Development and validation of criteria for determining undernutrition in community-dwelling older men and women: The Short Nutritional Assessment Questionnaire 65+

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SUMMARY

Background & aims

There is no valid, fast and easy-to-apply set of criteria to determine (risk of) undernutrition in community-dwelling older persons. The aim of this study was to develop and validate such criteria.

Methods

Selection of potential anthropometric and undernutrition-related items was based on consensus literature. The criteria were developed using 15-year mortality in community-dwelling older persons ≥ 65 years (Longitudinal Aging Study Amsterdam, *n* = 1687) and validated in an independent sample (InCHIANTI, *n* = 1142).

Results

Groups distinguished were: (1) undernutrition (mid-upper arm circumference <25 cm *or* involuntary weight loss ≥4 kg/6 months); (2) risk of undernutrition (poor appetite *and* difficulties climbing staircase); and (3) no undernutrition

(others). Respective hazard ratio's for 15-year mortality were: (1) 2.22 (95% CI 1.83–2.69); and (2) 1.57 (1.22–2.01) ((3) = reference). The area under the curve (AUC) was 0.55. Comparable results were found stratified by sex, excluding cancer/obstructive lung disease/(past) smoking, using 6-year mortality, and applying results to the InCHIANTI study (hazard ratio's 2.12 and 2.46, AUC 0.59).

Conclusions

The developed set of criteria (SNAQ^{65+}) for determining (risk of) undernutrition in community-dwelling older persons shows good face validity and moderate predictive validity based on the consistent association with mortality in a second independent study sample.

1. INTRODUCTION

There is an increasing awareness and evidence that undernutrition is an important modifiable risk factor for poor clinical outcome in older persons in Western society. Based on observational studies, undernutrition is found to be associated with increased morbidity,[1] mortality[2] and a reduced quality of life,[3] even after adjustment for (severity of) illness. A recent Cochrane review of (quasi) randomized controlled trials,[4] showed that the provision of extra energy and protein to undernourished older persons results in weight gain and a reduced mortality, providing evidence for the causality of the association between undernutrition and mortality and for a beneficial effect of a nutritional intervention among undernourished older persons. This emphasizes the importance of screening for and subsequently treating undernutrition in older persons.

Over the last two decades, more than 20 tools have been developed that determine (the risk of) undernutrition in older persons.[5] However, many of them are poorly validated and most have been developed for institutionalized persons (including nursing homes and hospitals) only. However, also in community-dwelling older persons, the prevalence of undernutrition is estimated to be relatively high – varying around 15–24% depending on the specific study population and the applied criteria to determine undernutrition,[6] thus stressing the need for screening for undernutrition in this population as well.

For determining undernutrition among community-dwelling older persons, a set of criteria needs to be valid and fast and easy-to-apply, without the need of calculation or – especially for the home situation – use of heavy or expensive equipment. At present, reliability and validity has been thoroughly established only for three tools that can be used in community-dwelling older persons.[5] These include the (short form) "Mini Nutritional Assessment" (MNA-SF),[7] the "Seniors in the Community: Risk evaluation for eating and nutrition" (SCREEN),[8] and the "Nutrition Screening Initiative DETERMINE checklist."[9] However, the latter two tools are quite extensive, consisting of 17[8] and 10[9] questions respectively, and require specific skills from professionals which make them less applicable for use at home. Initially, the MNA-SF incorporated the assessment of body mass index (BMI), which is an impractical measure in the home situation,[10] but recently, BMI was substituted by calf circumference.[11] However, the MNA-SF incorporates questions on mobility,

psychological stress or acute disease, and neuropsychological problems that may increase the risk for undernutrition, but do not assess undernutrition itself. Although the MNA-SF distinguishes "risk of undernutrition" from "undernutrition", this is based on the calculation of a total score that incorporates all these items, which likely results in a highly sensitive but non-specific tool.[12, 13, 14 and 15]
Recently, the National Institute for Clinical Excellence[16] recommended the use of another simple tool, the Malnutrition Universal Screening Tool (MUST)[17] for determining undernutrition in the hospital or community. The MUST incorporates questions on unintentional weight loss, BMI or mid-upper arm circumference (MUAC), and acute illness combined with reduced nutritional intake. However, the MUST was developed for adults and uses cut-offs (for BMI and MUAC) that are applicable to adults and probably inadequate to older persons. Moreover, there are no published peer-reviewed validation studies conducted in community-dwelling older persons.
To summarize, there is at present no valid, and fast and easy-to-apply set of criteria to determine (risk of) undernutrition in community-dwelling older persons. Therefore, the aim of the present study was to develop and validate such criteria.

2. SUBJECTS AND METHODS

The present study uses existing data from two ongoing longitudinal epidemiological studies in older persons in the Netherlands and Italy.

2.1. Development study sample

The Longitudinal Aging Study Amsterdam (LASA) is an ongoing study on predictors and consequences of changes in physical, emotional, cognitive and social functioning in older people in the Netherlands. A random sample stratified by age and sex according to expected mortality after 5 years, was drawn from the population registries of 11 municipalities in three geographical areas of the Netherlands. A total of 3107 men and women aged 55–85 year were enrolled at the baseline examination in 1992–93. The total sample is representative of the Dutch general older population. Examinations consist of a general face-to-face interview and a medical interview in the respondent's home. The details of the LASA study have been described elsewhere.[18] For the present study, respondents aged ≥65 years at baseline (n = 2141) who were community-dwelling (n = 2001) were included. The study was approved by the Ethics Review Board of the VU University Medical Center, and informed consent was obtained from all respondents.

