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Original article

Prevalence of malnutrition among older adults in a population-based study - the HUNT Study

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SUMMARY

Background: Malnutrition is common in older adults and is associated with increased morbidity and mortality rates.
Aim: The aim of the study is to describe the prevalence of malnutrition based on low BMI, involuntary weight loss, and reduced food intake, in a Norwegian population of community-dwelling older adults and older adults living in nursing homes.
Methods: This population-based study is part of the fourth wave of the Trøndelag Health Study (HUNT4) and includes participants ≥70 years from the HUNT4 70+ cohort. The HUNT4 70+ cohort consist of 9930 (response rate 51.2%) participants. In the current study 8127 older people had complete dataset for inclusion in the analyses. Participants completed a self-report questionnaire and standardised interviews and clinical assessments at field stations, in participants' homes or at nursing homes. Malnutrition was defined using the following criteria: low BMI, involuntary weight loss and severely reduced food intake. The standardised prevalence of malnutrition was estimated using inverse probability weighting (IPW) with weights for sex, age and education of the total population in the catchment area of HUNT.
Results: Of the 8127 included participants, 7671 (94.4%) met at field stations, 356 (4.4%) were examined in their home, and 100 (1.2%) in nursing homes. In total, 14.3% of the population were malnourished based on either low BMI, weight loss, or reduced food intake, of which low BMI was the most frequently fulfilled criterion. The prevalence of malnutrition was less common among men than among women (10.1 vs 18.0%, $p < 0.001$), also after adjustment for age (OR 0.53, 95% confidence interval (CI) 0.46–0.61). The prevalence increased gradually with increasing age and the regression analysis adjusted for sex showed that for each year increase in age the prevalence of malnutrition increased with 4.0% (OR 1.04, 95% CI 1.03–1.05). The prevalence was higher both among older adults examined in their homes (26.4%)

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and residents in nursing home (23.6%), as compared to community-dwelling older adults who met at field stations (13.5%).
Conclusion: The prevalence of malnutrition is high in the older population. Special attention on prevention and treatment of malnutrition should be given to older women, the oldest age groups, and care-dependent community-dwelling older adults and nursing home residents.

1. Introduction

Malnutrition is widespread in older adults [1–4] and is associated with increased mortality [1,5] and morbidity [6–10]. Also, malnutrition leads to higher health care costs, mainly due to increased use of health care services [11,12]. A better insight into the prevalence of malnutrition in the general population of older adults is necessary for health authorities to plan for health care services, including nutritional care and follow-up.

Although malnutrition is widespread in older adults, most of the previous studies are based on smaller, selected populations and are seldom comparable between different populations such as nursing home residents and community-dwelling older adults. Thus, there is limited knowledge on the prevalence of malnutrition in the general older population.

Rates of malnutrition in studies vary considerably, not only by population and setting, but also largely by the criteria used to detect malnutrition [6]. In 2019, the GLIM criteria were suggested as international consensus diagnostic criteria for malnutrition [13]. In GLIM, a combination of phenotypic and etiological criterion is required for the diagnosis of malnutrition. The phenotypic criteria in GLIM are weight loss, low BMI or reduced muscle mass, while the etiological criteria are reduced food intake or assimilation, or disease burden/inflammation [13]. Even though the GLIM criteria might work well in clinical practice, these diagnostic criteria might have limitations in reflecting malnutrition in large population-based studies of older adults.

Due to the challenges in gathering complete datasets for GLIM in large scale population studies, we have used three key variables from the GLIM criteria, namely low BMI, weight loss and severely reduced food intake for the diagnosis of malnutrition. Each of these variables reflect direct nutritional challenges and are associated with reduced survival [13–21].

