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Food intake and prevalence of malnutrition in nursing homes. A multicenter observational study

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Objective. The aim of this study was to investigate malnutrition prevalence and its associated factors in NHs including resident food and liquid intake.

Methods. We conducted a multicenter observational study in Italian NHs. NHs were recruited using a convenience sample from regional register. To detect malnourished residents, we used Body Mass Index (BMI) < 18.5 kg/m^2 and another criterion based on unintentional weight loss combined with reduced BMI. We performed logistic regression to identify associated factors with malnutrition.

Results. We recruited 1795 residents that lived in 29 NHs. 76% were female, with mean age 85.4 ± 8.5 years. 275 out of 1787 residents (15.4, 95% CI 13.8-17.2%) were malnourished . Moreover, when we combined BMI measures (< 20 kg/m^2 if residents < 70 years or < 22 kg/m^2 if residents ≥ 70 years) with unintentional weight loss data in the previous 6 months (5-10% or greater than 10%) we found that 18.1% residents were malnourished. Malnourished residents drank less (median 702 ml per day) than well nourished ones (median 800 ml per day) and ate less, especially at dinner. Malnutrition was significantly associated to age, psychiatric disorders, disability in activity of daily life, feeding assistance, swallowing and chewing problems and poor fluid intake. Moreover, we found a higher number of malnourished residents amongst those who needed more feeding care during dinner, when there was a lower number of staff. This result confirms the strong relationship between the care feeding and malnutrition.

Conclusions. In this study we found that malnourished residents were older with poor functional ability, chewing problems, dependence in feeding and poor fluid intake. Interventions to prevent malnutrition in nursing homes are a priority for the practice and for further studies.

Key words: malnutrition, nursing homes, food intake, prevalence, observational study

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INTRODUCTION

Nutrition is important for wellbeing and health at all ages, but it is a core component of health maintenance in older people [1]. Malnutrition, in particular, protein-energy malnutrition, is a very common issue in older people and it worsens quality of life, increases mortality, morbidity, infection and pressure ulcers rate, and reduces wound healing [2-5]. In Nursing Homes (NHs) the malnutrition risk is higher because of the characteristics of the residents, who are older and frailer; coexisting malnutrition and severe frailty predict mortality in NHs setting [6].

In NHs, the prevalence of malnutrition ranges from 1.5 to 66.5%. This variability is due to different definitions of malnutrition and screening tools [2,7].

In 2015, the European Society of Clinical Nutrition and Metabolism (ESPEN) identified, after a consensus conference, two alternative criteria to diagnose malnutrition. The main criterion was the Body Mass Index (BMI) < 18.5 kg/m^2. As an alternative, malnutrition could be diagnosed combining unintentional weight loss (mandatory) and at least one of either reduced BMI or a low fat free mass index (FFMI). Unintentional weight loss must be more than 10% indefinite of time, or > 5% over the last 3 months. BMI cut-offs are < 20 kg/m^2 if < 70 years of age, or < 22 kg/m^2 if 70 years of age and FFMI cut offs are < 15 and 17 kg/m^2 in women and men [8].

Malnutrition in older people has a multifactor etiology that includes nutritional, clinical, neuropsychiatric and social factors [2,9]. The nutritional factors composed of inadequate habits, insufficient food intake, decreased appetite, drug-nutrient interaction and restrictive dietary prescriptions. Among the clinical factors, we count chewing difficulties, edentulous and ineffective management of the prosthesis, nausea, vomiting, mal-absorption, protracted diarrhea, chronic diseases and dysphagia. The neuro-psychiatric factors comprise confusion, depression, dementia and other neurological disorders. The social factors included the cultural level, poverty, institutionalization, inadequate assistance during meals [10-13].

A poor food intake is a predictor for mortality [13], therefore, it is essential to monitor food intake on people at risk to become malnourished [14]. Multifactorial strategies provided to NHs residents, such as organising mealtimes in a familiar way, favouring social interactions, providing individualised care, promoting self-feeding ability during the meal, seems to increase dietary intake [13-19]. Furthermore, it is fundamental to identify early malnutrition risk using systematically tools, such as the Malnutrition Universal Screening and to monitoring malnutrition with multidisciplinary approach, involving health care team [12,20].

In the recent years, several studies investigated malnutrition prevalence and food intake in NHs, especially examining disease related factors [17,21], but only a few studies were performed in Italian residential facilities [9,22,23].

Knowing the magnitude and the characteristics of malnourished people is a key element to implement preventive strategies. Therefore, this study proposed to describe in Italian NHs the prevalence of malnutrition and related risk factors, including functional factors and food intake. Specifically, we were interested in exploring the following questions:

- What was the prevalence of malnutrition among nursing homes' residents?
- Which demographic and main clinical characteristics were associated with malnutrition?
- Were food and fluid intake and feeding assistance associated with malnutrition?

METHODS

Study design

We carried out an observational prospective multicenter study in a network of NHs in Milan and Brescia (Northern Italy), from October to November 2016. Our research was a part of a wide multi method study that aimed to explore nutritional care in NHs.

Setting and participants

We involved regional NHs that included two main typologies of units based on residents' characteristics: residents with prevalent chronic clinical problems and functional impairments (NHs units) and residents with severe dementia and Behavioural and Psychological Symptoms of Dementia (special care units for dementia).