2.2. Validation study sample

InCHIANTI (Invecchiare in Chianti, aging in the Chianti area) is an epidemiological study with a main focus on factors contributing to loss of mobility in older persons in Italy. A random sample was drawn from the population registries of two municipalities (Greve in Chianti and Bagno a Ripoli) in the Chianti geographic area. A total of 1155 men and women aged ≥65 years were enrolled at the baseline examination in 1998. Examinations consist of a face-to-face interview at the respondent's home and a clinical test session, a medical examination and a functional evaluation on separate days at the study clinic. The details of the InCHIANTI study have been described elsewhere.[19] For the present study, only community-dwelling respondents (n = 1142) were included. The study was approved by the Italian

National Institute of Research and Care on Aging review board and informed consent was obtained from all respondents.

2.3. Selection of items

We selected fast and easy-to-assess anthropometric and other undernutrition-related-items that potentially could be included in the set of criteria based on (recent) consistency in the literature on items that assess: 1) undernutrition: BMI and self-reported involuntary weight loss[5, 16 and 20]; or 2) risk of undernutrition: a reduced nutritional intake[5 and 16] or a poor appetite.[5]

Since BMI may not always be a feasible measure in older persons[10] especially in a home situation, MUAC is proposed as an alternative anthropometric measure.[17] This was supported by a recent study in community-dwelling older persons that showed that a low MUAC was more strongly associated with mortality than a low BMI.[21] Therefore, MUAC was selected as a potential item instead of BMI.

Since a reduced nutritional intake should be involuntary and not based on following an energy restricted diet because of overweight, this item may be subject to bias and requires additional questioning and specific skills from home-care workers which makes it less applicable for use at home. In LASA nutritional intake was not assessed. Based on the InCHIANTI study, of 321 older persons who reported that they ate less over the last year, indeed, 54% indicated the reason was following a diet. A reduced appetite was reported in 35% and other reasons like difficulty chewing (10%) and swallowing (1%) were less often reported (data not shown, available on request). Therefore, a poor appetite was selected as a potential item and not a reduced nutritional intake.

In a unique longitudinal study, we previously found that poor appetite and functional limitations, as assessed by difficulties walking stairs, were the main independent determinants of incident undernutrition in community-dwelling older persons.[22] Therefore, these two items were selected as potential items that increase the risk of (future) undernutrition. However, as functional limitations are likely related to an increased mortality risk, but not necessarily through the pathway of undernutrition, this item was added to the model in a final step and only in combination with a poor appetite (see statistical analyses). To summarize, the potential items to be included in the set of criteria were: a low MUAC, self-reported involuntary weight loss, a poor appetite, and functional limitations.

2.4. Measures LASA

Vital status and date of death was traced until June 1, 2007 through the registers of municipalities in which the respondents were living. Survival time was calculated in days from the baseline measurement in 1992–1993 to June 1, 2007. For 6 respondents, survival time was censored at April 1, 2003 due to incomplete follow-up after this date.

Anthropometric data were collected during the medical interview by trained research nurses using a standardized protocol. Height was measured to the nearest 0.1 cm using a stadiometer and weight was measured to the nearest 0.1 kg using a calibrated bathroom scale (Seca, model 100, Lameris, Utrecht, the Netherlands). Knee height of the left leg was measured using a Mediform sliding caliper (Medical Express, Beaverton, OR, USA) with the knee and ankle joints fixed at 90° angles. In 112/1604 respondents with no valid height measurement, height was imputed by either a follow-up measurement, a prediction rule based on knee height, or self-reported

height.[21] BMI was calculated as body weight (kg) divided by height (m) squared. MUAC was measured at the left arm in duplicate to the nearest 0.001 m at a point midway between the lateral projection of the acromion process of the scapula and the inferior margin of the olecranon process of the ulna. The midway point was determined with the arm bent at the elbow at a 90° angle, while the actual measure was performed with the arm hanging loose. The mean of two MUAC measurements was used for the analyses. MUAC was dichotomized into <25 cm and ≥25 cm based on the 5th percentile of the LASA study sample (for both men and women separately). The cut-off of 5% was chosen on the principle of defining limits of normal in continuously normally distributed variables by determining the lower 95% confidence limit in a random population-based sample and has been applied before for MUAC.[6]

Self-reported weight change in the last 6 months was assessed during the face-to-face medical interview by trained research nurses. Information was obtained on the direction of weight change (gained or lost), the amount (in kg) and the reason of weight change. Based on the latter question, a distinction was made between voluntary and involuntary weight change in the past 6 months. Voluntary weight change was due to diet or physical activity, while involuntary weight change was the result of disease, poor appetite, social factors, or a by the participant reported "unknown" reason. For involuntary weight loss a cut-off of 4 kg (<4 kg *versus* ≥4 kg) was used. This was based on a change of ≥5% in 6 months, which is considered clinically relevant [6, 23 and 24] and corresponded to 4 kg when applied to the average men and women of LASA. A cut-off in kg instead of percentages was used to facilitate an easy assessment.

Appetite during the last week was assessed with the following question from the Dutch translation of the Center for Epidemiologic Studies Depression Scale (CES-D)[25]: "I did not feel like eating; my appetite was poor," with response categories: 1 = "rarely or none of the time"; 2 = "some or little of the time"; 3 = "occasionally or moderate amount of the time"; and 4 = "most or all of the time". Two categories were created: no problems with appetite (answer 1) and poor appetite last week (answer 2–4). Difficulty walking up and down a staircase was used to determine functional limitations and was assessed by the question "Can you walk up and down a staircase of 15 steps without stopping?" Response categories were: 1 = "yes"; 2 = "yes, with difficulty"; 3 = "not able without help"; and 4 = "cannot". Two categories were created: no difficulties (answer 1) and difficulties (answer 2–4).

