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Factors associated with (risk of) undernutrition in community-dwelling older adults receiving home care: a cross-sectional study in the Netherlands

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Abstract

Objective: It is generally thought that causes of undernutrition are multifactorial, but there are limited quantitative studies performed. We therefore examined a wide range of potential factors associated with undernutrition in community-dwelling older adults.

Design: Cross-sectional study.

Setting: Community-dwelling older adults (≥65 years) receiving home care in the Netherlands.

Subjects: Data on potential factors associated with (risk of) undernutrition were collected among 300 older adults. Nutritional status was assessed by the SNAQ^{65+} instrument. Undernutrition was defined as mid-upper arm circumference <25 cm or unintentional weight loss of ≥4 kg in 6 months. Being at risk of undernutrition was defined as having poor appetite and inability to walk up and down stairs of fifteen steps, without resting.

Results: Of all participants, ninety-two (31·7 %) were undernourished and twenty-four (8·0 %) were at risk of undernutrition. Based on multivariate logistic regression analyses, the statistically significant factors associated with (risk of) undernutrition ($P < 0·05$) were: unable to go outside (OR = 5·39), intestinal problems (OR = 2·88), smoking (OR = 2·56), osteoporosis (OR = 2·46), eating fewer than three snacks daily (OR = 2·61), dependency in activities of daily living (OR = 1·21), physical inactivity (OR = 2·01), nausea (OR = 2·50) and cancer (OR = 2·84); a borderline significant factor was depression symptoms (OR = 1·83, $P = 0·053$).

Conclusions: The study suggests that (risk of) undernutrition is a multifactorial problem and that associated factors can be found in several domains. These findings may support the development of intervention trials for the prevention and treatment of undernutrition in community-dwelling older adults.

Keywords
Mid-upper arm circumference
Weight loss
Cross-sectional
Older adults
Community-dwelling

In older adults, undernutrition or protein–energy malnutrition is a commonly reported and worldwide health problem[1], but there is considerable variety in the reported prevalence rates due to different assessment methods[2,3]. When based on low mid-upper arm circumference (MUAC < 25 cm) and/or unintentional weight loss of ≥4 kg in 6 months, the prevalence of undernutrition in community-dwelling older adults is estimated to be between 11 and 35 %[4]. The prevalence of (risk of) undernutrition, defined as poor appetite in the previous week in combination with difficulty climbing stairs, is estimated between 2 and 9 %[4]. Due to the ageing population, increasing pressure on health-care systems initiates a shift in care from the institutional setting to the community. For this reason, prevention and treatment of undernutrition in community-dwelling older adults is essential.

In order to prevent and treat undernutrition in community-dwelling older adults, clear insight into the primary and secondary factors associated with undernutrition is needed. In previous studies undernutrition in older adults was associated with poor health outcomes including decreased functionality[5,6], reduced quality of

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life[7] and higher mortality risk[8]. Thus, undernutrition may affect older adults' level of dependency and thereby the risk of early institutionalization[1,9,10]. A recent comprehensive systematic overview of twenty-eight observational studies on the determinants of undernutrition in community-dwelling older adults indicated that poor appetite, hospitalization, poor self-reported health, not being diabetic and being edentulous were important factors associated with undernutrition in community-dwelling older adults[11]. However, despite the volume of research conducted on potential factors associated with undernutrition over the past decade, many studies had a small sample size or were of poor quality. Besides, very few studies examined a broad range of potential factors from different domains. Furthermore, potential other important factors such as falls and chronic obstructive pulmonary disease were not studied.

A study assessing a wide range of potential factors associated with undernutrition from different domains in community-dwelling older adults is currently lacking. The aim of the present cross-sectional study was to examine potential factors associated with (risk of) undernutrition in community-dwelling older adults in the Netherlands.

Methods

Study population

The nutritional status of 936 subjects was screened using the Short Nutritional Assessment Questionnaire ($SNAQ^{65+}$) by nurses working in home care organizations in Amsterdam and dietitians of the Dutch Malnutrition Steering Group[4] in the Netherlands. All subjects received personal support by a home care nurse. Based on the $SNAQ^{65+}$ screening 502 subjects were well-nourished, seventy-four were at risk for undernutrition and 274 were undernourished; for the remaining eighty-six subjects screening information was incomplete. In close collaboration with these home care organizations, the screened subjects were invited to complete a questionnaire, excluding those who were institutionalized (*n* 24), aged <65 years (*n* 4), had a severe cognitive disorder (*n* 5), were unable to speak Dutch (*n* 4), no longer received home care (*n* 5) and those who had died between screening and the sending of the questionnaire (*n* 41). The detailed questionnaire was developed and pilot-tested in twenty-six subjects, and after minor adaptation, sent to the 827 eligible subjects. If no response was received from a subject after two weeks, a reminder was sent by regular mail. A total of 519 subjects were unable or unwilling to participate for different reasons, and 308 were willing to participate and completed the questionnaire. Figure 1 shows the specific reasons for exclusion and non-response. Statistical analyses were conducted in 300 participants.

Procedures and questionnaire

A questionnaire consisting of fourteen topics was used to examine the potential factors associated with (risk of) undernutrition among community-dwelling older adults. Eight topics were captured using questionnaires validated in older adults. Factors of interest were selected *a priori* based on a framework of previous research (a literature review[11] and a qualitative study on the self-reported causes of undernutrition by community-dwelling older adults (R van der Pols-Vijlbrief, HAH Wijnhoven, M Visser *et al.*, unpublished results)) and professional expertise. The questionnaire was pilot-tested giving consideration to the letter size and clarity of the questions. Completing the questionnaire took approximately 45 min and participants were allowed to receive help completing the questionnaire if needed. Three participants received help from one of the researchers. Finally, if the questionnaire was returned incomplete, follow-up telephone calls were made, when possible, to complete the missing information.