NHs were recruited using a convenience sample. First, we enlisted the NHs by the regional register, considering their ownership (public, private), unit typology (NHs units and special care units for dementia) and facility size: small (40-90 residents), medium (91-160 residents) and large (more than 160 residents). Further information on NH selection is reported in *Supplementary File*.

We invited 32 NHs, representing various facility sizes, 20 NHs of which also had special care units for dementia. Out of 32 NHs, 29 accepted to participate in the study. In every nursing home, we selected randomly some units and special care wards for dementia. We included all residents living in randomized units at the time of the study, excepting people admitted in hospital for acute treatment.

Data collection and measures

To measure the prevalence and factors associated to malnutrition, data regarding:

1) socio-demographic characteristics data of residents (gender, age, length of stay);
2) clinical characteristics: autonomy in Activities of Daily Living (ADL) assessed with the Modified Barthel Index [24,25]; cognitive function, using the Mini Mental State Examination (MMSE) [26,27]; comorbidity by the Cumulative Illness Rating Scale (CIRS), which includes psychiatric/mental disorders [28,29], previous falls and pressure ulcers;
3) nutritional conditions: chewing and swallowing problems and body mass index (BMI);
4) NH characteristics such as ownership, facility size and unit type;
5) residents' intake, which included fluid (ml/day) and food intake (in a day) and need of assistance in feeding during the meals.

All healthcare personnel received a training to collect research data in two steps. In the first step, researcher AC, LB and MM, for every NH, trained a contact nurse, all registered nurses and physicians involved in the study. In the second stage, each nurse, with the support of researchers, trained and supervised the assistant nurses before and during the study.

Demographic and clinical data were collected from residents' record with the support of nurses and physicians. All clinical data pertained to the previous three months; while MMSE and previous falls referred to six months prior to the study.

For all the residents that expressed positive consent, food and fluid intake were collected for two consecutive days including weekend days to detect any variability, through a specific questionnaire.

Intake observation tool, used in a previous pilot study [23], was reviewed and re-tested in one NH, before the study. Residents were observed continuously during the main meals (breakfast, lunch, dinner and refreshments).

After each meal, on the daily intake tool, the staff (nurses and assistant nurses) took note about: a) the type and amount of food and/or liquid consumed by residents b) time to consume the meal c) medications and feeding assistance during meal. The staff estimated the amount of food, in terms of portions eaten using a picture of a plate and a glass: full, three-quarters, half, a quarter, or nothing (observation tool are available in *Supplementary File*).

To guarantee reliable data, we planned maximum intake observations of two residents per day.

Outcome, sample size and data analysis

Primary outcome was nutritional status, codified as malnourished (BMI < 18.5) and well-nourished resident (BMI ≥ 18.5) [8]. In addition, we explored the secondary diagnostic criterion based on unintentional weight loss > 10% indefinite of time, combined with reduced BMI: < 20 or < 22 kg/m^2 in subjects younger or older than 70 years, respectively [8]. We chose above-mentioned criterion, according to a preliminary feasibility analysis study. According to criterion BMI < 18.5 to diagnose malnutrition, suggested by ESPEN [8], we expected prevalence of 30% malnourished residents.

The sample size was calculated on the average prevalence of malnutrition in NHs, as reported in the literature. Expecting a 30% prevalence of malnutrition, a sample of at least 323 people was estimated at 95% level of confidence, with a power of 80%. Calculating for possible dropouts of people unable to give the consent, we calculated a sample of approximately 700 residents in almost 23 NHs.

Regarding the intake and feeding assistance, we expected residents receiving more feeding assistance could be less malnourished.

With regard to nutritional conditions, we analysed the following variables: daily fluid intake (ml/day; calculated as the mean of intake in two consecutive days) and daily food intake at lunch and at dinner (categorised in 4 classes: 0-25%, 26-50%, 51-75%, 76-100%), feeding assistance during lunch and dinner (no assistance, minimal, supervision, active and total assistance). Details are shown in *Supplementary File.*

Categorical variables were reported using absolute frequencies and percentages.

Numerical variables were reported using mean and standard deviation or median, quartiles (Q_1, Q_3) and interquartile range (IRQ) for the variables with evident asymmetric distribution.

The prevalence of malnutrition and the association with the risk factors were assessed through univariate and multivariate logistic regression models, with nutritional status as response variable.

In the univariate analysis, the association was assessed including each factor in a logistic model as an explanatory variable.

In the multivariate analysis, we determined a priori the number of variables to put in the model, according to the 10-events-per-variable rule [30], to avoid overfitting [31]. According to this rule, the variables considered were: gender, age, type of unit, Barthel score, psychiatric/mental disorders, pressure ulcers, chewing difficulty, swallowing difficulty, feeding assistance, food intake at lunch, food intake at dinner, fluid intake. Age and gender were considered as potential confounding factors. Using a backward variable selection procedure we excluded variables with not significant contribution to the model, except the confounding factors that were always kept in the model.