To examine the influence of pre-existing illness and smoking on the association between risk groups and mortality (see paragraph on statistical analyses), the analyses were repeated excluding those with a smoking history or two important thinness associated chronic diseases: obstructive lung disease (OLD) and cancer.[26] The presence (yes or no) of OLD (asthma, chronic bronchitis or pulmonary emphysema) and cancer (malignant neoplasms) was determined by explicitly asking the participants whether they had these diseases. Smoking status and history was assessed and categorized into current, former, and never smokers. Former smokers who stopped smoking more than 15 years ago were classified as never smokers since mortality in former smokers approaches the level of never smokers after a smoking cessation time of 10–20 years.[27 and 28]

2.5. Measures InCHIANTI

Vital status and date of death were traced until October 1, 2006 through the Mortality General Registry maintained by the Tuscany Region and the death certificates that are deposited after the death at the Registry office of the Municipality of residence. Survival time was calculated in days from the baseline measurement in 1998 to October 1, 2006. Follow-up was 100% complete.

Anthropometric data were collected at the study clinic. Height was measured without shoes to the nearest 0.1 cm (HEALTH METER Inc, Bridgeview Illinois, USA). Weight was measured to the nearest 0.1 kg, with the participant wearing light clothes and without shoes, using a high precision mechanical scale (Seca, model 700, Medical Center, Artsana, Italy). BMI was calculated as body weight (kg) divided by height (m) squared. MUAC was measured once on the non dominant arm at the midpoint between the acromion and the olecranon with a flexible tape meter while the participant was standing and with the arm hanging loose. MUAC was similarly dichotomized into <25 cm and ≥25 cm based on the 5th percentile of the LASA study sample.

Self-reported weight loss and the amount (kg) of weight loss in the last 12 months were assessed during the face-to-face interview. No information was available on the reason of weight loss. A cut-off of 6 kg was used instead of 4 kg in LASA to account for the difference in time interval. Appetite during the last week was assessed using the Italian translation of same question from the CES-D[25] as described above. Difficulty climbing up and down a staircase was assessed by the question “Can you walk up and down a staircase of 10 steps without stopping?” Response categories were: 1 = “no difficulty”; 2 = “can without help but does not”; 3 = “with difficulty but without help”; and 4 = “unable to do it”. Two categories were created: no difficulties (answer 1–2) and difficulties (answer 3–4).

The presence (yes or no) of OLD and cancer was ascertained according to pre-established criteria that combine information on medical history, current pharmacological treatment, signs and symptoms, medical documents and hospital discharge records. Smoking status was assessed and categorized into current (within 3 years of the interview), former and never smokers. For former smokers, there was no information available on the cessation time.

2.6. Statistical analyses

Tree-structured survival analysis (TSSA)[29, 30 and 31] was used for the development of a risk model for predicting 15-year mortality risk in the LASA study sample. Advantages of this method over traditional model building strategies such as stepwise Cox regression are that it mimics the actual clinical thinking process and provides a clear description of complex interactions of the included items. In addition, compared to a multivariate model, a tree structure might be more efficient when applied to clinical practice since there is no need for applying a prediction formula and – depending on the finally developed tree – one or two items might already be sufficient to determine (risk of) undernutrition.

Potential predictors that were first examined were: self-reported involuntary weight loss ≥4 kg/6 months; MUAC <25 cm; and poor appetite last week. The analysis started with the entire cohort, called the root node. From this root node, for all candidate dichotomous items (involuntary weight loss, low MUAC, and poor appetite) the subsequent log rank statistic comparing the Kaplan–Meier survival curves were calculated. The predictor with the highest statistical significant value of

the log rank statistic was used for the first partition after the root node. The emerging two subgroups were again partitioned using the same procedure and a tree structure was created. The partitioning stopped when the log rank statistic was not statistically significant for any of the predictors. The groups that emerged without further splitting were called the end nodes. The right side of the node of each binary split contained the highest proportion of deaths at 15 years. Cases with missing values (a maximum of 15% was allowed) on the splitting variable were sent to the left daughter node. When the final tree was completed based on the described procedure above, “difficulties walking up and down a staircase” was added to the tree after the end node “poor appetite last week”. Based on the log rank statistic (statistically significant or not), further splitting by this item was decided upon.
Kaplan–Meier curves for predicting 15-year mortality rates in LASA were created based on the (five) end nodes of the finally developed classification tree. This classification tree was then validated using data from the InCHIANTI study, creating Kaplan–Meier curves for predicting 6-year mortality rates. For comparability, similar analyses were performed in LASA using 6-year mortality. Differences in survival curves between (five) subgroups were tested by a pairwise Wilcoxon (Gehan) test. Finally, based on visual inspection of the Kaplan–Meier curves and the proportion of deaths in each end node, different risk groups were created. Cox regression models were applied to study the mortality risk within these risk groups. To be able to compare the results between LASA and InCHIANTI, area under the curve (AUC), sensitivity and specificity were calculated, using the dichotomous outcome mortality (yes or no) at 15 year (LASA) and 6 year (InCHIANTI and LASA) respectively. These indices (AUC, sensitivity and specificity) are expected to be poor because people are dying for various reasons other than undernutrition. To examine if the results were consistent for men and women, the analyses were also performed stratified by sex. The analyses were also repeated excluding those with a smoking history (current or former<15 years) or OLD and cancer (see paragraph on measures LASA).

