 kg/m^2 AND weight loss >3 kg in the past 3 months unless otherwise stated	BMI <20 kg/m^2 AND weight loss AND severe decrease in food intake	BMI <20 kg/m^2 OR weight loss	BMI <20 kg/m^2 OR weight loss OR severe decrease in food intake
Community	AUPALESENS (427)	0	2.3	10.8	9.1	2.3	1.6	7.3	0	0	4.7	6.3
	ActiFE (791)	0	0	4.2	3.0	8.0	0.1	2.9	0	0	8.0	8.0
	LASA (1087)	0.1	1.7	5.7	4.6	4.0[1]	Not available	Not available	0[1]	Not available	5.8[1]	Not available
	ELDERMET (198)	1.5	3.0	9,6	7.6	4.5	1.5	8.1	0.5	0	7.1	8.6
	LiLACS NZ (360)	1.9	3.6	8.9	8.9	6.1[2]	Not available	Not available	0.8[2]	Not available	8.3[2]	Not available
Primary care center	Cork & Kerry (386)	0.8	1.3	4.4	1.3	Not available	4.1	9.1	Not available	Not available	Not available	Not available

Community with home care	ErnSiPP (333)	2.4	4.2	13.8[3]	13.5	10.5[6]	9.6	23.1	1.5[6]	0.9[6]	13.2[6]	16.2[6]
Day hospital	GDH (191)	0	1.6	6.8	6.3	12.6[7]	12.0	18.3	1.6[7]	1.6[7]	12.6[7]	15.7[7]
	ELDERMET (67)	6.0	9.0	17.9	17.9	6.0	1.5	22.4	1.5	1.5	13.4	13.4
Acute hospital and rehabilitation	ELDERMET (63)	4.3	9.4	18.3	19.0	5.0	3.4	15.3	0.9	0.5	13.5	16.0
	ODCACS (471)	1.3	4.5	10.8	10.8	9.1	7.2	32.3	1.7	0.8	11.9	13.8
	Hip Fracture (114)	2.6	6.1	17.5	17.5	14.0	34.2	46.5	2.6	2.6	17.5	39.5
Nursing home and long-term institution-alized care	AUPALESENS (132)	1.5	3.8	7.6	7.6	4.5	1.5	20.5	0	0	8.3	9.8
	ELDERMET (110)	9.1	18.2	33.6	33.6	3.6	8.2	13.6	0	0	21.8	27.3
	nutritionDay (1226)	8.9	17.9	29.9	29.5	7.7	4.0	17.0	1.1	0	24.6	26.8

539

540 [1] >5 kg weight loss in the past 6 months, participants with intended weight loss were included as participants without weight loss: N=7

541   [2] >5 kg weight loss in the past 6 months

542   [3] Height estimated from knee height in 45.6% of the 46 participants with BMI <22 kg/m^2

543   [4] Height estimated from knee height in the 1 participant with BMI <20 kg/m^2

544   [5] Height estimated from knee height in 45.5% of the participants 44 participants aged ≥70 years with BMI <22 kg/m^2

545   [6] Height estimated from knee height in 57.1% of all 14 participants with BMI<20 kg//m^2. Participants with intended weight loss were included as participants without weight loss: N=6

546   [7] Participants with intended weight loss were included as participants without weight loss: N=3

547

548

549

550

551

552   Supplementary Table 2: Prevalence (%) of malnutrition based on harmonized criteria in **female / male older people** in different settings