Low BMI is used to define underweight by the World Health Organization (WHO) [22]. For subjects 70 years and older, a BMI of <22 kg/m^2 is used as a cut-off value for malnutrition [13,15] and a cut-off <20 kg/m^2 is used as criterion for severe malnutrition [13]. The GLIM criteria [13] defines weight loss that qualifies for a malnutrition diagnosis as >5% within past 6 months, or >10% indefinite of time. The « Malnutrition in the Elderly» (MaNuEL) Knowledge Hub defines [17] malnutrition-qualifying weight loss as >3 kg in the past 3 months or >5 kg in the past 6 months. Reduced food intake predicts both weight loss and malnutrition [16]. Reduced food intake is included in the diagnostic criteria for malnutrition in GLIM [13], MaNuEL [17] and the Academy of Nutrition and Dietetics (AND) and American Society for Parenteral and Enteral Nutrition (ASPEN) [14].

Thus, the aim of this paper is to describe the prevalence of malnutrition based on low BMI, involuntary weight loss and reduced food intake in a large, population-based sample of community-dwelling older adults as well as older adults living in nursing homes.

2. Methods

2.1. Study design and study population

This population-based, cross-sectional study is part of the fourth wave of the Trøndelag Health Study (HUNT4) and includes participants ≥70 years from the HUNT4 70+ cohort [23]. The catchment area for inclusion to HUNT4 consisted of rural areas and small towns from all municipalities in the northern part of Trøndelag County (former Nord-Trøndelag County). In the HUNT4 70+ cohort, 9930 older adults (51.2%) participated (Fig. 1). Data collection and methods for the HUNT4 70+ cohort has been described previously [24–26]. Briefly, participants completed a self-report questionnaire at home or nursing homes, whereas standardised interviews and clinical assessments were conducted at field stations, in participants' homes or at nursing homes. The home visits was offered based on the participant's preference and was predominantly performed in care-dependent older adults. This facilitated recruitment of older and frail participants. Trained health care workers performed the clinical assessments using standardised protocols. Data were collected between September 2017 and March 2019.

Exclusion criteria for this study were missing information on body mass index (BMI), involuntary weight loss last six months and food intake last four weeks (n=1803). Thus, the sample for analysis

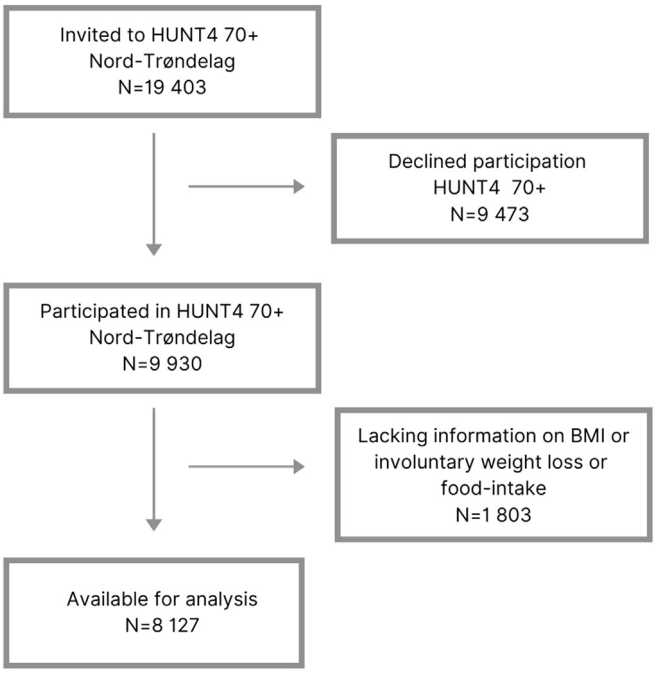

Fig. 1. Flow chart study sample (n = 8127).

included 8127 participants, 81.8% of the HUNT4 70+ participants (Fig. 1).

2.2. Malnutrition

The criteria of malnutrition in this study were based on three important and globally used indicators of malnutrition: low BMI, involuntary weight loss and reduced food intake [13–15,17]. These criteria were studied separately, and in different combinations. To describe the prevalence of malnutrition, low BMI, involuntary weight loss, or severely reduced food intake were used, each as defined below. In addition, different combinations of these three criteria as well as severely low BMI, and moderate or severely reduced food intake were used for additional analyses (Supplementary Tables 1 and 2). These combinations also facilitate comparisons to other studies and definitions.