Undernutrition

The study outcome, (risk of) undernutrition, was determined with the $SNAQ^{65+}$, a screening instrument consisting of four items: (i) unintentional weight loss of ≥4 kg in the past 6 months; (ii) MUAC < 25 cm; (iii) loss of appetite in the past week; and (iv) inability to walk up and down stairs of fifteen steps without resting. The $SNAQ^{65+}$ screening tool was developed and validated by Wijnhoven *et al.* in two large longitudinal studies[4]. An advantage of the use of MUAC over BMI is the easy measurement in older adults using a simple tape, without the hinder of standing problems, fluid retention and heavy equipment. Moreover, low MUAC showed a stronger association with mortality risk than low BMI. The cut-off point to define thinness is based on the 5th percentile in a community-dwelling sample and is 25 cm for both men and women[12]. Persons were classified as undernourished if they either experienced unintentional weight loss of ≥4 kg in the past 6 months or if their MUAC was <25 cm. A person was considered at risk of undernutrition if a poor appetite was experienced in the previous week in combination with difficulty climbing stairs. Finally, a person was considered well-nourished if none of the above was applicable.

Operationalization of (risk of) undernutrition

The $SNAQ^{65+}$ questions from the questionnaire and the MUAC measurement from the $SNAQ^{65+}$ screening (performed by the home care nurse) were used (*n* 287). If the MUAC measurement from the initial $SNAQ^{65+}$ screening was missing, the self-reported MUAC from the questionnaire was used (*n* 5). This MUAC was self-assessed using a measurement tape provided with the questionnaire. A specific colour indicated whether the MUAC was <25 cm. For three participants who received assistance completing the questionnaire, the MUAC measurement was performed

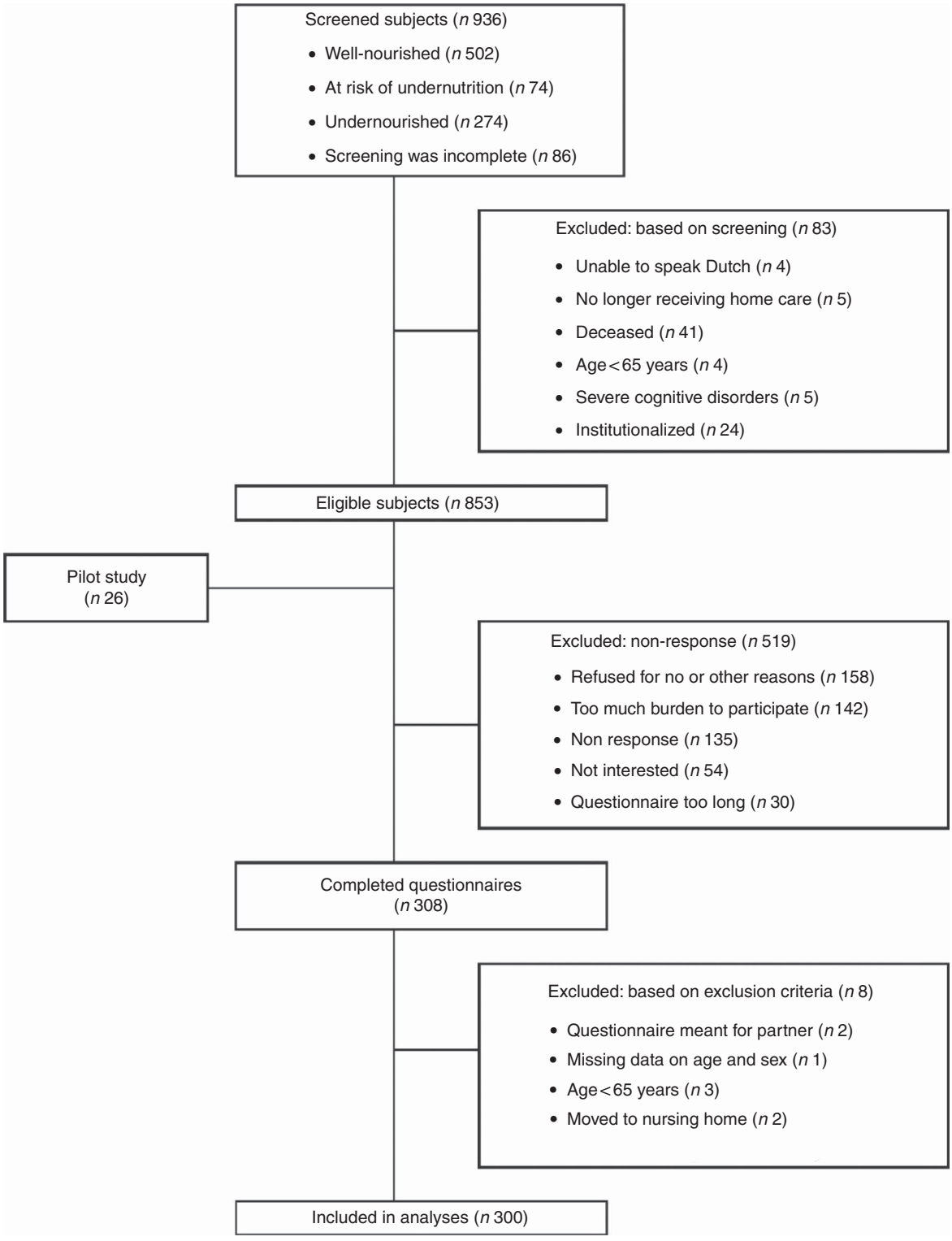

Fig. 1 Flowchart of the screening, inclusion and response of participants

by a researcher. For five participants all information on MUAC was missing.