The results from the univariate and multivariate analysis were reported in terms of estimated Odd Ratio (OR) of malnutrition with respective 95% confidence intervals,

and tests of association. The overall association was assessed by the Likelihood Ratio (LR) test (chi-square distribution).
For each test, the statistical significance was considered if the p-value was lower than 0.05. All the analyses were performed with the R software version 3.4.1 for Windows [32].
The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline was used to report the findings. Adherence to the STROBE checklist and further information on statistical analysis are documented in *Supplementary File.*

RESULTS

Residents characteristics, malnutrition prevalence and food intake

We recruited 1795 residents who lived in 29 NHs located in two provinces in Northern Italy, and we collected the data, from October to December 2016.
Primarily, we detected clinical and nutritional data, including all 1795 recruited residents. Out of 1795 residents, 8 had missing data on nutritional status. Residents were average 85.4 (± 8.5) years old; the 75.8% were female.
Overall, we found that out of 1787 residents, 275 were malnourished (15.4, 95% C.I. 13.8- 17.2%) (Tab. I). The women, older residents, with pressure ulcer, with chawing and swallowing problems were more malnourished; these differences were statistically significant.
Moreover, according to second diagnostic criterion by ESPEN, when we considered the combination of BMI (20 kg/m^2 if residents < 70 years old or < 22 kg/m^2 if residents ≥ 70 years old) and unintentional weight loss (between 5-10% and greater than 10%) we found that 7.6% of residents (128 out of 1675) were malnourished *(see also Supplementary file).*
In the second stage of the study, we observed food and liquid intake, excluding residents on tube feeding or parenteral nutrition. Therefore, we included 1300 residents who met eligibility criteria and consented to meals observation (Tab. II).
Tables I-II show the main characteristics of participants comparing malnourished to those well nourished residents.
Malnourished residents drank less (median 702 ml per day) than well nourished (median 800 ml per day). Also they ate less, especially at the dinner; indeed the residents who ate nothing to half of the meal were 13.6% among the malnourished and 9% among well nourished people. Moreover malnourished residents needed more feeding care than the well-nourished one: 40.8 *vs* 18.7% residents received total assistance during the meals (Tab. II).

Factors associated with malnutrition

Results of the logistic regression models are presented in Tables III, IV and V.
In univariate analysis, malnutrition was significantly associated with female gender, older age, severe mental disorders, poor autonomy in daily activities (Barthel Index), and pressure ulcers in the last three months. In addition, residents were more malnourished when needed total assistance in feeding, had chewing and swallowing problems (Tab. III).
Overall, we found that more malnourished residents had a daily-reduced fluid and dinner food intake and had higher need of assistance during meals, especially during dinner (total assistance OR 3.92, 95% CI 2.60-5.93) (See Table IV). Finally, we found a lower prevalence of malnutrition in residents who lived in larger NHs (OR 0.62, 95% CI 0.42-0.90). No significant association emerged for the remaining variables.
In the multivariate analysis, we found significant association with nutritional status for: age, pressure ulcers, chewing difficulty, fluid intake, and feeding assistance (Tab. V).

DISCUSSION

This study aimed to measure the prevalence of malnutrition and to explore the variables associated with malnutrition, including food intake in Northern Italian NHs. Based on our knowledge, this is one of the few studies conducted in Italian facilities [9,22,23], that involved a large sample of NH residents. In addition, it is one of the first studies that used the ESPEN criteria [8], to intercept malnourishment within NHs, although recently new criteria to diagnosis malnutrition have been developed by the Global Leadership Initiative on Malnutrition (GLIM) malnutrition [33]. The new GLIM criteria define malnutrition considering phenotypic (weight loss, low body mass index (BMI) and reduced muscle mass) and etiologic (reduced food intake or assimilation and inflammation) variables [33].
According the cut off of BMI < 18.5 Kg/m^2, prevalence of malnutrition in our study was 15%, similarly to other studies [2]. Interestingly, when used an alternative diagnostic criterion, based on the combination of unintentional weight loss, and low BMI we found a higher rate of 18% [8].
Older age, female, functional ability, psychiatric/mental disorders, pressure ulcers, chewing problems, swallowing problems, lower daily liquid intake and lower food intake were associated with a higher risk of being malnourished in univariate analysis. The results about older age and female are in line with findings from Keller et al. [34], but they are inconsistent with Van Zwienen et al. [21]
Moreover, a strong association between malnutrition and pressure ulcers has also been found in other studies [35-37].

Table I. Demographic and clinical characteristics of NHs residents.