2.3. Body mass index

At field stations weight was measured to the nearest 0.1 kg using InBody 770 Body Composition Analyzer (InBody Co., Ltd., Seoul, Korea). Height was measured to the nearest mm, using a connected digital stadiometer. In home visits and nursing homes, weight and height were measured using Seca 813 scale and Seca 217 stadiometer (Seca, Germany). Weight and height measurements were performed with the participants wearing light clothes and without shoes. Height was measured to the nearest cm and weight to the nearest 0.1 kg. BMI was calculated as body weight (in kilograms) divided by squared body height (in meters). All participants were >70 years, therefore age-specific cut off for low BMI (<22 kg/m^2) were used [13,15]. Severely low BMI was defined as < 20 kg/m^2.

2.4. Involuntary weight loss

Information on involuntary weight loss was obtained in a self-reported questionnaire by the following question: “For the last six months, have you involuntarily lost more than 5 kg body weight? Alternative: Yes or No”.

2.5. Food intake

At field stations and home visits, information about food intake were self-reported in a standardised interview as part of the HUNT4 70+ examination. The following question were asked: “How will you describe your food intake in the last four weeks?” Alternative: 1) More than usual, 2) As usual, 3) Less than usual (3/4), 4) Half of usual, 5) Almost nothing. For nursing home residents, an adapted interview protocol was applied and health personnel who knew the participants well provided information about the food intake with the same response alternatives as given in the interviews at field stations and home visits. An answer of “half as usual” or “almost nothing” were defined as severely reduced food intake.

2.6. Covariates and variables for characteristics

Information on education, marital status and self-reported general health was obtained in a self-reported questionnaire by the following questions: “What is your highest level of education?”. The participants level of education was categorised in primary school (<10 years), secondary school (10–12 years) and college/university (>12 years). “Marital Status” was categorised in unmarried, married, divorced/separated and widow/widower. The responses from “How is your health at the moment?” was categorised in good or poor. Cognitive function was evaluated by various assessment tools and questionnaires, as described by Gjøra et al. [25]. Medical doctors with clinical and scientific expertise diagnosed the participants with no cognitive impairment (CogIm), mild cognitive impairment (MCogIm), dementia or other reasons for cognitive impairment based on DSM-5 diagnostic criteria [27].

2.7. Ethics

The HUNT4 Survey including HUNT4 70+ was approved by the Norwegian Data Protection Authority. Participation was voluntary, based on informed consent and was obtained from all participants or their closest proxy. The current study was performed in accordance with relevant guidelines and regulations and was approved by the Norwegian Regional Committees for Medical and Health Research Ethics (145790/REK Midt) and the Norwegian Centre for Research Data (NSD 815857). The study was performed in accordance with the Declaration of Helsinki.

2.8. Statistical analysis

General descriptive statistics are presented as mean with standard deviation (SD) or frequency with percentages. The prevalence of malnutrition with standardised proportions and 95% confidence intervals (CIs) was estimated using inverse probability weighting (IPW) [28] to take account of non-participation of invited inhabitants in HUNT4 70+. The IPW was generated based on probability of participation in the total population in the catchment area of HUNT4 70+ (previous Nord-Trøndelag County). It was predicted from a logistic regression model in which a dichotomous participation variable was regressed against sex, age of five groups (70–74 years; 75–79 years; 80–84 years; 85–89 years; 90+ years), and education of three groups (<10 years; 10–12 years; >12 years). IPW was performed under the assumption of missing at random (MAR). The data used for calculating IPW were from Statistics Norway. This weighting allowed us to calculate representative prevalence estimates of the region of Trøndelag. The ‘svy’ command in Stata was used to apply the weighting for all analyses.