Factors associated with undernutrition

Potential factors were categorized into the following domains: demographic, social, financial, lifestyle, disease and care, psychological, physical function, food intake and appetite, and oral function. Factors in the anthropometric domain included MUAC and BMI, the latter calculated from self-reported height and body weight (kg/m^2). MUAC was used as part of the outcome measure and BMI was used only for descriptive purposes.

Demographic domain

The demographic domain included sex (male/female), age (years) and level of education. Level of education was categorized as low (no education, elementary school, primary vocational education, general secondary education), medium (secondary vocational education, general higher education) or high (higher vocational education, academic education) according to the Dutch classification of education of the Central Bureau for Statistics[13].

Social domain

Participants' marital status was assessed (married, unmarried, divorced or widowed) and categorized into widowed (yes/no). The living situation was categorized as either living alone or with someone else. Eating alone most of the time was classified by eating alone on four or more days per week. The six-item validated Lubben Social Network Scale (LSNS-6) was used to determine the quantity of the social network. Participants were classified as having either a small social network (score <12) or a normal to large social network (score ≥12)[14]. Additionally, social support in healthy eating (yes/no) was assessed by a single item[15].

Financial domain

Net monthly household income was divided into three categories, low (<€975), medium (between €975 and €1386) and high (≥€1386). The lowest category represents income below the social welfare level, the medium category represents income between the social welfare level and the median income level, and the highest category represents income above the moderate level of income of older adults in the Netherlands in 2015[16]. Furthermore, the financial ability to buy food was assessed by using a single item of the Determine Your Nutritional Health Checklist (NSI Checklist)[17,18].

Lifestyle domain

Smoking status was categorized as current, former (stopped smoking in the past 15 years)[19,20] and non-smokers (those who never smoked and smokers who stopped smoking more than 15 years ago). Alcohol use was examined based on the number of days per week that alcohol was consumed and the number of consumed glasses per day, and classified according to the principles of Garretsen: light, moderate, excessive or very excessive alcohol use[21]. Physical activity was examined by the self-reported number of days per week that moderate physical activity was performed for more than 30 min and dichotomized according to the Dutch guidelines for healthy physical activity (NNGB) for older adults (<5 d/week and ≥5 d/week)[22].

Disease and care domain

The self-reported number of chronic diseases identified by a general practitioner or physician was categorized as either fewer than two chronic diseases or two or more chronic diseases (multi-morbidity)[23]. The number of medications prescribed by a doctor was categorized as using either five or more (polypharmacy) or fewer than five medications[24,25]. Hospital admission in the past 6 months was dichotomized (yes/no). Overall self-reported health was assessed on a scale from 1 to 5. This was dichotomized into either poor (<3) or normal to good health (≥3). The presence of several health complaints (yes/no) in the past month was determined: nausea, intestinal problems and fatigue. Pain was determined by six items (pain while sitting, standing, changing position and walking, constant pain and pain intensity) from the Nottingham Health Profile's questionnaire (NHP)[26]. Pain was present when at least one of the above-mentioned items was scored as yes[27].

Psychological domain

Cognitive decline was assessed using the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE)[28]. This sixteen-item questionnaire compares aspects of the cognitive function to 10 years earlier. The score summation was divided by 16, with a score higher than 3·3 indicating cognitive decline[29]. The presence of depressive symptoms was assessed with the validated ten-item Center for Epidemiologic Studies Depression scale (CES-D-10). A score of 10 or higher was used as the clinical cut-off for depressive symptoms[30].

Physical functioning domain

The level of dependency in activities of daily living (ADL) was assessed using the Barthel index[31]. This validated questionnaire consists of ten items on different ADL: feeding, moving from the wheelchair to bed and returning, performing personal hygiene, getting on and off the toilet, bathing, walking on a level surface/propelling a wheelchair, ascending and descending stairs, dressing and undressing, continence of bowels and bladder control. The sum of scores ranges from 0 to 20, with a higher score indicating a higher level of independence[31]. To determine difficulties in aspects of instrumental ADL, participants were asked whether they needed assistance during several activities including taking care of the household (yes/no), buying groceries (yes/no) and preparing meals (yes/no).

Mobility was assessed using a single item from the Mini Nutritional Assessment (MNA) tool, which asked participants whether they were bound to the bed or chair and/or whether they were able to move around the house but unable to go outside independently (or were able to go outside independently)[32]. Difficulty climbing stairs was assessed using the SNAQ^{65+} item (yes/no). The ability to walk 100 m with or without an assisting tool was also assessed (yes/no). Furthermore, the number of falls in the past 6 months was assessed (any fall incident/no fall incident).

The questions used to assess visual function and hearing ability originate from the Organisation for Economic Co-operation and Development's long-term disability indicator[33–35]. Visual function was assessed by two questions: if a person could read the newspaper and was able to recognize a person's face from a distance of 4 m. If both of these items were answered with 'yes, without difficulty', this was considered good visual function. All other combinations were considered as limited visual functioning. Two similar items were used to identify problems in hearing during a conversation in a group and with one individual, with or without a hearing aid. The classifications made were similar to those of visual function.