	Malnourished (n = 275)	Well nourished (n = 1512)	Overall (n = 1787)	*P*-value
Female * n (%)	236 (85.8)	1119 (74.0)	1360 (75.8)	< .001
Age (years) †				< .001
Mean (SD)	87.5 (8.4)	85.0 (8.4)	85.4 (8.5)	
Range	51.2-105.5	49.0-105.2	49.0-105.5	
CIRS comorbidity Index §				
Mean (SD) †	5.55 (2.07)	5.41 (2.11)	5.43 (2.11)	.32
CIRS severity index ‖				
Mean (SD) †	2.04 (0.39)	2.02 (0.40)	2.02 (0.40)	.23
Range	1.00-3.46	1.00-3.38	1.00-3.46	
Psychiatric/mental state				
(including dementia (14^ category of CIRS)*				.006
No problem	22 (8.0)	131 (8.7)	153 (8.6)	
Mild	15 (5.5)	89 (5.9)	104 (5.8)	
Moderate	66 (24.0)	519 (34.3)	585 (32.7)	
Severe	132 (48.0)	633 (41.9)	765 (42.8)	
Very severe	39 (14.2)	138 (9.1)	177 (9.9)	
Missing	1 (0.4)	2 (0.1)	3 (0.2)	
Barthel score **				
Median; Q1-Q3‡	8; 0-23	24; 6-57	21; 5-52	< .001
Range	0-95	0-100	0-100	
Missing*	3 (1.1)	1 (0.1)	4 (0.2)	
Chewing problem *				
No	133 (48.4)	1037 (68.5)	1170 (65.5)	< .001
Yes	140 (50.9)	468 (31.0)	608 (34.0)	
Missing	2 (0.7)	7 (0.5)	9 (0.5)	
Swallowing problem*				
No	183 (66.5)	1252 (82.8)	1435 (80.3)	< .001
Yes	90 (32.7)	254 (16.8)	344 (19.3)	
Missing	2 (0.7)	6 (0.4)	8 (0.4)	
Pressure ulcers*				
None	227 (82.5)	1371 (90.6)	1598 (89.4)	< .001
One or more	48 (17.5)	140 (9.3)	187 (10.6)	
Missing	0	1 (0.1)	1 (0.1)	
Accidental falls*				
No falls	232 (84.5)	1263 (83.5)	1495 (83.7)	.72
One or more falls	41 (4.9)	242 (16.0)	283 (15.8)	
Missing	2 (0.4)	7 (0.5)	9 (0.5)	
Length of stay (years)				
Median; Q1-Q3 ‡	2.3; 0.8-5.2	2.0; 0.8-4.4	2.1; 0.8-4.5	.20
Range	0.0-66.9	0.0-76.6	0.0-76.6	
Missing*	3 (1.1)	8 (0.5)	11 (0.6)	

* N (%); † SD (standard deviation); ‡ Q1-Q3 (IQR Interquartile Range);
§ **CIRS (Cumulative Illness Rating Scale)**; **CIRS Comorbidity score** ranges represents the number of categories in which a score greater than or equal to three is obtained (excluding the cognitive-behavioural category) the range score is from 0 (no disease) to 13 (13 diseases).
‖ **CIRS (Cumulative Illness Rating Scale)** CIRS **Severity score** results from the average of the scores of the first 13 categories (excluding the psychiatric / behavioural pathologies category).
** **Barthel score** ranges from 0 (severe dependent) to 100 (autonomy).

The level of assistance received during mealtimes was significantly associated with a greater number of malnourished residents, similarly to other studies [2,9-12,34]. This is a crucial issue for healthcare professionals that should pay closer attention to nutrition problems and food intake among NHs' residents [15].

Table II. Food and fluid intake characteristics of NHs residents.

	Malnourished (n = 169)	Well nourished (n = 1131)	Overall (n = 1300)	*P*-value
Fluid intake (ml)				
Median; Q_1-Q_3‡	702; 612-881	800; 672-854	796; 650-975	< .001
Range	435-1550	310-1800	310-1800	
Missing*	14 (8.2)	104 (9.2)	118 (9.1)	
Food intake at lunch (portion)*				
0-25%	7 (4.1)	28 (2.5)	35 (2.7)	.17
26-50%	12 (7.1)	70 (6.2)	82 (6.3)	
51-75%	37 (21.9)	184 (16.3)	221 (17.0)	
76-100%	112 (66.3)	848 (75.0)	960 (73.8)	
Missing	1 (0.6)	1 (0.1)	2 (0.2	
Food intake at dinner (portion)*				
0-25%	3 (1.8)	28 (2.5)	31 (2.4)	.013
26-50%	20 (11.8)	73 (6.5)	93 (7.2)	
51-75%	40 (23.7)	196 (17.3)	236 (18.2)	
76-100%	106 (62.7)	829 (73.3)	935 (71.9)	
Missing	0 (0.0)	5 (0.4)	5 (0.4)	
Feeding lunch, day 1*				< .001
No assistance	41 (24.3)	494 (43.7)	535 (41.2)	
Minimal assistance	28 (16.6)	250 (22.1)	278 (21.4)	
Supervision	24 (14.2)	106 (9.4)	130 (10.0)	
Active assistance	9 (5.3)	44 (3.9)	53 (4.1)	
otal assistance	63 (37.3)	223 (19.7)	286 (22.0)	
Did not eat that day	4 (2.4)	10 (0.9)	14 (1.1)	
Missing	0 (0.0)	4 (0.4)	4 (0.3)	
Feeding dinner, day 1 *				< .001
No assistance	44 (26.0)	530 (46.9)	574 (44.2)	
Minimal assistance	26 (15.4)	222 (29.6)	248 (19.1)	
Supervision	19 (11.2)	98 (8.7)	117 (9.0)	
Active assistance	8 (4.7)	32 (2.8)	40 (3.1)	
Total assistance	69 (40.8)	212 (18.7)	281 (21.6)	
Did not eat that day	2 (1.2)	3 (2.7)	33 (2.5)	
Missing	1 (0.6)	6 (0.5)	7 (0.5)	

* N (%); ‡ Q1-Q3 (IQR Interquartile Range) (*Details are shown in Supplementary File*)

Differently to Pezzana et al. [38], we found a higher prevalence of malnutrition in small sized NHs. This difference could be due to diverse local health systems, although both studies were conducted in Italy. Moreover, our results could be explained because bigger NHs have a more standardized approach to deal with nutrition services and the quality of nutritional care could be better. They have probably also more technical and human resources. Many factors such as the dining room environment, quality of the food, eating behaviours and preferences, clinical conditions, and level of autonomy in the activity of daily life, can influence food intake among NHs residents [34].