3. Results

Of the 2001 eligible LASA respondents, 314 (15.7%) were excluded because they had missing data on *both* MUAC and weight loss; leaving 1687 respondents to be included in the final analyses. Compared to included respondents, excluded respondents were somewhat older (75.9 year *versus* 74.5 year), more often had difficulties walking up and down a staircase (37% *versus* 30%), but had no higher prevalence of a poor appetite. None of the InCHIANTI respondents was excluded because the percentages of missing values for MUAC (135/1142 = 11.8%) and weight loss (17/1142 = 1.5%) were less than 15%.
During the follow-up period of 15 years, 609/836 (73%) of men and 488/851 (57%) of women in the LASA study died (Table 1), with mortality rates of 84 and 55 per 1000 person-years respectively. Based on 6-year follow-up, mortality rates per 1000 person-years were 70 (men) and 39 (women) in LASA and 57 (men) and 38 (women) in InCHIANTI. In both men and women of LASA, those who died within 15 years had a lower MUAC and more often reported involuntary weight loss, poor appetite, or difficulty walking up and down a staircase ($P < 0.05$), but had similar BMI (Table 1) compared to those who survived. Comparable results were found for 6-year mortality in both LASA and InCHIANTI (Table 2). Participants who died

within 6 years in InCHIANTI were slightly older (mean difference of 1 year). Furthermore, participants of InCHIANTI were more often female and had a higher BMI but a lower MUAC than participants of LASA. Furthermore, the prevalence of a low MUAC (<25 cm) was more than twice as high in InCHIANTI and the prevalence of a poor appetite was higher (19% *versus* 13%). The prevalence of (involuntary and voluntary) weight loss and difficulties walking up and down a staircase was comparable in the two studies (Table 2).

[TABLE1]

[TABLE 2]
The classification tree for predicting 15-year mortality risk in LASA is presented in Fig. 1 and the log rank statistics used for building this tree are shown in Table 3. Overall, 65% of the LASA sample died within 15 years. The first partition in the tree was based on the item “MUAC <25 cm” (largest log rank chi-square as shown in Table 3). Of the respondents with a MUAC <25 cm, 89% died within 15 years, while of those with a MUAC ≥25 cm, 64% died. Those with a MUAC ≥25 cm were further partitioned into respondents who reported involuntary weight loss ≥4 kg/6 months (81% died) or respondents who did not (63% died), and so on.

[FIGURE 1]

[TABLE 3].
The final classification tree consisted of five end nodes. Kaplan–Meier curves for predicting 15-year mortality based on these five groups are depicted in Fig. 2. All emerging subgroups I, II and III (not IV) had statistically significantly poorer survival when compared to group V. After visual inspection of these curves, three different groups can be created. Groups I and II from Fig. 1 have the highest mortality risk and include the items MUAC <25 cm and involuntary weight loss ≥4 kg/6 months which determine the actual state of undernutrition so that this group was labeled as “undernutrition”. Group III had an intermediate mortality risk and was labeled as “at risk of undernutrition” since poor appetite and difficulties climbing stairs are risk factors of undernutrition rather than that they measure the actual state of undernutrition. Groups IV and V were labeled as “no undernutrition”. Similar curves were found for 6-year mortality on the LASA and InCHIANTI sample (Fig. 3), except that in InCHIANTI, the mortality risk of weight loss (group II) seemed somewhat lower and the mortality risk of a poor appetite and difficulties climbing stairs (group III) somewhat higher (relative to “no undernutrition; groups I and II), when compared to LASA.

[FIGURE 2]

[FIGURE 3]
As shown in Table 4, the hazard of 15-year mortality was raised in the group at risk of undernutrition (hazard ration (HR) = 1.57 (95% CI 1.22–2.01)) and was highest in the group with undernutrition (HR = 2.22 (95% CI. 1.83–2.69)) when compared to the group without undernutrition. The area under the curve (AUC) for predicting

mortality was 0.55 (0.52–0.58) when comparing those with or at risk of undernutrition with no undernutrition. Similar results were found for men (respective HR's: 1.73 (1.13–2.65); and 2.44 (1.86–3.20), AUC = 0.55 (0.51–0.56)) and women (respective HR's: 1.81 (1.33–2.47); and 2.24 (1.70–2.96), AUC = 0.56 (0.52–0.60)). When excluding those with OLD, cancer or (past) smoking, the mortality hazards remained elevated in LASA (respective HR's: 1.83 (1.23–2.27); and 1.83 (1.35–2.49), AUC = 0.54 (0.50–0.58)). Similar HR's were found for 6-year mortality in the LASA sample (respective HR's: 1.47 (1.01–2.15); and 2.64 (2.03–3.39), AUC = 0.56 (0.53–0.59)) and somewhat higher HR's in the InCHIANTI sample (respective HR's: 2.12 (1.27–3.62); and 2.46 (1.87–3.23), AUC = 0.59 (0.55–0.63)) (Table 4).