The standardised prevalence estimates were stratified by sex, age groups and test location. Prevalence differences between groups were assessed using chi-squared test, and trend in prevalence across age categories were assessed by logistic regression with age categories as an ordinal variable. A two-sided $p < 0.05$ was considered statistically significant. Furthermore, to explore the independent association of sex and age on malnutrition, multivariable logistic regression model was used with sex and age as independent variables, and odds ratio (ORs) with 95% CIs were estimated. All statistical analyses were performed with Stata/MP V.17.

3. Results

Table 1 shows basic characteristics of the study population. Women represented 52.7% of the study population. The mean age of the total population was 77.0 years, and women were slightly older than the men. There were fewer women in the youngest age group (70–74 years), and more women in the oldest age group (85 + years). The mean BMI of the study sample was 27.2 kg/m^2. Secondary school was the highest level of education for 45.2% of the population. Fewer women (52.2%) than men (73.9%) were married, while 35.1% of the women and 11.8% of the men were widow/widower. Among the 8127 participants, 9.3% had dementia and 35.6% had MCogIm. MCogIm was more frequent among men (38.5%) than women (33.1%). Almost two-thirds of the population reported their general health to be good, among whom slightly more men than women reported their general health to be good. Most of the participants (94.4%) were examined at field stations,

Table 1
Characteristics of study population (n = 8127).

	Women n = 4282 (52.7%)	Men n = 3845 (47.3%)	Total n = 8127
Age, mean (SD, min–max)	77.3 (5.95, 70.0–100.9)	76.7 (5.46, 70.0–101.0)	77.0 (5.7, 70–101)
Age, n (%)			
70–74 yrs	1882 (44.0)	1817 (47.3)	3699 (45.5)
75–79 yrs	1184 (27.7)	1081 (28.1)	2265 (27.9)
80–84 yrs	681 (15.9)	598 (15.6)	1279 (15.7)
85+ yrs	535 (12.5)	349 (9.1)	884 (10.9)
BMI, mean (SD), kg/m^2	27.1 (4.83)	27.3 (3.77)	27.2 (4.36)
Education, n (%)			
Primary school	1520 (35.5)	778 (20.3)	2298 (28.3)
Secondary school	1825 (42.6)	1845 (48.0)	3670 (45.2)
College/University	937 (21.9)	1222 (31.8)	2159 (26.6)
Marital status, n (%)			
Unmarried	116 (2.7)	212 (5.5)	328 (4.0)
Married	2234 (52.2)	2843 (73.9)	5077 (62.5)
Widow/widower	1502 (35.1)	454 (11.8)	1956 (24.1)
Divorced/separated	425 (10.0)	330 (8.6)	755 (9.3)
Unknown	5 (0.1)	6 (0.2)	11 (0.1)
Cognitive function, n (%)			
No CogIm	2416 (56.4)	1992 (51.8)	4408 (54.2)
MCogIm	1416 (33.1)	1480 (38.5)	2896 (35.6)
Dementia	412 (9.6)	346 (9.0)	758 (9.3)
Other reasons for CogIm	4 (0.1)	1 (0.03)	5 (0.1)
Unknown	34 (0.8)	26 (0.7)	60 (0.7)
Self-reported health, n (%)			
Good	2591 (60.5)	2520 (65.5)	5111 (62.9)
Poor	1593 (37.2)	1256 (32.7)	2849 (35.0)
Unknown	98 (2.3)	69 (1.8)	167 (2.1)
Test location, n (%)			
Field station	3969 (92.7)	3702 (96.3)	7671 (94.4)
Home	242 (5.7)	114 (3.0)	356 (4.4)
Nursing home	71 (1.7)	29 (0.8)	100 (1.2)

BMI: body mass index; SD: standard deviation; CogIm: cognitive impairment; MCogIm: mild cognitive impairment. The data are presented as mean and standard deviation or n (%).

while 4.4% were examined in their homes and 1.2% were examined at nursing homes.