The multivariate logistic regression confirmed the positive association among malnutrition, swallowing and chewing problems, as other studies [39,40]. Nurses play a strategic role in systematic assessment of residents' oral health, since they could intercept at early stages a dysfunction in chewing and swallowing or other issues and adapt the food consistency and flavour consequently [41].

Multivariate analysis didn't confirm the association between malnutrition and female gender, differently from a study conducted in hospitals within the same geographic area [42]. However, as in the mentioned study [42], older age and pressure ulcers were associated with malnutrition also in multivariate analysis. This could represent a trend in the older population in Italy, as well as worldwide in developed countries.

Feeding assistance at dinner was also confirmed in the multivariate analysis, as a factor significantly associated with malnutrition. This is consistent with new GLIM

Table III. Association between malnutrition and demographic and clinical variables: univariate analysis.

	Strength of association: OR (95% C.I.)	LR test: Chi-square (df)	*P*-value
Gender		19.512 (1)	< .001
Male	1		
Female	2.13 (1.49-3.04)		
Age *	1.48 (1.25-1.75)	22.128 (1)	< .001
length of stay		3.659 (3)	.30
0-1 year	1		
1.1-3 years	0.95 (0.67-1.33)		
3.1-10 years	1.27 (0.92-1.74)		
> 10 years	1.11 (0.60-2.07)		
Type of structure		2.796 (1)	.09
Public	1		
Private	1.31 (0.95-1.80)		
Facility size		17.344 (2)	< .001
40-90 residents	1		
91-160 residents	1.08 (0.74-1.58)		
> 160 residents	0.62 (0.42-0.90)		
Type of unit		0.195 (1)	.65
Nursing home units	1		
Special care units for dementia	0.93 (0.69-1.23)		
Unit size		2.57 (1)	.10
Small	1		
Medium/high	1.33 (0.95-1.87)		
Pressure ulcers		14.605 (1)	< .001
None	1		
One or more	2.07 (1.45-2.96)		
Accidental falls		0.197 (1)	.65
None	1		
One or more	0.92 (0.64-1.32)		
CIRS severity index	1.21 (0.88-1.67)	1.353 (1)	.24
CIRS comorbidity index	1.03 (0.97-1.10)	0.961 (1)	.32
Psychiatric/mental disorders (by CIRS)		15.822 (4)	.003
1 No problem	1		
2 Mild	1.00 (0.49-2.04)		
3 Moderate	0.76 (0.45-1.27)		
4 Severe	1.24 (0.76-2.02)		
5 Very severe	1.68 (0.95-2.99)		
AdL - Barthel score †	1.27 (1.20-1.35)	80.770 (1)	< .001
Chewing difficulty		40.023 (1)	< .001
No	1		
Yes	2.33 (1.80-3.03)		
Swallowing difficulty		33.384 (1)	< .001
No	1		
Yes	2.42 (1.82-3.23)		
Feeding assistance (Barthel Index)		58.630 (4)	< .001
None	1		
Minimal	1.19 (0.72-1.97)		
Supervision	2.70 (1.73-4.22)		
Active	2.33 (1.41-3.85)		
Total	3.94 (2.52-6.16)		

* The OR was calculated for a 10-year increase of age; † The OR was calculated for a 10 point decrease of Barthel score

Table IV. Association between malnutrition and food intake: univariate analysis.

	Strength of association: OR (95% C.I.)	Global test: Chi-square (df)	*P*-value
Fluid intake* (ml):	1.15 (1.07-1.24)	14.481 (1)	< .001
Food intake at lunch		4.978 (3)	.17
0-25	1		
26-50	0.77 (0.26-2.26)		
51-75	0.90 (0.35-2.35)		
76-100	0.59 (0.24-1.47)		
Food intake at dinner		10.753 (3)	.013
0-25	1		
26-50	2.47 (0.68-8.97)		
51-75	1.84 (0.53-6.35)		
76-100	1.15 (0.34-3.86)		
Feeding assistance, lunch, day 1		39.085 (3)	< .001
None	1		
Minimal	1.35 (0.82-2.23)		
Supervision	2.73 (1.58-4.71)		
Active	2.46 (1.12-5.40)		
Total	3.40 (2.23-5.20)		
Feeding assistance, dinner, day 1		47.919 (3)	< .001
None	1		
Minimal	1.41 (0.85-2.35)		
Supervision	2.34 (1.31-4.17)		
Active	3.01 (1.31-6.93)		
Total	3.92 (2.60-5.93)		

*The OR was calculated for a 100-ml decrease of liquids; We stated only first day because we did not observe any difference between first and second day under observation.

Table V. Association between malnutrition and demographic, clinical and food intake: multivariate analysis.