[TABLE 4]

4. DISCUSSION

This study describes the development and validation of a fast and easy-to-apply set of criteria, named the Short Nutritional Assessment Questionnaire 65+ (SNAQ^{65+}), for determining (the risk of) undernutrition in community-dwelling older persons. Because a gold standard to determine undernutrition is lacking, the development of the SNAQ^{65+} was performed based on the association with 15-year mortality using undernutrition-related items that are considered important according to recent consensus literature. Based on the SNAQ^{65+} the following groups can be distinguished: (1) undernutrition (MUAC <25 cm *or* involuntary weight loss ≥4 kg in 6 months); (2) risk of undernutrition (poor appetite last week *and* difficulties climbing a staircase); and (3) no undernutrition (others).

The predictive validity of the SNAQ^{65+} was consistent for men and women and for those without cancer/obstructive lung disease or a past smoking status. For the development of the SNAQ^{65+} we used long-term, i.e. 15-year, mortality as an outcome measure. This strengthens the conclusions because it provides more conservative effect estimates compared to short-term mortality which may be confounded by (severe) underlying illness. This likely explains the slightly higher AUCs in the analyses with 6-year mortality. Another strength of the study is that the developed set of criteria was applied to another comparable community-dwelling study sample from Italy, the InCHIANTI study. In this validation step similar or even higher AUCs were observed when compared to LASA, despite slight differences in how items were measured and the prevalence of the items. This supports the generalizability of our findings to community-dwelling older persons.

Because there is no generally accepted, gold standard to determine undernutrition, a novel approach was used to develop and validate the SNAQ^{65+} by using all-cause mortality as an outcome measure. A disadvantage of this method is that traditional diagnostic parameters such as the area under the curve, sensitivity and specificity cannot be interpreted in the traditional sense. The predictive value of the SNAQ^{65+} for predicting mortality was overall poor (area under the curve (AUC) of 0.55 (0.52–0.58) when comparing those with or at risk of undernutrition with no undernutrition). This was to be expected because people are dying for various other reasons than undernutrition. Likewise, the presented values for sensitivity and specificity, and for AUC in Table 4 cannot be compared to diagnostic situations where there is a gold standard and correspondence of the index test is expected to be close to 100%. We used these diagnostic parameters in a prediction setting solely to find the best

determinants for (risk of) undernutrition and not to maximize prediction of mortality. When in the future a (consensus) definition of undernutrition in older persons is available, the performance of the SNAQ^{65+} and other screening instruments need to be evaluated using these traditional diagnostic statistics. The validity to the SNAQ^{65+} was tested by comparing its relationship with mortality using an independent sample of older persons.

For the selection of items, we used predefined cut-off scores for MUAC and involuntary weight loss based on previous consensus.[6, 23 and 24] Furthermore, we only included items that are directly related to (risk of) undernutrition according to consensus literature and not underlying risk factors of undernutrition like chronic diseases and social factors. This choice is justified by a previous longitudinal study, in which several socio-economic, psychological, medical, functional, lifestyle, and social factors were found to be associated with the development of undernutrition in community-dwelling older persons, but only a poor appetite and difficulties walking stairs remained in a multivariate model.[22] For example, it is well possible that some patients with diabetes develop a poor appetite as a result of their disease. When determining the risk of undernutrition with the SNAQ^{65+}, only those with a poor appetite are included – when they also have difficulties climbing stairs – and not all patients with diabetes.

In practice, it may be difficult for older persons to differentiate voluntary from involuntary weight loss, especially for those with cognitive impairment. This may require specific skills from home-care workers. However, additional analyses with respect to the 15-year mortality risk in LASA, incorporating voluntary weight loss ≥4 kg in 6 months as a separate category showed that voluntary weight loss was not associated with an increased mortality risk (HR = 1.04 (95% CI 0.67–1.60)) when compared to the reference group without risk factors present (group V, Fig. 2) while involuntary weight loss was (2.05 (95% CI 1.58–2.67)). This analysis confirms previous reports that involuntary should be separated from voluntary weight loss.[32]

To justify determining (the risk of) undernutrition in community-dwelling older persons, it needs to be an important health problem, there should be an acceptable (screening) tool, and there should be a beneficial (cost-effective) (nutritional) intervention.[33] Although recent evidence summarizing 25 controlled trials suggests a beneficial effect of protein and energy supplements on weight gain and reduced mortality in undernourished older persons in general,[4] the beneficial effect in community-dwelling undernourished older persons specifically (7 controlled trials) is still not clear. However, the quality of some of the included trials was suboptimal and the methods of defining undernutrition varied and were usually based on a low BMI (with cut-off varying from 21 to 27) with or without taking “weight loss” into account. Therefore, in an ongoing study our group is investigating whether intensive treatment by the dietitian is (cost) effective compared to usual care in community-dwelling older persons (≥65 years) who are considered undernourished persons according to the SNAQ^{65+}.

In conclusion, the SNAQ^{65+} can be used to determine (the risk of) undernutrition in older community-dwelling persons. It uses a fast and easy-to-apply set of criteria, without the need of calculation or heavy or expensive equipment, which is very relevant for application in the home situation. The inclusion of items was based on (recent) consistency in the literature on items that determine (the risk of) undernutrition. The SNAQ^{65+} shows good face validity and moderate predictive

validity based on the consistent association with all-case mortality in a second independent study sample. Future studies are needed to determine the association of the SNAQ^{65+} with other outcome measures such as frailty, disability, hospitalization and institutionalization and to determine the benefits of nutritional or other interventions on these outcomes in older community-dwelling persons identified with (risk of) undernutrition according to the SNAQ^{65+}.