Food and appetite domain

Appetite was assessed using the Simplified Nutritional Appetite Questionnaire ($SNAQ^{app}$). This validated questionnaire consists of four items concerning appetite. The total score ranges from 4 to 20, with a higher score indicating a better appetite[36]. Furthermore, loss of taste and smell was determined by the question asking whether participants experienced a decline in smell or taste in the past 10 years (yes/no). Accessibility to food was assessed by asking if there were days when they did not have enough food due to a lack of time, difficulty getting groceries, a specific diet, a cooking inability or a dysfunctional stove (yes/no); or they could answer that 'another reason' caused inaccessibility to food. The number of snacks consumed per day was classified as fewer than three snacks daily (*v.* three or more daily). Finally, a question was posed if participants were occasionally skipping meals (yes/no).

Oral functioning domain

Self-reported oral health was determined on a scale ranging from 1 to 5 and was classified into either poor/moderate (≤3) or good oral health (>3). Oral problems were assessed, including teeth or gum problems, denture problems, dry mouth, biting or chewing difficulties, and swallowing problems (yes, any problem *v.* no problems). Chewing surface was examined based on four items assessing the number of natural teeth in the upper and lower jaw and partial or complete dentures in the upper and lower jaw. This was dichotomized as having a full chewing surface or having no or partial chewing surface. In addition, participants were asked whether or not they used dentures and if they experienced problems regarding their food intake as a result of denture problems.

Data analyses

Characteristics of both undernourished participants and participants at risk of undernutrition were compared with those of the well-nourished group by using *post hoc* analyses (independent Bonferroni α test) for continuous variables and Fisher's exact test (two-sided) for dichotomous variables.

Missing items were imputed by performing multiple imputations[37]. Patterns in missing items were analysed to check whether data were missing completely at random. This was verified by the Expectation–Maximization algorithm test ($P = 0{\cdot}396$). In total, 0·11 % of the values were missing in 7·33 % of the participants in 17·8 % of the variables used for analyses. Five data sets with five iterations were created. Multiple imputation by chained equations was used to impute the single items. Variables included in the imputation model were those with one or more missing values or those that were related to a variable with missing values: MUAC, body weight, education, income, social support in healthy eating, number of medications, limitation in hearing, and all single items of the CES-D-10, LNSN-6 and Barthel index. For statistical analyses, the pooled variable was used. The significance was calculated based on the median of *P* values, since research suggests that the median is more reliable than the mean of *P* values (I Eekhout, unpublished results).

Univariable logistic regression analyses were performed to investigate the association between all potential factors associated with (risk of) undernutrition, with the well-nourished group as reference. The five most frequently reported chronic diseases – osteoarthritis, osteoporosis, heart failure, diabetes mellitus and rheumatoid arthritis – were tested in univariable analyses. Furthermore, chronic obstructive pulmonary disease[38], cancer[39] and kidney failure[40] were included in univariable analyses since previous research presented these as risk factors for undernutrition.

Potential effect modification by sex and age was tested and if present, analyses were stratified by age (<83 years and ≥83 years based on median age) or sex. Additionally, linearity was checked for all continuous variables and multicollinearity was assessed using the variance inflation factor for all variables associated ($P < 0{\cdot}10$) with the outcome in univariable analyses, and Cohen's κ was used for correlation of dichotomous variables. A variance inflation factor >10 or a Cohen's $\kappa > 60\,\%$ was considered a high correlation, and the variable with the lowest *P* value in the univariable analysis was subsequently used in multivariable analyses.

For multivariable regression analyses, the stepwise forward selection procedure was used and factors with *P* value $< 0{\cdot}10$ in univariable analyses were included. In every step the determinant with the strongest association, meaning the lowest *P* value, was added to the model for the next step, until none of the variables had a *P* value $< 0{\cdot}10$[41]. The quality of the final models was tested by performing the Hosmer and Lemeshow test. Results were presented as odds ratios with 95 % confidence intervals, a *P* value of <0·05 was considered statistically significant. Sensitivity analyses in complete cases were done for testing whether the imputation had affected the

conclusions. For all statistical analysis, the statistical software package IBM SPSS Statistics Version 21 was used.

Results

The characteristics of the study sample are presented in Table 1. According to the $SNAQ^{65+}$ screening the original group (*n* 936) and the sub-sample (*n* 300) were comparable based on nutritional status (percentage undernourished and risk group). All 300 included participants received support in personal care (100·0 %), additional support was needed in the household (67·7 %), with groceries (61·3 %) and in preparing meals (35·7 %). Their average age was 81·7 (SD 7·6) years, 68·3 % were female, 72·7 % were living alone, and their mean BMI was 25·8 (SD 5·2) kg/m^2. Ninety-two participants were undernourished, twenty-four were at risk of undernutrition and 184 were well-nourished. There were more current or former smokers in the risk group (41·7 %) and the undernourished group (35·1 %) compared with the well-nourished group (17·4 %). As expected, in the well-nourished group BMI and MUAC were higher compared with the risk group and the undernourished group. Within the undernourished group, fifty-one participants were undernourished based on weight loss, thirty-one based on low MUAC and ten based on both criteria.

Univariable analyses

Univariable analyses showed that twenty-seven factors were associated with (risk of) undernutrition ($P < 0{\cdot}10$) wherefrom nineteen variables were significantly associated ($P < 0{\cdot}05$; Table 2). Effect modification was tested and found for some factors (e.g. living alone, need assistance with groceries or preparing meals and visual impairment). However, as stratification resulted in small subgroups and large confidence intervals due to low statistical power, no stratification was performed in univariate and multivariable analyses.