	Strength of association: OR (95% C.I.)	LR test: Chi-square (df)	*P*-value
Gender		3.83 (1)	0.05
Male	1		
Female	1.63 (1.00-2.65)		
Age		6.81 (1)	.009
< 80 years	1		
≥ 80 years	1.99 (1.19-3.34)		
Pressure ulcers		5.49 (0)	.019
No	1		
Yes	1.89 (1.11-3.22)		
Chewing difficulty		10.58 (1)	.001
No	1		
Yes	1.97 (1.31-2.96)		
Fluid intake* (ml)	1.14 (1.05-1.24)	10.26 (1)	.001
Feeding assistance, dinner		8.42 (1)	.003
Low	1		
High	1.84 (1.22-2.77)		

*The OR was calculated for a 100-ml decrease of liquids.

criteria in which one among the etiological variable is food intake [33]. This result confirms the strong relationship between feeding care and malnutrition. In fact, to provide a correct meal intake, it is important to offer residents an individualized nutritional care, guaranteeing them a sufficient time to eat and adequate staff during mealtimes [14-19,42]. To overcome staff shortage issues in healthcare facilities, some strategies that could improve food intake in older people include the involvement of trained relatives or voluntaries during mealtimes [16,43].

This study confirmed the association between some variables and malnutrition. Therefore, NHs healthcare professionals should consider such variables in order to adopt prompt preventive strategies. Malnutrition can be considered a disease in the disease [42] and if not adequately prevented, it can worsen the clinical outcome in an already extremely frail population. Malnutrition among NHs residents should be treated by a multidisciplinary team, that include all healthcare professionals, dieticians, NHs food services' and canteens' personnel [20,44]. Moreover, in order to ensure adequate nutritional intake, multimodal interventions should take into account individualised and comprehensive nutritional, hydration, oral care and mealtime assistance [44]. For future studies, the new GLIM [33]criteria should be used for the diagnosis of malnutrition.

Limitations

This study has some limitations. Firstly, a different person in each NH performed data collection. Although the personnel involved in each facility received specific training and support by researchers, we cannot exclude some inaccuracies in data collection, due to the complexity of data.

Another possible weakness is selection bias, since we involved voluntary NHs. This could affect the reliability of the association, because of confounding variables, even if the sample size might have partially reduced this risk.

To detect the intake, we used similar tools adopted by some facilities. We reviewed and re-tested each tool for the estimation of the amount of food and liquid, even if we did not test the interrater reliability (staff agreement).

Moreover, based on the feasibility analysis, in order to detect malnutrition it was not possible using a standard malnutrition risk tool and the fat free mass index (FFMI), since many NHs did not use regularly both and preferred not to implement them during that time.

Finally, even if we involved a large sample, our findings could not be representative of all Italian NHs.

CONCLUSIONS

Older people living in residential facilities are frailer, and therefore they are at a higher risk of complications such as malnutrition. This study provided a comprehensive description of malnutrition prevalence in NHs' residents. In our study malnutrition was associated with older age, pressure ulcers, chewing problems, fluid intake and feeding assistance. Therefore, healthcare personnel should systematically monitor resident's nutritional status, including oral health, and prevent and treat malnutrition and dehydration as soon as possible. In order to favorite a good nutrition, it is important to offer residents an individualized nutritional care, guaranteeing them a sufficient time to eat and adequate staff during mealtimes.

The strong point of this study is that we involved a large number of NHs, with different size, in a vast area. Therefore, our findings could be considered a good picture of recent situation about malnutrition in the Italian NHs.

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We applaud the nursing homes that agreed to participate in this study and made a great effort to encourage the involvement of consented residents. It was a challenge, considering that obtaining informed consent from nursing home residents, is a mainly obstacle, especially form resident with cognitive impairment. Moreover, we believe that these studies could promote a cultural change among all people – administrators, personnel, residents, relatives – involved for any level of the research. Finally, we thank Amalia Morelli for the valuable support on the English translation.

Conflict of interest statement

All the Authors declare no conflicts of interest.

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Authors' contributions

AC, EZ and LB: study concept and design; MZ, MM, MCG and GA: acquisition of data; AC, LB, EZ, GM, AN, AI and ML: Analysis and interpretation of data; AC and LB: drafting of the manuscript; EZ, AN and ML: critical revision of the manuscript for important intellectual content.

Ethical consideration

The ethical committee of each province (Number protocol: P1_267_2016; P2_2444_2016) and the Institutional Review Boards (IRB) of every participating NHs approved the study. All residents or their legal guardians (e.g. next of kin) were invited to give written informed consent, before participating in the study. All data were anonymised and collected in accordance with Italian regulations and the 1964 Helsinki Declaration and its latest amendments.

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SUPPLEMENTARY FILE "PREVALENCE OF MALNUTRITION AND FOOD INTAKE IN NURSING HOMES. A MULTI-CENTER OBSERVATIONAL STUDY"

Definition of Sample size and NHs residents' involvement

Before proceeding with recruitment, the NHs contractualized with the Regional Health Care System were classified on the basis of their size defined on number of beds and/or the presence of specialised unit for dementia. Expecting a 30% prevalence of malnutrition, we estimated involving 1000 residents, recruiting 23 NHs, that represent 10% of the overall contractualized NHs. We invited NHs in order to obtain a sample of residents equally representative of different NH size (see Table 1).

Additional information on statistical analysis plan

The main goal of the analysis was to assess the prevalence of malnutrition and its association with the variables previously illustrated. Categorical variables were reported using absolute frequencies and percentages. Numerical variables were reported using mean and standard deviation or median quartiles (Q1 Q3) for the variables with evident asymmetric distribution. The prevalence of malnutrition and the association with the considered factors were assessed through logistic regression models with nutritional status as response variable. The strength of association was estimated as the ratio of the odds (OR) of malnutrition for each category of the explanatory variable considering one category

Table 1. Definition of sample size and involved residents' NHs.