Setting	Study (N per sex: female / male)	BMI <18.5 kg/m^2	BMI <20 kg/m^2	BMI <22 kg/m^2	Age specific BMI (<20 in participants ≥65 to <70, <22 kg/m^2 in participants ≥70 years)	Weight loss >3 kg in the past 3 months unless otherwise stated	Severe decrease in food intake (MNA)	Moderate decrease in food intake (MNA)	BMI <20 kg/m^2 AND weight loss	BMI <20 kg/m^2 AND weight loss AND severe decrease in food intake	BMI <20 kg/m^2 OR weight loss	BMI <20 kg/m^2 OR weight loss OR severe decrease in food intake
Community	AUPALESENS (287 / 140)	0 / 0	2.8 / 1.4	13.2 / 5.0	11.5 / 4.3 (287 / 140)	1.7 / 3.6	1.4 / 2.1	7.3 / 7.1	0 / 0	0 / 0	4.5 / 5.0	5.9 / 7.1
	ActiFE (325 / 466)	0 / 0	0 / 0	7.7 / 1.7	5.54 / 1.29 (325 / 466)	8.6 / 7.5	0.3 / 0	3.7 / 2.4	0 / 0	0 / 0	8.6 / 7.5	8.6 / 7.5
	LASA (592 / 495)	0.2 / 0	2.2 / 1.2	7.4 / 3.6	5.74 / 3.23 (592 / 495)	3.7[1] / 4.4[1]	Not available	Not available	0[1] / 0[1]	Not available	5.9[1] / 5.7[1]	Not available
	ELDERMET (108 / 90)	2.8 / 0	4.6 / 1.1	16.7 / 1.1	13.0 / 1.11 (108 / 90)	5.6 / 3.3	0.9 / 2.2	9.3 / 6.7	0 / 1.1	0 / 0	10.2 / 3.3	11.1 / 5.6
	LiLACS NZ (187 / 173)	2.1 / 1.7	3.7 / 3.5	9.5 / 8.1	9.63 / 8.09 (187 / 173)	7.0 / 5.2[2]	Not available	Not available	0.5 / 1.2[2]	Not available	9.6 / 6.9[2]	Not available
Primary care	Cork & Kerry	1.6 / 0	2.6 / 0	7.8 / 1.0	2.59 / 0	Not available	4.7 / 3.6	10.9 / 7.3	Not available	Not available	Not available	Not available

center	(193 / 193)				(193 / 193)							
Community with home care	ErnSiPP (212 / 121)	1.9 / 3.3	3.8 / 5.0	14.2[3] / 13.3[4]	14.2 / 12.4 (212 / 121)	10.4 / 10.7[7]	10.4 / 8.3	23.1 / 23.1	0.9 / 2.5[7]	0.9 / 0.8[7]	13.2 / 13.2[7]	16.5 / 15.7[7]
Day hospital	GDH (138 / 53)	0 / 0	1.4 / 1.9	6.5 / 7.5	5.80 / 7.55 (138 / 53)	10.9 / 17.0[8]	12.3 / 11.3	19.6 / 15.1	1.4 / 1.9[8]	1.4 / 1.9[8]	10.9 / 17.0[9]	13.8 / 20.8[8]
	ELDERMET (32 / 35)	12.5 / 0	18.8 / 0	31.3 / 5.7	31.3 / 5.71 (32 / 35)	9.4 / 2.9	3.1 / 0	28.1 / 17.1	3.1 / 0	3.1 / 0	25.0 / 2.9	25.0 / 2.9
Acute hospital and rehabilitation	ELDERMET (33 / 30)	0 / 6.7	12.1 / 16.7	18.2 / 20.0	18.2 / 20.0 (33 / 30)	6.1 / 10.0	0 / 6.7	33.3 / 33.3	3.0 / 3.3	0 / 3.3	15.2 / 23.3	15.2 / 26.7
	ODCACS (246 / 225)	1.2 / 1.3	4.9 / 4.0	12.6 / 8.9	12.6 / 8.89 (246 / 225)	10.2 / 8.0	8.5 / 5.8	35.0 / 29.3	1.6 / 1.8	1.2 / 0.4	13.4 / 10.2	15.9 / 11.6
	Hip Fracture (87 / 27)	2.6 / 0	6.9 / 3.7	19.5 / 11.1	19.5 / 11.1 (87 / 27)	16.1 / 7.4	39.1 / 18.5	43.7 / 55.6	3.4 / 0	3.4 / 0	19.5 / 11.1	44.8 / 22.2
Nursing home and long-term institution-alized care	AUPALESENS (100 / 32)	1.0 / 3.1	4.0 / 3.1	6.0 / 12.5	6.0 / 12.5 (100 / 32)	5.0 / 3.1	2.0 / 0	21.0 / 18.7	0 / 0	0 / 0	9.0 / 6.3	11.0 / 6.3
	ELDERMET (81/ 29)	12.4 / 0	22.2 / 6.9	35.8 / 27.6	35.8 / 27.6 (81 / 29)	2.5 / 6.9	7.4 / 10.3	14.8 / 10.3	0 / 0	0 / 0	24.7 / 13.8	28.4 / 24.1

		nutritionDay (910 / 316)	9.9 / 6.0	18.7 / 15.8	30.1 / 29.4	29.7 / 29.1 (910 / 316)	6.5 / 11.1	3.7 / 4.7	17.3 / 16.5	0.9 / 1.6	0 / 0	24.3 / 25.3	26.3 / 28.2