STATEMENT OF AUTHORSHIP

The study was conducted, analyzed, and interpreted by the investigators independently of the sponsor. Authors contributions were as followed: HW, MB and MV carried out the design of the study. HW and JS performed the statistical analyses. HW drafted the manuscript. MB, MV, HK, HV, JS, DD, LF had significant advice concerning interpretation of the results and critical review of the manuscript. All authors have reviewed and approved of the manuscript prior to submission.

CONFLICT OF INTEREST STATEMENT

None of the authors had a conflict of interest or financial interest in regard to the publication of this work.

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TABLES AND FIGURES

Table 1.

Baseline characteristics of the Longitudinal Aging Study Amsterdam (questionnaire development) by 15-year all-cause mortality and sex.

	Men				**Women**			
	Overall (*n* = 836)	**Survived (*n* = 227)**	**Died (*n* = 609)**	***P* [a]**	**Overall (*n* = 851)**	**Survived (*n* = 363)**	**Died (*n* = 488)**	***P* [a]**
Age (mean ± SD), y	74.7 ± 5.7	70.6 ± 4.7	76.2 ± 5.2	0.000	74.2 ± 5.9	70.7 ± 4.6	76.8 ± 5.4	0.000
Body mass index (mean ± SD), kg/m^2	25.8 ± 3.3	25.9 ± 2.8	25.7 ± 3.4	0.470	27.7 ± 4.6	27.8 ± 4.6	27.6 ± 4.7	0.534
Mid-upper arm circumference (mean ± SD), cm	30.4 ± 3.1	31.1 ± 2.6	30.2 ± 3.2	0.000	31.5 ± 3.9	31.9 ± 3.6	31.2 ± 4.0	0.011
Mid-upper arm circumference <25 cm (%)	4.4	1.3	5.8	0.011	3.4	1.1	5.4	0.002
Involuntary weight loss ≥4 kg in 6 months	4.3	0.9	5.6	0.005	6.0	3.6	7.9	0.015
Poor appetite last week (%)	9.2	5.3	10.7	0.023	16.8	12.4	20.2	0.004
Difficulty climbing up and down a staircase (%)	23.0	9.7	28.0	0.000	37.3	24.7	47.4	0.000
Smoking status (%	54.2	45.8	57.4	0.004	22.3	19.6	24.6	0.095

	Men				Women			
	Overall (*n* = 836)	**Survived (*n* = 227)**	**Died (*n* = 609)**	***P*** [a]	**Overall (*n* = 851)**	**Survived (*n* = 363)**	**Died (*n* = 488)**	***P*** [a]
current or past <15 yrs)								
Presence of obstructive lung disease (%)	13.9	9.7	15.5	0.042	10.7	8.5	12.3	0.101
Presence of cancer (%)	8.2	4.0	9.7	0.010	11.5	8.6	13.8	0.025

a
The difference between alive and deceased persons is tested by a Yates corrected chi-square test for frequency measures and the Student's *t*-test for normally distributed data.

Table 2.
Baseline characteristics of the LASA sample (development sample) and InCHIANTI sample (validation sample) by 6-year all-cause mortality.

	LASA				InCHIANTI			
	Overall (*n* = 1687)	**Survived (*n* = 1215)**	**Died (*n* = 472)**	***P*** [a]	**Overall (*n* = 1142)**	**Survived (*n* = 862)**	**Died (*n* = 280)**	***P*** [a]
Age (mean ± SD), *y*	74.5 ± 5.8	73.3 ± 5.6	77.3 ± 5.3	0.000	75.4 ± 7.6	73.3 ± 6.3	81.8 ± 7.6	0.000
Sex (% male)	49.6	44.6	62.3	0.000	43.6	40.7	52.5	0.001
Body mass index (mean ± SD), kg/m^2	26.7 ± 4.1	27.0 ± 4.0	26.1 ± 4.3	0.000	27.5 ± 4.1	27.5 ± 4.1	27.1 ± 4.0	0.176
Mid-upper arm circumference (mean ± SD), cm	31.0 ± 3.5	31.3 ± 3.4	30.1 ± 3.7	0.000	28.6 ± 3.3	29.1 ± 3.2	26.9 ± 3.2	0.000
Mid-upper arm circumference < 25 cm (%)	4.0	2.6	7.8	0.000	10.5	6.8	24.3	0.000
Voluntary and involuntary	7.4	5.4	12.7	0.000	5.3	4.4	8.3	0.014

	LASA				InCHIANTI			
	Overall (*n* = 1687)	**Survived (*n* = 1215)**	**Died (*n* = 472)**	***P*** [a]	**Overall (*n* = 1142)**	**Survived (*n* = 862)**	**Died (*n* = 280)**	***P*** [a]
weight loss[b]								
Poor appetite last week (%)	13.1	11.6	16.8	0.006	18.7	17.4	24.0	0.024
Difficulty climbing up and down a staircase (%)[c]	30.4	25.6	42.6	0.000	26.9	18.4	52.9	0.000
Smoking status (% current or past < 15 yrs)[d]	38.1	34.9	47.0	0.000	40.9	40.1	43.2	0.363
Presence of obstructive lung disease (%)	12.3	10.8	16.1	0.003	9.7	8.1	14.6	0.001
Presence of cancer (%)	9.9	8.3	13.8	0.001	6.2	6.7	4.6	0.209

a
The difference between alive and deceased persons is tested by a Yates corrected chi-square test for frequency measures and the Student's *t*-test for normally distributed data.
b
LASA: ≥4 kg in past 6 months; InCHIANTI: ≥6 kg in past 12 months.
c
LASA: 15 steps without stopping InCHIANTI: 10 steps.
d
InCHIANTI: % current or past smoking.