	40-90 residents N (%)	91-160 residents N (%)	> 160 residents N (%)	Total N (%)
MI -Tot residents contractualized NHs	3926 (57)	7004 (60)	4872 (15)	15802 (131)
MI - number minimum residents for sample size*	118 (6)	210 (6)	146 (2)	474 (14)
MI - Tot residents in NHs invited	303 (4)	959 (11)	1319 (7)	2581 (22)
MI - Selected residents in NHs	63 (2)	504 (11)	903 (7)	1470 (20)
BS - Tot residents in contractualized NHs	3389 (55)	2759 (25)	512 (3)	6660 (83)
BS - N minimum residents for sample size*	102 (5)	83 (3)	15 (1)	200 (9)
BS - Tot residents in NHs invited	391 (5)	480 (4)	175 (1)	1046 (10)
BS - selected residents in NHs	115 (5)	162 (3)	65 (1)	342 (9)
Tot invited residents in both provinces	**694 (9)**	**1439 (15)**	**1494 (8)**	**3527 (32)**
Tot selected residents in both provinces	**178 (7)**	**666 (14)**	**968 (8)**	**2396 (29)**
Tot effective residents in both provinces	**250**	**639**	**906**	**1795**

MI: Milano; BS: Brescia; *N residents: 30% tot residents that lived in 10% accredited NHs

Table 2. Further clinical characteristics of NHs residents and organizational characteristics.

	Malnourished (n = 275) N (%)	Well nourished (n = 1512) N (%)	Overall (n = 1787) N (%)	*P*-value
MMSE (cognitive status)				< .001
> 24 (intact)	23 (8.4)	247 (16.3)	270 (15.0)	
20-24 (borderline)	16 (5.8)	223 (14.7)	239 (13.4)	
17-19 (mild impairment)	13 (4.7)	131 (8.7)	144 (8.1)	
10-16 (moderate impairment)	38 (13.8)	255 (16.9)	293 (16.4)	
0- 9 (severe impairment)	83 (30.2)	258 (17.1)	341 (19.1)	
Missing	2 (0.7)	24 (1.6)	26 (1.5)	
Not applicable	100 (36.4)	374 (24.7)	474 (26.6)	
MUST (malnutrition risk)				< .001
Low risk (0)	-	1054 (69.7)	1054 (58.9)	
Medium risk (1)	-	259 (17.1)	259 (14.5)	
High risk (2 or more)	254 (92.4)	106 (7.0)	360 (20.1)	
Missing	21 (7.6)	93 (6.2)	114 (6.4)	
Feeding by Barthel Index				< .001
Total assistance	86 (31.5)	253 (16.7)	339 (19.0)	
Active assistance	41 (14.9)	204 (13.5)	245 (13.7)	
Supervision	78 (28.4)	335 (22.2)	413 (23.1)	
Minimal assistance	78 (28.4)	370 (24.5)	408 (22.8)	
No assistance	30 (10.9)	348 (23.0)	378 (21.2)	
Missing	2 (0.7)	2 (0.1)	4 (0.2)	
Province				
Brescia	60 (21.8)	256 (16.9)	316 (17.7)	0.06
Milano	215 (78.2)	1256 (83.1)	1471 (82.3)	
NH ownership type				
Public	54 (19.6)	366 (24.2)	420 (23.5)	0.11
Private	221 (80.4)	1146 (75.8)	1367 (76.5)	
Facility size				< .001
40-90 residents	45 (16.4)	204 (13.5)	249 (13.9)	
91-160 residents	123 (44.7)	515 (34.1)	638 (35.7)	
> 160 residents	107 (38.9)	793 (52.4)	900 (50.4)	
Type of ward				
Nursing home	212 (77.1)	1147 (75.9)	1359 (76.0)	0.71
Special care units for dementia	63 (22.9)	365 (24.1)	428 (24.0)	
Unit size:				
Small	226 (82.2)	1300 (86.0)	1526 (85.4)	0.12
Medium/high	49 (17.8)	212 (14.0)	261 (14.6)	

MMSE: Mini Mental State Examination; The maximum score is 30 points.
MUST: Malnutrition Universal Screening Tool

Table 3. Malnourished residents according to combined unintentional weight loss with BMI.

	Unintentional weight loss			
	No or < 5%	**5-10%**	**> 10%**	**Total**
Underweight (BMI)	N (%)	N (%)	N (%)	
No	866 (60.0)	87 (50.9)	17 (27.9)	970 (57.9)
Yes*	577 (40.0)	**84 (49.1)**	**44 (72.1)**	**705 (42.0)**
Total	1443 (100.0)	171 (100.0)	61 (100.0)	1675§

Underweight BMI (Body Mass Index) *Yes: BMI < 20 kg/m^2 in residents < 70 years; or BMI <22 kg/m^2 in residents ≥ 70 years

§ total referred 1675 because 212 residents without weight or height in 6 previous months

as reference. The variables measured on continuous scale (i.e.: age, length of stay, severity and comorbidity indices, Barthel score and liquids intake) were included in the regression models as linear terms in their original measurement scale.