Table 2 presents the standardised prevalence of nutritional characteristics and malnutrition according to sex, different age groups and test location. In total, 14.3% (95% CI 13.6–15.1) of the population was malnourished. Without non-response weighting the total prevalence of malnutrition was 0.2% lower than the standardised prevalence. BMI <22 kg/m^2 was the most frequently appearing criteria of malnutrition (9.1%, 95% CI 8.5–9.7), followed by involuntary weight loss (5.5%, 95% CI 5.0–6.0) and severely reduced food intake (1.3%, 95% CI 1.1–1.6). For the group of older adults who reported an involuntary weight loss of 5 kg in the last 6 months, the weight loss corresponded to an average of at least 6.7%. The prevalence of malnutrition was lower among men (10.1%, 95% CI 9.2–11.2) than among women (18.0%, 95% CI 16.9–19.2) ($p < 0.001$). The nutritional characteristics BMI <22 kg/m^2 ($p < 0.001$), involuntary weight loss ($p = 0.016$) and severely reduced food intake ($p < 0.001$) were all more frequently observed among the women. The additional analyses of prevalence using different combinations of criteria as well as severely low BMI (BMI< 20 kg/m^2), and moderate reduced food intake are presented in Supplementary Tables 1 and 2

The standardised prevalence of malnutrition gradually increased with increasing age, from 11.9% (95% CI 10.9–13.0) among those 70–74 years of age to 22.2% (95% CI 19.5–25.1) of the participants ≥85 years of age ($p < 0.001$) (Table 2). Also, for each the three criteria separately, there was an increase of malnutrition with increasing age (BMI <22 kg/m^2, p for trend <0.001; weight loss, p for trend <0.001; severely reduced food intake, p for trend = 0.001).

The prevalence of malnutrition was higher among participants visited in their homes (26.4%, 95% CI 22.0–31.4)) and in nursing homes (23.6%, 95% CI 16.2–33.1) as compared to participants at the field stations (13.5%, 95% CI 12.8–14.3) ($p < 0.001$) (Table 2). Low BMI was more frequently observed among participants in nursing homes (18.6%) than participants examined in their home (13.6%) and at field station (8.7%). Also, the prevalence of severely reduced food intake differed between the different locations ($p < 0.001$). Notably, involuntary weight loss was more frequent among the participants visited in their home (13.1%) than at nursing homes (10.6%) and at field stations (5.0%). Participants examined at home were older, had higher rates of dementia and lower self-perceived health than participants examined at field stations (Supplementary Table 3).

The independent association of sex and age on malnutrition is shown in Table 3. Multivariable regression analysis adjusted for age, confirmed the prevalence difference between sex and showed that men were 47% less likely to be malnourished than women (OR 0.53, 95% CI 0.46–0.61). The multivariable regression analysis for each separate criteria for malnutrition gave similar results for each criterion. Multivariable regression analysis adjusted for sex, confirmed the prevalence difference in age and showed that for each year increase in age the prevalence risk of malnutrition increased with 4.0% (OR 1.04, 95% CI 1.03–1.05). For each individual criteria for malnutrition there were similar results. The additional analyses using other criteria of malnutrition showed similar results and are presented in Supplementary Table 4.

4. Discussion

4.1. Main findings

The prevalence of malnutrition among older adults over 70 years was 14% based on either low BMI, weight loss, or reduced food intake. The prevalence of malnutrition was higher among

Table 2
Standardised prevalence of nutritional characteristics and malnutrition.