Table 3.
Steps taken during tree-structured survival analysis to develop a risk model for predicting 15-year mortality risk in the LASA study sample (see also Fig. 1).

Items included (Sample)	**Log rank chi-square (*P*)**	**Proportion dead at 15 years**	**Conclusion**
Entire cohort		65%	
Mid-upper arm circumference (MUAC) <25 cm[a]	39.7 (0.000)	89%	1st partition

Items included (Sample)	Log rank chi-square (*P*)	Proportion dead at 15 years	Conclusion
Involuntary weight loss ≥4 kg/6 months[b]	32.0 (0.000)	83%	
Poor appetite last week[c]	14.0 (0.000)	74%	
MUAC ≥25 cm		64%	
Involuntary weight loss ≥4 kg/6 months[b]	27.6 (0.000)	81%	2nd partition
Poor appetite last week[c]	10.2 (0.001)	72%	
MUAC ≥25 cm & no involuntary weight loss		62%	
Poor appetite last week[c]	4.9 (0.027)	70%	3rd partition
MUAC ≥25 cm & no involuntary weight loss & poor appetite		70%	
Difficulty climbing up and down a staircase[d]	6.7 (0.010)	78%	4th partition
MUAC <25 cm		89%	
Involuntary weight loss ≥4 kg/6 months[b]	0.1 (0.714)	93%	No further partition
Poor appetite last week[c]	0.5 (0.462)	94%	No further partition
MUAC ≥25 cm & involuntary weight loss		81%	
Poor appetite last week[c]	2.2 (0.135)	88%	No further partition

a
Versus: mid-upper arm circumference ≥25 cm.
b
Versus: no involuntary weight loss ≥4 kg/6 months.
c
Versus: no poor appetite last week.
d
Versus: no difficulty climbing up and down a staircase.

Table 4.
Prediction of 15-year (LASA) and 6-year (LASA and InCHIANTI) mortality risk by three groups[a] based on the end nodes of the classification tree depicted in Fig. 1.

Groups (I–II; III; IV–V)[a]	Hazard ratio (95% CI)	Cut-off risk groups	AUC (95% CI)[b]	Sens[c]	Spec[d]
LASA, 15-year mortality					

Groups (I–II; III; IV–V)[a]	Hazard ratio (95% CI)	Cut-off risk groups	AUC (95% CI)[b]	Sens[c]	Spec[d]
IV–V (no undernutrition): reference	1.00				
III (risk of undernutrition)	1.57 (1.22–2.01)	I–II–III *versus* IV–V	0.55 (0.52–0.58)	0.17	0.93
I–II (undernutrition)	2.22 (1.83–2.69)	I–II *versus* III–IV–V	0.54 (0.51–0.56)	0.11	0.96
LASA, 6 year mortality					
III (risk of undernutrition)	1.47 (1.01–2.15)	I–II–III *versus* IV–V	0.56 (0.53–0.59)	0.22	0.90
I–II (undernutrition)	2.64 (2.07–3.39)	I–II *versus* III–IV–V	0.56 (0.52–0.59)	0.16	0.95
InCHIANTI, 6 year mortality					
III (risk of undernutrition)	2.12 (1.27–3.62)	I–II–III *versus* IV–V	0.59 (0.55–0.63)	0.31	0.87
I–II (undernutrition)	2.46 (1.87–3.23)	I–II *versus* III–IV–V	0.57 (0.53–0.61)	0.25	0.90

a
I–II: MUAC<25 cm or involuntary weight loss; III: poor appetite & difficulty climbing staircase; IV–V: poor appetite only or no risk factors present.
b
AUC = Area Under the Curve.
c
Sens = sensitivity.
d
Spec = specificity.