Multivariable analyses

No multicollinearity was found (highest Cohen's $\kappa = 0{\cdot}51$ and highest variance inflation factor = 2·08) and therefore all factors with a *P* value < 0·10 in univariable analyses were included in the first step of the forward stepwise procedure. Table 3 presents the final multivariable model of the stepwise forward selection procedure for factors associated with (risk of) undernutrition. Factors that were statistically significantly ($P < 0{\cdot}05$) and positively associated with (risk of) undernutrition included: being unable to go outside, having intestinal problems, smoking, having osteoporosis, eating fewer than three snacks daily, being ADL dependent, being physically inactive, nausea and cancer. Depression symptoms were found to be borderline significantly associated with (risk of) undernutrition ($P = 0{\cdot}053$). In sensitivity analyses using the original data set including complete cases only, no other or different factors were found as compared with the imputed analyses.

Discussion

The purpose of the present cross-sectional study was to examine potential factors associated with undernutrition from multiple domains in community-dwelling older adults. Several factors from different domains were found to be statistically significantly associated with (risk of) undernutrition: being unable to go outside, having intestinal problems, smoking, having osteoporosis, eating fewer than three snacks daily, being ADL dependent, being physically inactive, nausea, cancer and depressive symptoms (borderline significant).

In the present study, poor appetite (based on the $SNAQ^{app}$) was univariately associated with (risk of) undernutrition, but was not be included in the multivariate model as a poor appetite ($SNAQ^{65+}$) was part of the dependent variable (risk of) undernutrition. Previous research showed that poor appetite is an independent determinant of undernutrition defined as low BMI, MUAC or unintentional weight loss in community-dwelling older adults[11,35]. A poor appetite is found to be associated with lower nutritional intake[42] and thereby increases the risk of undernutrition[43]. Smoking was associated with (risk of) undernutrition and with being at risk of undernutrition. A possible explanation for this association is that smoking is known to reduce taste perception and appetite[44,45]. Moreover, smoking may increase the feeling of fullness when consuming a hot evening meal, thereby lowering energy intake[46]. In addition, smoking is known to increase resting energy expenditure, which could lead to higher energy needs[47]. Depressive symptoms were borderline significantly associated with undernutrition in multivariable analyses. Depression is shown to be associated with a poor appetite[48]. This may explain the observed link between depression and undernutrition.

Similar to other studies[49,50], intestinal problems (such as diarrhoea and constipation) were associated with undernutrition in the current study. Diarrhoea may cause excessive losses (malabsorption) thereby increasing energy requirements, and constipation may increase feeling of fullness and reduce appetite[51]. Osteoporosis was associated with undernutrition and an explanation for this could be that participants with osteoporosis had a less adequate daily nutritional intake. Low protein intake and low calcium intake are associated with an increase in bone loss[52], and furthermore low BMI is shown to be a risk factor for osteoporosis and fractures[53]. Osteoporosis may thus be a consequence rather than a cause of (risk of) undernutrition. However, due to the observational design no causality statements can be made. Consumption of fewer than three snacks daily was associated with (risk of) undernutrition, which may be explained by a decrease in energy intake resulting in weight loss. Nausea and cancer

Table 1 Characteristics of the study population of community-dwelling older adults (≥65 years) receiving home care in the Netherlands, classified according to nutritional status