553

554   [1] >5 kg weight loss in the past 6 months, participants with intended weight loss were included as participants without weight loss: N=7

555   [2] >5 kg weight loss in the past 6 months

556   [3] Height was estimated by knee height in 36.6% of all affected participants

557   [4] Height was estimated by knee height in 62.5% of all affected participants

558   [5] Height was estimated by knee height in 34.5% of all affected participants

559   [6] Height was estimated by knee height in 66.6% of all affected participants

560   [7] Participants with intended weight loss were included as participants without weight loss: N=6

561   [8] Participants with intended weight loss were included as participants without weight loss: N=3

562

563

564 Supplementary Table 3: Prevalence (%) of malnutrition based on harmonized criteria in different settings by **age group** in **65-<75 / 75-<85 / ≥85 year** old adults

Setting	Study (N per age group: 65-<75 / 75-<85 / ≥85 years)	BMI <18.5 kg/m^2	BMI <20 kg/m^2	BMI <22 kg/m^2	Age specific BMI of <20 kg/m^2 in participants ≥65 to <70 and <22 in participants ≥70 years	Weight loss >3 kg in the past 3 months unless otherwise stated	Severe decrease in food intake (MNA)	Moderate decrease in food intake (MNA)	BMI <20 kg/m^2 AND weight loss	BMI <20 kg/m^2 AND weight loss AND severe decrease in food intake	BMI <20 kg/m^2 OR weight loss	BMI <20 kg/m^2 OR weight loss OR severe decrease in food intake
Community	AUPALESENS (181 / 178/ 68)	0 / 0 / 0	1.7 / 1.1 / 7.4	12.7 / 4.5 / 22.1	8.84 / 4.49 / 22.1	2.2 / 3.3 / 0	1.7 / 1.7 / 1.5	3.3 / 7.3 / 17.6	0 / 0 / 0	0 / 0 / 0	3.9 / 4.5 / 7.4	5.5 / 6.2 / 8.8
	ActiFE (499 / 254 / 38)	0 / 0 / 4.4	0 / 0 / 3.2	0 / 0 / 7.9	2.61 / 3.15 / 7.89	7.0 / 9.8 / 7.9	0 / 0.4 / 0	2.2 / 3.5 / 7.9	0 / 0 / 0	0 / 0 / 0	7.0 / 9.8 / 7.9	7.0 / 9.8 / 7.9
	LASA (611 / 365 / 111)	0 / 0.3 / 0	1.8 / 1.4 / 2.7	5.6 / 4.4 / 10.8	3.60 / 4.38 / 10.8	4.1 / 3.3 / 6.3[1]	Not available	Not available	0 / 0 / 0[1]	Not available	5.9 / 4.7 / 9.0[1]	Not available
	ELDERMET (109 / 72 /17)	0 / 1.4 / 11.8	1.8 / 1.4 / 17.6	8.3 / 6.9 / 29.4	4.59 / 6.94 / 29.4	4.6 / 5.6 / 0	0 / 4.2 / 0	6.4 / 11.1 / 5.9	0.9 / 0 / 0	0 / 0 / 0	5.5 / 6.9 / 17.6	5.5 / 11.1 / 17.7
	LiLACS NZ (0 / 151 / 209)	- / 0.6 / 2.0	- / 1.8 / 4.0	- / 7.8 / 9.2	- / 9.27 / 8.61	- / 5.3 / 6.7[2]	Not available	Not available	- / 0.7 / 0.1[2]	Not available	- / 6.6 / 9.6[2]	Not available
Primary care	Cork & Kerry	0 / - / -	0 / - / -	0 / - / -	1.29 / - / -	Not available	3.4 / - / -	10.3 / - / -	Not available	Not available	Not available	Not available