	Total	BMI[a] <22 kg/m^2			Involuntary weight loss[b]			Severely reduced food intake[c]			Prevalence of malnutrition[d]		
		N	%	95% CI	N	%	95%CI	N	%	95% CI	N	%	95% CI
Total		733	9.1	(8.5–9.7)	430	5.5	(5.0–6.0)	100	1.3	(1.1–1.6)	1149	14.3	(13.6–15.1)
Sex													
Women	4282	532	12.3	(11.4–13.4)	253	6.0	(5.3–6.8)	71	1.8	(1.4–2.2)	771	18.0	(16.9–19.2
Men	3845	201	5.4	(4.7–6.2)	177	4.8	(4.1–5.5)	29	0.8	(0.5–1.1)	378	10.1	(9.2–11.2)
p-chi^2			<0.001				0.016		<0.001			<0.001	
Age, n (%)													
70–74 yrs	3699	273	7.2	(6.4–8.1)	165	4.6	(3.9–5.3)	35	1.0	(0.7–1.4)	442	11.9	(10.9–13.0)
75–79 yrs	2265	197	8.7	(7.6–10.0)	107	4.7	(3.9–5.7)	24	1.1	(0.7–1.6)	304	13.5	(12.1–15.0)
80–84 yrs	1279	132	10.0	(8.5–11.9)	84	6.7	(5.4–8.2)	14	1.0	(0.6–1.7)	208	16.1	(14.1–18.2)
85+ yrs	884	131	15.0	(12.7–17.6)	74	8.4	(6.7–10.4)	27	3.1	(1.1–1.6)	195	22.2	(19.5–25.1)
p for trend[e]			<0.001			<0.001			0.001			<0.001	
Women													
70–74 yrs	1882	209	10.9	(9.5–12.4)	91	4.9	(4.0–6.0)	23	1.3	(0.9–0.2)	299	15.7	(14.1–17.5)
75–79 yrs	1184	137	11.4	(9.7–13.3)	60	5.0	(3.9–6.4)	17	1.5	(0.9–0.2)	196	16.4	(14.4–18.7)
80–84 yrs	681	96	13.5	(11.1–16.3)	53	7.8	(6.0–10.1)	10	1.4	(0.7–2.6)	142	20.2	(17.3–23.4)
85+ yrs	535	90	16.9	(13.9–20.4)	49	9.1	(6.9–11.9)	21	3.9	(2.6–6.0)	134	24.9	(21.4–28.8)
p for trend[e]			<0.001			<0.001			0.003			<0.001	
Men													
70–74 yrs	1817	64	3.4	(2.7–4.3)	74	4.2	(3.4–5.3)	12	0.7	(0.4–1.2)	143	7.9	(6.7–9.3)
75–79 yrs	1081	60	5.8	(4.5–7.4)	47	4.4	(3.3–5.9)	7	0.7	(0.3–1.4)	108	10.3	(8.5–12.3)
80–84 yrs	598	36	6.1	(4.4–8.3)	31	5.4	(3.8–7.6)	4	0.6	(0.2–1.6)	66	11.3	(8.9–14.2)
85+ yrs	349	41	11.9	(8.8–15.8)	25	7.2	(4.9–10.5)	6	1.7	(0.8–3.8)	61	17.7	(14.0–22.3)
p for trend[e]			<0.001			0.026			0.187			<0.001	
Test location													
Field station	7671	669	8.7	(8.1–9.3)	373	5.0	(4.5–5.5)	78	1.0	(0.8–1.3)	1034	13.5	(12.8–14.3)
Home	356	46	13.6	(10.3–17.7)	46	13.1	(9.9–17.1)	18	5.0	(3.2–7.9)	92	26.4	(22.0–31.4)
Nursing home	100	18	18.6	(12.0–27.7)	11	10.6	(5.9–18.0)	4	4.1	(1.5–10.4)	23	23.6	(16.2–33.1)
p-chi^2			<0.001			<0.001				<0.001		<0.001	

BMI: body mass index; CI: confidence interval; IPW: inverse probability weighting The standardised proportions and 95% confidence interval (CIs) were estimated using IPW that was generated based on probability of participation in the total population in the catchment area of HUNT4 70+. The probability was predicted from a logistic regression model in which a dichotomous participation variable was regressed against sex, age groups and education.

[a] Age-specific (>70 years) criterion for malnutrition.
[b] Involuntary weight loss >5 kg last six months.
[c] Severely reduced food intake; An answer of "half of usual" or "almost nothing".
[d] Malnutrition is defined as BMI<22 kg/m^2 or weight loss >5 kg last six months or severely reduced food intake.
[e] p for trend was tested by logistic regression with age groups as an ordinal variable.

Table 3
Association between sex, age and the prevalence of malnutrition and nutritional characteristics.