	All (*n* 300)		Well-nourished (*n* 184)†		Risk undernutrition (*n* 24)†		Undernutrition (*n* 92)†	
	n or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD
Demographic domain								
Female	205	68·3	120	65·2	21	87·5*	64	69·6
Age (years)‡	81·7	7·6	81·9	7·5	82·6	7·0	81·2	7·9
Low education§	218	73·4	128	69·9	16	69·6	74	81·3
Social domain								
Widowed	153	51·0	97	52·7	11	45·8	45	48·9
Living alone	218	72·7	136	73·9	18	75·0	64	69·6
Eating alone, >4 d/week	188	62·7	118	64·1	15	62·5	55	59·8
Small social network, LSNS-6 < 12§	162	54·2	101	54·9	16	66·7	45	49·5
Poor social support in healthy eating§	176	58·9	100	54·3	19	79·2*	57	62·6
Financial domain								
Low/medium income, ≤ €1385§	143	48·8	80	44·4	12	52·2	51	56·7
Limited financial ability to buy food	16	5·3	5	2·7	0	0·0	11	12·0*
Anthropometric domain								
BMI (kg/m^2)‡	25·8	5·2	27·4	5·2	26·2	3·9	23·1	4·6*
MUAC (cm)‡,‖	29·0	4·5	30·4	4·1	29·0	3·5	26·2	4·2*
Lifestyle domain								
Former or current smoker	75	25·0	32	17·4	10	41·7*	33	35·9*
Moderate or excessive alcohol use	50	16·7	32	17·4	5	20·8	13	14·1
< 5 d PA/week, ≥30 min/d	135	45·0	69	37·5	14	58·3	52	56·5*
Disease and care domain								
Two or more chronic diseases	167	55·7	94	51·1	19	79·2*	54	58·7
Osteoarthritis	94	31·3	52	28·3	12	50·0*	30	32·6
Osteoporosis	71	23·7	31	16·8	10	41·7*	30	32·6*
Heart failure	70	23·3	45	24·5	8	33·3	17	18·5
Diabetes	65	21·7	42	22·8	5	20·8	18	19·6
Rheumatoid arthritis	46	15·3	29	15·8	2	8·3	15	16·3
COPD	40	13·3	24	13·0	4	16·7	12	13·0
Kidney failure	19	6·3	9	4·9	4	16·7*	6	6·5
Cancer	29	9·7	13	7·1	5	20·8*	11	12·0
Polypharmacy, ≥5 medications/d§	158	53·0	94	51·6	15	62·5	49	53·3
Hospital admission past 6 months	100	33·3	53	28·8	9	37·5	38	41·3*
Poor self-reported health	67	22·3	28	15·2	10	41·7*	29	31·5*
Nausea	51	17·0	18	9·8	10	41·7*	23	25·0*
Intestinal problems	107	35·7	48	26·1	14	58·3*	45	48·9*
Fatigue	158	52·7	83	45·1	21	87·5*	54	58·7*
Pain (NHP)	187	62·3	114	62·0	18	75·0	55	59·8
Psychological domain								
Cognitive decline, IQCODE > 3·3§	135	45·3	77	41·8	9	39·1	49	53·8
Depression, CES-D-10 ≥ 10	110	36·8	54	29·5	11	45·8	45	48·9*
Physical functioning domain								
ADL dependency, Barthel‡,¶,‖	16·9	3·3	17·1	3·1	15·5	3·8	16·8	3·6
Need assistance in household	203	67·7	123	68·0	18	75·0	62	65·3
Need assistance with groceries	184	61·3	103	55·7	20	83·3*	61	66·3
Need assistance in preparing meals	107	35·7	57	31·0	15	62·5*	35	38·0
Unable to go outside	81	27·0	31	16·8	13	54·2*	37	40·2*
Difficulties climbing stairs	175	58·3	98	53·3	24	100·0*	53	57·6
Difficulties in 100 m walk	72	24·0	36	19·6	8	33·3	28	30·4
Fall incident in past 6 months	121	40·3	69	37·5	8	33·3	44	47·8
Visual impairment	72	24·0	41	22·3	7	29·2	24	26·1
Limited hearing§	61	20·4	38	20·7	4	17·4	19	20·7
Food and appetite domain								
Appetite, SNAQ^{app}‡,¶	14·8	2·2	15·5	1·7	13·2	2·2*	13·9	2·6*
Poor appetite, SNAQ^{65+}	64	21·3	8	4·3	24	100·0*	32	34·8*
Loss of taste	101	33·7	49	26·9	14	58·3*	38	41·3*
Loss of smell	92	30·7	54	29·3	6	25·0	32	34·8
Low accessibility to food	46	15·3	17	9·2	4	16·7	25	27·2*
< 3 snacks/d	206	68·7	115	62·5	17	70·8	74	80·4*
Skipping meals	86	28·7	42	22·8	13	54·2*	31	33·7*
Oral functioning domain								
Poor/moderate oral health	92	30·7	55	29·9	8	33·3	29	31·5
Oral problems	136	45·3	77	41·8	13	54·2	46	50·0
Teeth or gum problem	35	11·7	26	13·7	1	4·2	8	8·7
Denture problem (*n* 244)	38	15·6	20	13·7	4	18·2	14	18·4
Dry mouth	78	26·0	41	22·3	8	33·3	29	31·5
Biting or chewing difficulties	44	14·7	25	13·6	6	25·0	13	14·1

Table 1 *Continued*

	All (*n* 300)		Well-nourished (*n* 184)†		Risk undernutrition (*n* 24)†		Undernutrition (*n* 92)†	
	n or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD
Swallowing problem	23	7·6	13	7·1	3	12·5	7	7·6
No or partial chewing surface	34	11·3	20	10·9	2	8·3	12	13·0
Problems in eating due to oral problem	30	10·0	16	8·7	4	16·7	10	10·9
Partial or full dentures	244	81·3	146	79·3	22	91·7	76	82·6

LSNS-6, six-item Lubben Social Network Scale; MUAC, mid-upper arm circumference; PA, physical activity; COPD, chronic obstructive pulmonary disease; NHP, Nottingham Hamilton Profile; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; CES-D-10, ten-item Center for Epidemiologic Studies Depression scale; ADL, activities of daily living; $SNAQ^{app}$, Simplified Nutritional Appetite Questionnaire; $SNAQ^{65+}$, Short Nutritional Assessment Questionnaire. Original data are presented; values are number and percentage per group for categorical variables.

*Statistically significant difference from no undernutrition ($P < 0·05$). *P* value is derived from *post hoc* analyses (independent Bonferroni *α* test) for continuous variables, Pearson's χ^2 test (two-sided) for categorical variables and Fisher's exact test (two-sided) for dichotomous variables.

†Classification based on the $SNAQ^{65+}$.

‡Values are mean and standard deviation for continuous variables.

§Missing values in categorical variables: limited hearing, *n* 1 in risk group; social network, *n* 1 in undernourished group; social support, *n* 1 in undernourished group; cognitive decline, *n* 1 in undernourished and *n* 1 in risk group; depression, *n* 1 in well-nourished group; income, *n* 4 in well-nourished, *n* 1 in risk and *n* 2 in undernourished group; medication, *n* 2 in well-nourished group; education, *n* 1 in well-nourished, *n* 1 in risk and *n* 1 in undernourished group.