First, the association was assessed separately for each factor (univariate analysis), including each factor in a logistic model as explanatory variable. In multivariate analysis we followed the guidelines described in Harrell's textbook (Harrell FE. Regression modelling strategies With Applications to Linear Models Logistic and Ordinal Regression and Survival Analysis. 2nd ed. Springer editor. 2015. 582 p.) to avoid the possibility of unreliable conclusions caused by overfitting the model. The data considered for the multivariable model consisted of 1116 records of subjects with complete information of the variables listed below. The number of variables to be considered in the analysis was determined a priori, according to the 10-event-per-variable rule (Peduzzi P, Concato J, Kemper E, et al. A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol 1996;49:1373-1379). Within the 1116 available records 97 events (i.e. primary outcomes, malnourished subjects) were observed, thus the maximum number of coefficients to be included in the model was 97/10 = approximately 10. The choice of variables was based on clinical judgement:

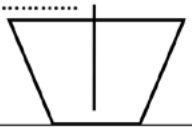
- Gender (M/F);
- Age (codified as categorical variables with two modalities: ≤ 80 years; > 80 years;
- NH ownership (public, private);
- NH size (40-90 residents; 91-160 residents; > 160 residents);
- Barthel Index score (0-90; 91-100);
- Mental state by CIRS (1-3; 4-5);
- Pressure ulcers (None, present);
- chewing difficulty (No/YES);
- swallowing difficulty (No/YES);
- assisted nutrition by Barthel Index (low = minimal or no assistance; high = partial or constant or total assistance);
- daily total liquids intake;
- daily food intake at lunch (0-50; 51-100);
- daily food intake at dinner (0-50; 51-100);
- assisted nutrition at lunch at day 1 (low = minimal or no assistance; high = partial or constant or total assistance);
- assisted nutrition at dinner at day 1 (low = minimal or no assistance; high = continuous or substantial or total assistance).

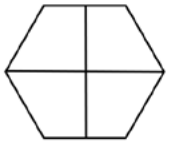
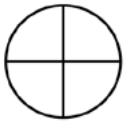
The model building procedure was as follows: first, a model with all the variables above as independent variables was fitted. Then (a backward variable selection technique was used for excluding variables with not significant multivariate association with nutritional status. The procedure was "constrained" to keep age and gender in the model at every step, due to their role of potential confounders.

The results from all the models (univariate and multivariate) were reported in terms of estimated OR of malnutrition with respective 95% confidence intervals and tests of association. Concerning the latter ones the overall association was assessed by Likelihood Ratio (LR) test (chi-square distribution). Moreover the Wald test (student t distribution) was used in the following circumstances:

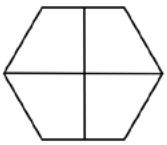
- in univariate analysis, for categorical variables with more than two modalities: when the global association resulted statistically significant, the test was used for multiple comparisons between pre-specified modalities;
- in multivariate analysis, to assess the association between nutritional status and each of the variables included in the model.
- For each test, statistical significance was deemed when the p-value was lower than 0.05. All the analyses were performed with the R software version 3.4.1 (R Core Team, 2017).

Institution code /Unit _____ Residents' code _____ Date ____/___/_____

BREAKFAST		Morning snack		Afternoon snack	
Hour		Hour		Hour	
☐ Nothing ☐ (tea, milk) ☐ (cookies, yogurt, fruit …)	**Capacity ml** …… 	☐ Nothing ☐ (tea, milk) ☐ (cookies, yogurt, fruit …)	**Capacity ml** …… 	☐ Nothing ☐ (tea, milk) ☐ (cookies, yogurt, fruit …)	**Capacity ml** …… 

LUNCH	Meal starting hour _____		Meal ending hour _____		
Main course	Second course	Side dish	One plate meal - shake	Fruits	Water Beverages
					**Capacity ml** …… 

Where meals are consumed: ☐ In the dining room ☐ In the bedroom ☐ In bed
Meals' assistance: ☐ No (the resident is autonomous ☐ The resident is encouraged to eat
☐ The resident receives help cutting/chopping food ☐ The resident needs to be fed
Who feeds the resident: ☐ Nurse assistant ☐ Nurse ☐ Family member ☐ Volunteer worker ☐ Other
Feeder position: ☐ Sitting ☐ Standing
Does the resident take any oral medication during meals ☐ No ☐ Yes intact ☐ yes hidden in the food

DINNER	Meal starting hour _____		Meal ending hour _____		
Main course	Second course	Side dish	One plate meal - shake	Fruits	Water Beverages
					**Capacity ml** …… 

Where meals are consumed: ☐ In the dining room ☐ In the bedroom ☐ In bed
Meals' assistance: ☐ No (the resident is autonomous ☐ The resident is encouraged to eat
☐ The resident receives help cutting/chopping food ☐ The resident needs to be fed
Who feeds the resident: ☐ Nurse assistant ☐ Nurse ☐ Family member ☐ Volunteer worker ☐ Other
Feeder position: ☐ Sitting ☐ Standing
Does the resident take any oral medication during meals ☐ No ☐ Yes intact ☐ yes hidden in the food

				**Instructions:** Blacken the portion consumed for each course (or just single course in case one plate meal or shake); Blacken the amount of liquids (water (drinks) taken in the space " **ml** ……" indicate the mug/glass capacity in **ml scale measure**.