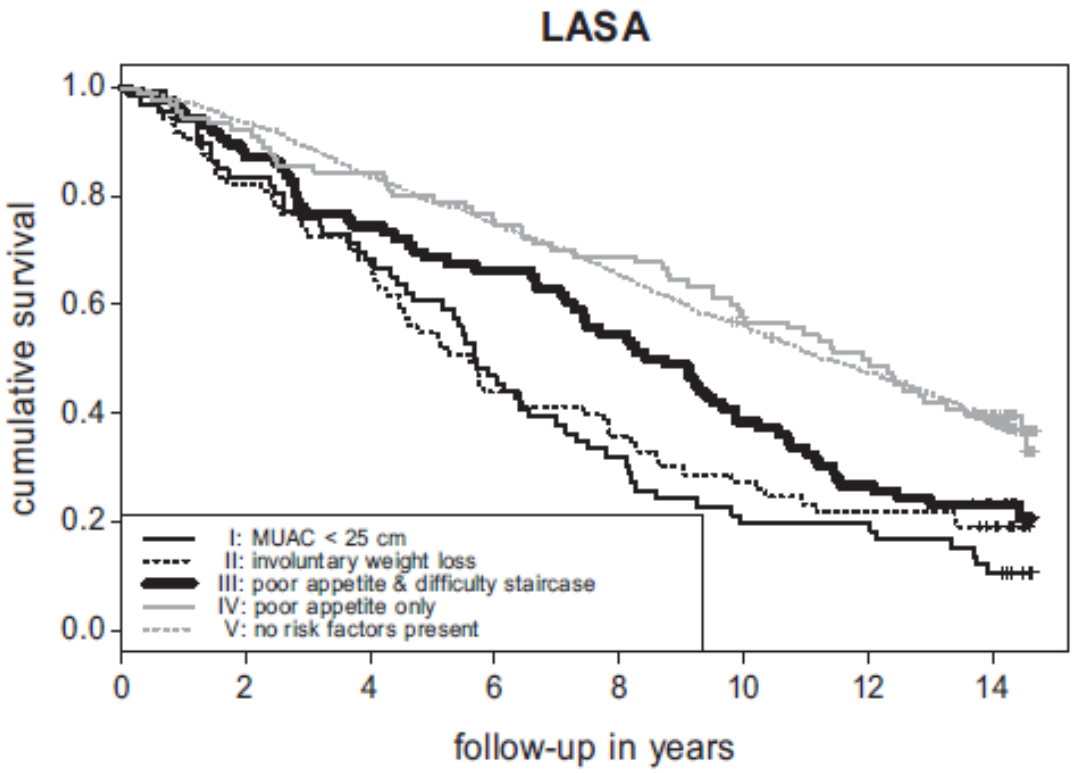

Fig. 2. Kaplan–Meier curves for predicting 15-year mortality in community-dwelling older persons in the LASA study by 5 groups based on the 5 end nodes of the developed classification tree depicted in Fig. 1. Groups I, II, and III had a statistically significantly poorer survival ($p < 0.01$) compared to group V.

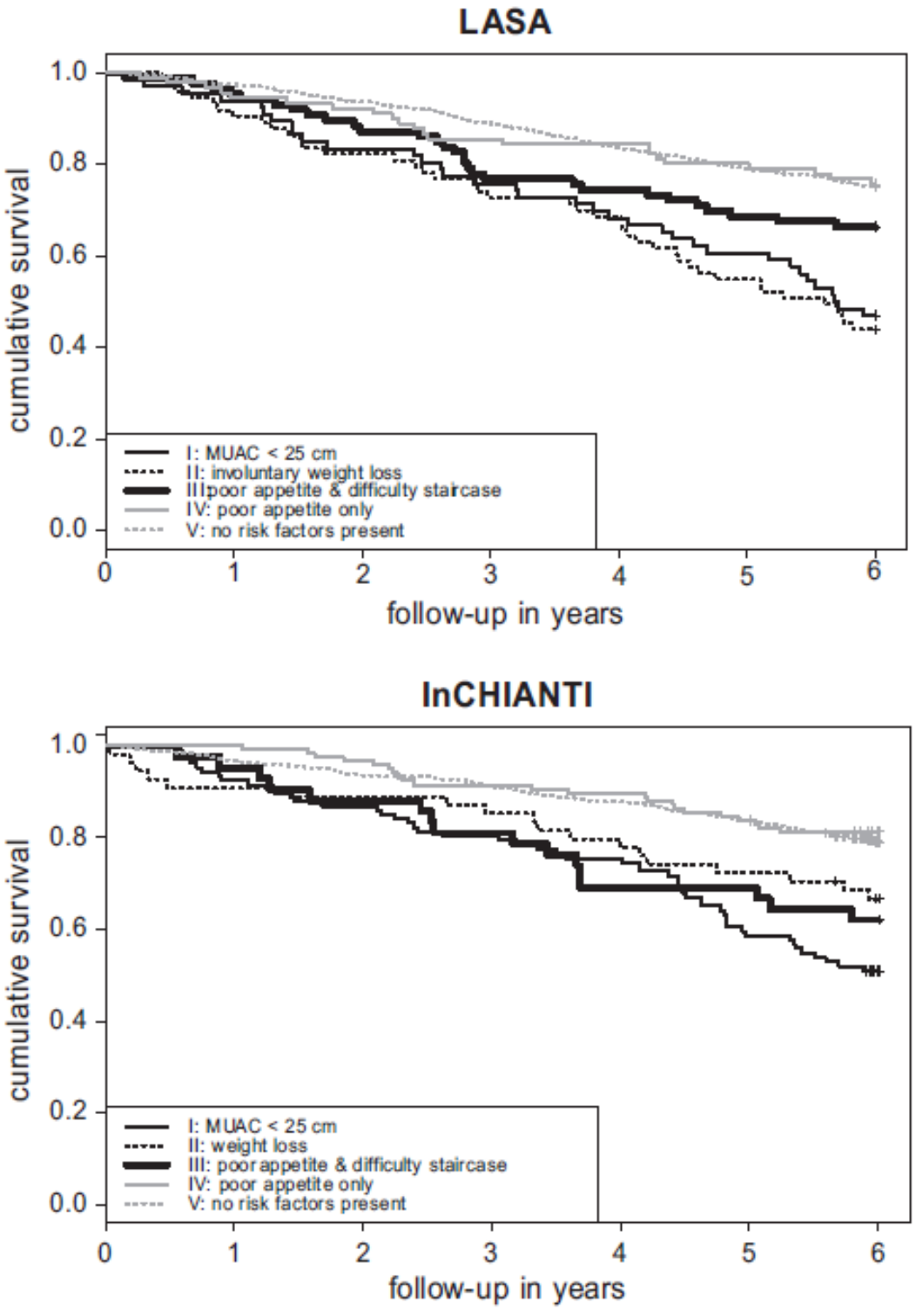

Fig. 3. Kaplan–Meier curves for predicting 6-year mortality in community-dwelling older persons in the LASA and InCHIANTI study by 5 groups based on the 5 end nodes of the developed classification tree depicted in Fig. 1. Groups I, II, and III had a statistically significantly poorer survival ($p < 0.05$) compared to group V.