Malnutrition[a]	OR*	95% CI
Men	0.53	(0.46–0.61)
Age	1.04	(1.03–1.05)
Nutritional characteristics		
BMI<22 kg/m^2		
Men	0.42	(0.35–0.50)
Age	1.04	(1.03–1.06)
Involuntary weight loss[b]		
Men	0.81	(0.66–0.99)
Age	1.04	(1.02–1.06)
Severely reduced food intake[c]		
Men	0.46	(0.29–0.71)
Age	1.07	(1.03–1.10)

BMI: body mass index; CI: confidence interval; OR: odds ratio.
*Multivariable logistic regression model with malnutrition or single nutritional characteristics of malnutrition as dependent variable, and sex (women as reference) and age (continuous) as independent variables.

[a] Malnutrition defined as BMI<22 kg/m^2 or involuntary weight loss >5 kg last six months or severe reduced food intake.
[b] Involuntary weight loss >5 kg last six months.
[c] Severely reduced food intake; An answer of "half of usual" or "almost nothing".

those visited in their homes and among residents in nursing homes, as compared to community-dwelling older adults who met at fields stations, higher among women and increased gradually with increasing age. This is the first study to present the prevalence of malnutrition in a general population of older adults in Norway.

Most studies report on the risk of malnutrition using screening tools. Crichton and co-workers [29] reported that malnutrition rates in community-dwelling older adults in Northern Europe was 1.9–2.5% measured by the malnutrition diagnostic tools Mini Nutritional Assessment (MNA), Subjective Global Assessment (SGA) or Patient-Generated Subjective Global Assessment (PG-SGA). The prevalence in Northern Europe (1.9%) was among the lowest prevalence reported globally and was much lower than in our population. In Europe overall, Crichton et al. [29] reported a prevalence of 2.8% among community-dwelling older adults and 11.2% for those receiving home care. The MaNuEL-consortium reviewed prevalence studies of malnutrition in older adults and showcased the variations in prevalence across studies and settings but did not conclude on a prevalence rate [17]. We speculate that the higher prevalence in our population is due to an older population, and the inclusion of both care-dependent and -independent older adults. However, the occurrence of malnutrition varies greatly depending on the tools used and the agreement with malnutrition diagnostic criteria.

Malnutrition is of concern as it increases both morbidity and mortality. In older adults in Northern and Central Norway, mortality increased by 20% for each 2,5 kg/m^2 decrease in BMI below 25 kg/m^2 [19]. Beck and Ovesen suggested a BMI cut-off of 24 kg/m^2 when screening for malnutrition in older adults [30]. In the GLIM criteria, a BMI below 22 kg/m^2 is suggested as the cut-off for malnutrition in persons over 70 years, while a BMI below 20 kg/m^2 fulfils the criterion for severe malnutrition in this age group [13]. The prevalence of low BMI in our population is within the range of

those found in the MaNuEL-study, in which BMI <22kg/m^2 was present in 4–11% of community-dwelling older adults and 8–34% of nursing home residents, while BMI <20 kg/m^2 was found in up to 4% of community-dwelling older adults and 4–18% of nursing home residents [17]. In another population of Norwegian older adults, 3% had a BMI below 20 kg/m^2 [19], however this population was restricted to community-dwelling older adults who met at field stations.

For those reporting a recent weight loss, an average loss of at least 6.7% could be considered significant and a reason for concern in this population of older adults. Weight loss of more than 5 kg in the last six months was most frequent in older adults participating through home visits and older adults in nursing homes. In general, in our population weight loss was higher or in the higher ranges of that reported for older adults by Wolters et al. [17]. Other studies have reported higher rates of involuntary weight loss than ours, such as 10% of an Irish population of older adults in which assessments were performed both at field stations and by home visits [31], and 16% of nursing home residents in the Netherlands [32].