center	(386 / 0 / 0)[3]											
Community with home care	ErnSiPP (71 / 141 / 121)	1.4 / 2.8 / 2.5	5.6 / 3.5 / 4.2	8.4 / 12.7 / 18.2	7.04 / 12.8 / 18.2	12.7 / 14.2 / 5.0[4]	8.5 / 9.2 / 10.7	23.9 / 24.8 / 20.7	2.8 / 1.4 / 0.8	1.4 / 0.7 / 0.8	15.5 / 16.3 / 8.3[4]	18.3 / 17.7 / 13.2[4]
Day hospital	GDH (47 / 103 / 41)	0 / 0 / 0	0 / 2.9 / 0	4.3 / 6.8 / 9.8	2.13 / 6.80 / 9.76	21.3 / 9.7 / 9.8[5]	19.1 / 9.7 / 9.8	8.5 / 23.3 / 17.1	0 / 2.9 / 0[5]	0 / 2.9 / 0[5]	21.3 / 9.7 / 9.8[5]	25.5 / 12.6 / 12.2[5]
	ELDERMET (11 / 40 / 16)	0 / 7.5 / 6.3	0 / 12.5 / 6.3	0 / 20.0 / 25.0	0 / 20.0 / 25.0	9.1 / 2.5 / 12.5	0 / 2.5 / 0	9.1 / 22.5 / 31.3	0 / 2.5 / 0	0 / 2.5 / 0	9.1 / 12.5 / 18.8	9.1 / 12.5 / 18.8
Acute hospital and rehabilitation	ELDERMET (7 / 38 / 18)	0 / 2.6 / 5.6	0 / 15.8 / 16.7	14.3 / 18.4 / 22.2	14.3 / 18.4 / 22.2	0 / 7.9 / 11.1	0 / 5.3 / 0	14.3 / 31.6 / 44.4	0 / 2.6 / 5.6	0 / 2.6 / 0	0 / 21.1 / 22.2	0 / 23.7 / 22.2
	ODCACS (131 / 234 / 106)	0.8 / 1.3 / 1.9	2.3 / 4.7 / 6.6	11.5 / 8.1 / 16.0	11.5 / 8.12 / 16.0	5.3 / 10.3 / 11.3	3.1 / 8.1 / 10.4	25.2 / 35.5 / 34.0	0 / 2.1 / 2.8	0 / 0.9 / 1.9	7.6 / 12.8 / 15.1	7.6 / 15.4 / 17.9
	Hip Fracture (0 / 58 / 56)	0 / 0 / 5.4	0 / 1.7 / 10.7	0 / 12.1 / 23.2	- / 12.1 / 23.2	0 / 10.3 / 17.9	0 / 32.8 / 35.7	0 / 46.6 / 46.4	0 / 0 / 5.4	0 / 0 / 5.4	0 / 12.1 / 23.2	0 / 34.5 / 44.6
Nursing home and long-term institution-alized care	AUPALESENS (6 / 37 / 89)	0 / 0 / 2.2	0 / 2.7 / 4.5	0 / 5.4 / 9.0	0 / 5.41 / 8.99	16.1 / 5.4 / 3.4	0 / 2.7 / 1.1	50.0 / 18.9 / 19.1	0 / 0 / 0	0 / 0 / 0	16.7 / 8.1 / 7.9	16.7 / 10.8 / 9.0
	ELDERMET (17/ 45 / 48)	0 / 6.7 / 14.6	5.9 / 13.3 / 27.1	17.7 / 33.3 / 39.6	17.6 / 33.3 / 39.6	5.9 / 6.7 / 0	5.9 / 8.9 / 8.3	11.8 / 15.6 / 12.5	0 / 0 / 0	0 / 0 / 0	11.8 / 20.0 / 27.1	17.6 / 28.9 / 29.2

	nutritionDay (108 / 295 / 823)	3.7 / 7.5 / 10.1	9.3 / 18.3 / 19.0	19.4 / 28.5 / 31.8	14.8 / 28.5 / 31.8	11.1 / 6.1 / 7.8	0.9 / 4.7 / 4.1	11.1 / 13.9 / 19.0	1.9 / 0.3 / 1.2	0 / 0 / 0	18.5 / 24.1 / 25.5	19.4 / 26.4 / 27.8

565

566   [1] >5 kg weight loss in the past 6 months, participants with intended weight loss were included as participants without weight loss: N=7

567   [2] > 5 kg in the past 6 months

568   [3] Only participants ≥70 years were included in the study

569   [4] Participants with intended weight loss were included as participants without weight loss N= 6

570   [5] Participants with intended weight loss were included as participants without weight loss: N=3

571

572

573