‖Data available for MUAC: total, *n* 247; well-nourished, *n* 153; risk group, *n* 20; undernourished, *n* 74. Data available for BMI: total, *n* 293; well-nourished, *n* 180; risk group, *n* 23; undernourished, *n* 90. Data available for ADL: total, *n* 298; *n* 1 missing in risk and undernourished group.

¶$SNAQ^{app}$ values range from 4 to 20, with higher numbers representing a better appetite; Barthel score ranges from 0 to 20 with higher numbers representing a higher degree of independency in ADL.

were associated with (risk of) undernutrition. It is generally known that gastrointestinal symptoms such as nausea and vomiting are associated with unintentional weight loss especially among cancer patients receiving cancer treatment strategies[54]. Besides, cancer patients suffer from unintentional weight loss because of indirect tumour effects, treatment side-effects and psychological factors. Metabolic changes such as mechanical obstruction or systemic effects caused by tumour cells (glucose intolerance, fat depletion, protein turnover) may induce loss of appetite or increase energy expenditure[55].

Dependency in ADL, inability to go outside and physical inactivity were all associated with poor nutritional status in the multivariate model. It is possible that these factors result in difficulty purchasing food and groceries and difficulties preparing meals, which in turn could result in inadequate energy intake leading to undernutrition. Inability to go outside and, univariately associated, limited financial ability to buy food and low accessibility to food are all components of food insecurity that is shown to be associated with undernutrition among older adults[56–58]. However, we cannot exclude that the association is reverse; a decreased functionality might be a consequence of undernutrition (e.g. unintentional weight loss)[5,59] and low dietary intake[60] in the older adults.

In contrast to some other studies[43,61,62], low self-reported health was not associated with undernutrition in the multivariate model. A possible explanation for this is that in those studies undernutrition was defined using the MNA[61–63], a tool which includes information on health status. Therefore, it is to be expected that health status is associated with the MNA score. In the present study, health status was not included in the nutritional assessment tool ($SNAQ^{65+}$). In the current study, no factors from the social and oral function domain were found to be associated with (risk of) undernutrition. It is possible that some of the social or oral factors are sex- or age-related, since our stratified univariable analyses showed a statistically significant association of living and eating alone and undernutrition in female participants (OR = 2·33 and OR = 1·75) but not in male participants (OR = 0·20 and OR = 0·16). Oral factors, such as swallowing problems, showed non-significant positive and negative effect sizes (OR for male = 3·13, OR for female = 0·53) and for chewing difficulty the effect size was higher for younger compared with older participants (OR for age <83 years = 4·48, OR for age ≥83 years = 1·27). However, since stratification resulted in large confidence intervals due to the small sample size, these results should be interpreted with caution (results not shown).

The present study has several strengths, limitations and methodological issues. The extensive assessment of a broad range of factors related to undernutrition from several domains is a unique point and a major strength of the study. The domains were all assessed using short questionnaire versions validated in a large and often frail older population. Statistical analyses were exhaustive and included a multivariable model of acceptable quality (Hosmer and Lemeshow test: $P = 0·919$). Besides, handling of missing data was done by multiple imputations using the state-of-the-art multiple imputation by chained equations method. Multiple imputation is found to be more accurate than mean item imputation and complete case analyses[64]. Further, single items were imputed instead of the overall score of questionnaires[37].

The following limitations need to be discussed. The potential factors revealed in the present study are related to protein–energy malnutrition specifically and other

Table 2 Univariable associations of factors were associated with (risk of) undernutrition among community-dwelling older adults (≥65 years) receiving home care in the Netherlands

	Univariable analyses	
	OR	95 % CI
Demographic domain		
Female	1·39	0·83, 2·31
Age (years)	0·99	0·96, 1·03
Low education	1·47	0·86, 2·52
Social domain		
Widowed	0·87	0·54, 1·38
Living alone	0·86	0·51, 1·45
Eating alone >4 d/week	0·87	0·54, 1·41
Small social network, LSNS-6 < 12	0·95	0·60, 1·51
Poor social support in healthy eating	1·60*	0·99, 2·59
Financial domain		
Low/medium income, ≤€1385	1·52*	0·95, 2·44
Limited financial ability to buy food	3·64**	1·23, 10·76
Lifestyle domain		
Current or former smoker	2·69**	1·57, 4·59
Moderate or excessive alcohol use	0·84	0·45, 1·59
< 5 d PA/week, ≥30 min/d	2·28**	1·42, 3·67
Disease and care domain		
Two or more chronic diseases	1·67**	1·04, 2·69
Osteoarthritis	1·53*	0·93, 2·52
Osteoporosis	2·62**	1·51, 4·53
Heart failure	0·92	0·52, 1·60
Diabetes	0·92	0·52, 1·64
Rheumatoid arthritis	0·89	0·46, 1·70
COPD	1·11	0·56, 2·21
Kidney failure	2·58*	0·96, 6·94
Cancer	2·04*	0·94, 4·42
Polypharmacy, ≥5 medications/d	1·16	0·73, 1·86
Hospital admission past 6 months	1·65**	1·01, 2·70
Poor self-reported health	2·85**	1·62, 5·01
Nausea	3·54**	1·88, 6·65
Intestinal problems	2·97**	1·82, 4·86
Fatigue	2·29**	1·41, 3·70
Pain, NHP	1·06	0·66, 1·72
Psychological domain		
Cognitive decline, IQCODE > 3·3	1·55*	0·97, 2·47
Depression, CES-D-10 ≥ 10	2·36**	1·45, 3·84
Physical functioning domain		
ADL dependency, Barthel†	0·94	0·87, 1·00
Need assistance in household	0·95	0·58, 1·56
Need assistance with groceries	1·86*	1·13, 3·04
Need assistance in preparing meals	1·78**	1·09, 2·88
Unable to go outside	3·74**	2·19, 6·41
Difficulties in 100 m walk	1·86**	1·08, 3·20
Fall incident in past 6 months	1·37	0·85, 2·19
Visual impairment	1·32	0·77, 2·26
Limited hearing	1·01	0·57, 1·80
Food and appetite domain		
Appetite, $SNAQ^{app}$†	0·66**	0·58, 0·76
Loss of taste	2·14**	1·31, 3·49
Loss of smell	1·13	0·68, 1·86
Low accessibility to food	3·16**	1·65, 6·07
< 3 snacks/d	2·27**	1·33, 3·88
Skipping meals	1·98**	1·19, 3·30
Oral functioning domain		
Poor/moderate oral health	1·13	0·68, 1·86
Oral problems	1·44	0·90, 2·30
Teeth or gum problems	0·58	0·27, 1·26
Denture problems (*n* 244)	1·56	0·78, 3·12
Dry mouth	1·57*	0·93, 2·65
Biting or chewing difficulties	1·34	0·71, 2·56
Swallowing problems	1·20	0·51, 2·84
No or partial chewing surface	1·09	0·53, 2·26
Problems in eating due to oral problem	1·62	0·76, 3·46
Partial or full dentures	1·41	0·76, 2·63

