

## Original article

# Long-term association between malnutrition and all-cause mortality among older adults: A 10-years follow-up study



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## SUMMARY

**Background & aims:** Prior studies have shown an association between malnutrition and mortality. However, it is uncertain whether malnutrition assessed with the Mini Nutritional Assessment (MNA) instrument is suitable for providing long-term prognostic information regarding older adults admitted to hospital. The aim of the present study was to examine if MNA-assessed malnutrition was associated with long-term mortality in older adults admitted to hospital and for how long the association persisted.

**Methods:** 1768 older adults ( $\geq 65$  years old) admitted to a Swedish hospital were assessed with the 18-item MNA during 2008–2009 and followed-up after 10 years. All-cause mortality (ACM) was analyzed separately for the five follow-up periods 0 to  $\leq 2$  years,  $>2$  to  $\leq 4$  years,  $>4$  to  $\leq 6$  years,  $>6$  to  $\leq 8$  years, and  $>8$  to  $\leq 10$  years using Cox regression models adjusted for important demographic, nutritional, and clinical confounders.

**Results:** The participants were on average 78.1 years old at baseline, with 56.0% being females. At 10 years follow-up, 174 (94.1%) malnourished patients, 757 (75.9%) patients at risk of malnutrition, and 297 (50.7%) well-nourished patients had died. For all follow-up periods, malnourished patients and patients at risk of malnutrition had significantly higher risks of early death in the adjusted regression analyses when compared with well-nourished patients (all  $P < 0.05$ ), with the highest risk observed for malnourished patients. For patients still alive at 8 years, the risk of death during the following two years was 2.7 times higher for patients being malnourished at baseline ( $P = 0.013$ ) and 1.9 times higher for patients being at risk of malnutrition at baseline ( $P = 0.001$ ), compared with patients being well-nourished at baseline.

**Conclusions:** MNA-assessed malnutrition is an important independent predictor of long-term mortality in older adults admitted to hospital and the association is consistent over 10 years of follow-up. In clinical practice, MNA may provide long-term prognostic information to rule out those at low risk of mortality and therefore in less need of further assessment and intervention, such that the resources can focus on those in actual need of nutritional support.

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## 1. Introduction

In Europe, 70% of older adults admitted to hospital are either malnourished or at risk of malnutrition [1]. From previous studies, it is well-known that malnutrition and risk of malnutrition are

associated with increased mortality [2–6]. In clinical practice, using the Mini Nutritional Assessment (MNA) instrument has been recommended for identifying malnutrition and risk of malnutrition among older adults [7]. However, it is uncertain if being malnourished or at risk of malnutrition also implies an increased long-term mortality. Previous studies have often been limited by their short follow-up time (mostly one-year mortality), with longer observation periods being needed for predicting the long-term effects of malnutrition on mortality among older adults [3].

For the few studies examining long-term mortality, the results are conflicting. In a study of 444 hospitalized patients (mean age 85

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### Abbreviations

ACM	all-cause mortality
ARM	at risk of malnutrition
BMI	body mass index
CCI	Charlson Comorbidity Index
COPD	chronic obstructive pulmonary disease
HCP	healthcare professionals
HR	hazard ratio
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th Revision
MN	malnourished
MNA	Mini Nutritional Assessment
NAS	nutritional assessment status
ONS	oral nutritional supplement
PIN	personal identification number
PR	Population Register
RCT	randomized controlled trial
TTD	time to death
VNAS	Västerås Nutritional Assessment Study
WN	well-nourished

years), MNA-assessed malnutrition failed to significantly predict mortality at 1- and 4-years follow-up [8]. The authors argued that MNA may not be a suitable instrument for predicting mortality in a hospital population due to the overriding impact of co-morbidities and acute disease. Likewise, another study of 437 inpatients found that MNA-assessed malnutrition was not significantly associated with 3-year all-cause mortality (ACM) [9]. However, contrary to this, in a cohort study of 96 nursing home residents, MNA-assessed malnutrition was found to be useful to predict the risk of death over a 9-year follow-up period [10]. In a Swedish study of 351 women in the general population, participants at risk of malnutrition were more than twice as likely to die during the 10-year follow-up compared to those with a normal nutritional status [11]. Moreover, a study of 209 geriatric outpatients found that malnutrition predicted the risk of mortality from 6 months to 7 years follow-up [12]. Notably, all these studies used quite a small sample size, at most 444 participants.