Severely reduced food intake was present in 1.3% of our population, with higher prevalence among older adults in nursing homes and for those visited in their homes. In the MaNuEL-project, much higher rates of severely reduced food intake were reported among 10% of community-dwelling older adults, but similar percentages as ours among nursing home residents [17]. It should be noted that the number of missing values for this variable was high in our study. One possible explanation is that food intake is generally difficult and resource-intensive to assess. When estimating energy intake by observation, as many as 81% of nursing home residents were found to have an intake below 90% of their needs [32].

We found the highest prevalence of malnutrition among the older adults examined at home. They were also older, had higher rates of dementia, lower self-perceived health and had higher rates of widows/widowers than participants examined at field stations (Supplementary Table 3). This group of older adults may be particularly vulnerable to malnutrition as they are care-dependent, yet do not have access to continuous health care follow-ups the same way nursing home residents have. In addition, women were more likely to be malnourished independently of age. This is in line with previous findings, where women were 45% more likely to be malnourished as compared to men [29]. Thus, home care workers should have a special focus on frequent screening for malnutrition and monitoring weight in these older adults.

4.2. Strengths and limitations

Our study has a large sample size compared to other studies, and the entire older population of a Norwegian county was invited. The assessments in HUNT4 70+ were performed both at field stations and by ambulatory teams, and thus the study includes both care-dependent and care-independent older adults. Furthermore, the attrition of non-participation was addressed by applying IPW for sex, age and education.

Our study also has limitations. We cannot exclude selection bias completely, even though we have used IPW. Those who were excluded from the analyses due to missing data on BMI, involuntary weight loss and food intake had higher rates of dementia and poor self-perceived health than among included participants. In addition, more than half of the participants at nursing homes and those examined at home were excluded due to one or more missing variables (Supplementary Table 5). There is reason to believe that we exclude more of the most vulnerable older adults, that our malnutrition estimates are conservative, and that the true prevalence is higher especially among the care-dependent older adults.

In HUNT4 70+, measurements were collected by many assessors. However, the assessors were all health care workers, and received training based on a standardised protocol. Furthermore, we cannot rule out recall bias as both involuntary weight loss and food intake were self-reported by the participant, their next-of-kin, or health care personnel with first-hand knowledge of the participant. Finally, the participants in the HUNT Study are mainly of European ancestry and the findings may not be generalizable to other populations [23].

4.3. Clinical and societal implications

Our study presents the prevalence of malnutrition in a representative population of older adults in Norway. Our estimate is likely to be a conservative one. We had a high number of missing data among the nursing home residents, who are the most vulnerable in our population. Still, the prevalence of malnutrition is higher in our study compared to most of the previous studies among older adults [17]. For the affected older individuals, malnutrition can contribute to frailty, cognitive impairment, increased risk of falls and infections, reduced quality of life, and premature mortality [33,34]. Therefore, health and care workers should give special attention to prevention and treatment of malnutrition in care-dependent older adults living at home and in nursing homes, the oldest adults, and older women. For the society, malnutrition leads to increased use of health- and care services, and thus higher health- and care costs [11,12]. Since malnutrition affects individuals, but also has a profound impact on the total health and care cost, knowledge about the prevalence of malnutrition is vital for accurate planning of current and future health and care services. This is especially relevant considering the increasing population of older adults.

5. Conclusions

The prevalence of malnutrition is high among older adults. Malnutrition is increasing with increasing age, and is more prevalent in older women, and among care-dependent older adults. Updated prevalence numbers can be used in the planning of current and future health and care services.

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Authors' contributions

MK: Conceptualization, Methodology, Investigation, Formal analysis, Writing - Original Draft, Visualization, Project administration. IP, LT: Conceptualization, Methodology, Writing - Original Draft, Supervision. TNF: Conceptualization, Methodology, Writing - Original Draft, Supervision, Project administration. YQS: Methodology, Formal analysis, Writing - Original Draft. LG, HKS, PT, GS: Resources, Project administration, Methodology and Investigation in the HUNT4 70+ Survey, Writing - Review & Editing. BHS: Methodology, Resources, Writing - Review & Editing. All authors approved the final manuscript.

Declaration of competing interest

HKS is a board member in NOEN AS. All other authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2023.08.016.

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