LSNS-6, six-item Lubben Social Network Scale; PA, physical activity; COPD, chronic obstructive pulmonary disease; NHP, Nottingham Hamilton Profile; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; CES-D-10, ten-item Center for Epidemiologic Studies Depression scale; ADL, activities of daily living; $SNAQ^{app}$, Simplified Nutritional Appetite Questionnaire.

Imputed data are presented; values are odds ratios and 95 % confidence intervals for undernutrition (*n* 94) and risk of undernutrition (*n* 24) *v.* no undernutrition (*n* 182).

*Statistically significant different from well-nourished ($P < 0·10$).

**Statistically significant different from well-nourished ($P < 0·05$).

†$SNAQ^{app}$ values range from 4 to 20, with higher numbers representing a better appetite; Barthel score ranges from 0 to 20 with higher numbers representing a higher degree of independency in ADL.

Table 3 Stepwise multivariable model showing factors associated with (risk of) undernutrition in community-dwelling older adults (≥65 years; *n* 300) receiving home care in the Netherlands

	OR	95 % CI	*P* value
Unable to go outside	5·39	2·46, 11·81	<0·001
Intestinal problems	2·88	1·57, 5·28	0·001
Current or former smoker	2·56	1·37, 4·77	0·003
Osteoporosis	2·46	1·27, 4·76	0·007
< 3 snacks/d	2·61	1·37, 4·97	0·003
ADL dependency	1·21	1·09, 1·35	0·001
< 5 d PA/week, ≥30 min/d	2·01	1·13, 3·59	0·018
Nausea	2·50	1·14, 5·48	0·022
Cancer	2·84	1·12, 7·21	0·028
Depression, CES-D-10 ≥ 10	1·83	0·99, 3·36	0·053

PA, physical activity; ADL, activities of daily living; CES-D-10, ten-item Center for Epidemiologic Studies Depression scale.
Imputed data are presented. Multivariable model based on forward prediction model (Hosmer and Lemeshow test $P = 0·919$). Values are odds ratios and 95 % confidence intervals.

factors associated with specific nutrient deficiencies were not identified. All included older adults who lived at home and received home care. They are likely more disabled and/or frail compared with community-dwelling older adults in general. Since the questionnaire was self-administered, older adults unable to write or read, or older adults with severe cognitive decline might be underrepresented. Support from a family member or caregiver in completing the questionnaire was suggested in the information letter. Besides, three older adults completed the questionnaire with support of the researcher. Some (i.e. physical- and frailty-related) factors associated with (risk of) undernutrition could be more common in this group than in general community-dwelling older adults. Although the sub-sample of older adults used in the analyses was comparable to the initial screened group of older adults based on nutritional status, the sub-sample might differ on other underlying factors. Therefore, the results of the study should be generalized to the general older population with caution.

Another possible limitation is that a screening tool was used to define undernutrition risk based upon functional limitations and poor appetite. This screening tool has already been applied in the home care organization in the Netherlands and validated against mortality in two longitudinal cohorts. There is no agreement or gold standard on how to assess (risk of) undernutrition, so the definition of undernutrition should be kept in mind when interpreting the results[4]. For some participants, the time between the measurement of MUAC and completing the questionnaire was up to 18 months. It is therefore possible that the used MUAC was not representative of the actual MUAC at the time of completing the questionnaire. Additionally, due to a rather small sample size no stratification could be performed and it is possible that sex and age differences exist in the association with undernutrition. In further research with a larger sample size, potential effect modification by sex and age should be examined. Due to the observational nature of the study design it was not possible to make any statements about the causality of the factors associated with undernutrition. Intervention studies targeting associated factors in order to reduce undernutrition are necessary to obtain information on causality.

Conclusion

In conclusion, the present study underlines the hypothesis that the aetiology of undernutrition is multifactorial involving many different domains. Some associated factors, such as the number of daily snacks, dependency in ADL, physically inactivity or intestinal problems, are potentially modifiable and provide suggestions for preventive measures. Several non-modifiable associated factors such as cancer and osteoporosis show that increased awareness is needed in primary and secondary care to prevent or diminish undernutrition in old age.

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