In view of these conflicting data, we believe that it is important to use a large sample size of participants with a long observation period to examine if MNA-assessed malnutrition or risk of malnutrition are associated with long-term mortality in older adults admitted to hospital and for how long this association may persist. We have previously conducted a prospective cohort study including 1771 older adults admitted to hospital and analyzed ACM [6,13] as well as cause-specific mortality as outcomes [5], showing that MNA-assessed nutritional status predicts preterm death. The present study is a 10-years follow-up of this cohort to examine if malnutrition or risk of malnutrition are associated with long-term mortality in older adults admitted to hospital and for how long the association persists. The hypothesis was that malnutrition and risk of malnutrition assessed with MNA at baseline were independently associated with ACM during the whole 10 years period of follow-up.

#### 1.1. Aim

To examine the association between MNA-assessed nutritional assessment status (NAS) and ACM among older adults during 10 years of follow-up, focusing on how long the observed NAS at baseline was associated with ACM. The hypothesis was that malnutrition and risk of malnutrition assessed with MNA at

baseline were independently associated with ACM during the whole 10 years period of follow-up.

## 2. Materials and methods

### 2.1. Study design and participants

The present study is a prospective 10-years follow-up of the baseline Västerås Nutritional Assessment Study (VNAS), which examined the NAS of 1771 older adults ( $\geq 65$  years old) admitted to a medium-sized Swedish hospital (40% from internal medicine wards, 38% from surgical wards, and 22% from orthopaedic wards) during the period from March 2008 to May 2009. Details about the VNAS study, including sample size calculations and justifications for collecting information about specific variables, have been given in previous publications [4–6,13–16]. A flow chart describing the recruitment process is given in Fig. 1. Of the 1771 individuals in the VNAS cohort, 1768 (99.8%) could be linked to the national Swedish Population Register (PR) using each participant's unique Swedish Personal Identification Number (PIN) and followed-up for ACM during the 10 years after being included in the VNAS cohort, thus constituting the study sample for the present study.

### 2.2. Mini Nutritional Assessment (MNA) instrument

The MNA instrument used to evaluate the NAS of the participants consists of 18 items covering different risk factors for malnutrition, each having between two and four pre-specified answers with different scoring points to choose from. The 18 items are summarized to give a total score between 0 and 30 points, with higher values indicating a better NAS. Finally, the total score is used to classify each participant into one of the following three NAS groups: well-nourished (WN; 24–30 points), at risk of malnutrition (ARM; 17–23.5 points), or malnourished (MN; <17 points) [17,18].

### 2.3. Data collection

During the study period from March 2008 to May 2009, patients were consecutively enrolled in the VNAS cohort by 18 specially trained healthcare professionals (HCPs) who applied the MNA to evaluate the NAS of the patients within the first few days of the patients having been admitted to the ward. The MNA instrument consists of two parts, thus allowing a two-step screening procedure in the NAS evaluation [19]. However, for the present study, the full MNA instrument was used for all patients.

To calculate body mass index (BMI;  $\text{kg}/\text{m}^2$ ) for MNA question F, a stadiometer was used to measure the patient's height to the nearest centimeter, while a calibrated chair or mobile lift scale was used to measure weight to the nearest kilogram. For patients who were unable to stand upright, height was measured with a sliding caliper or estimated from their demi-span using the formulas given by Bassey [20]. The patient's BMI was then calculated using the standard formula  $\text{weight (kg)}/\text{height}^2 (\text{m}^2)$ .

The HCPs also collect data on demographic and clinical characteristics using a study-specific questionnaire. Electronic medical records were used to collect data on medical diagnoses at the date of discharge from hospital. Data on sex and date of birth were obtained from each participant's PIN, while data on country of birth and dates of death and emigration were obtained from the PR.

### 2.4. Study variables

The collected data included the full MNA instrument, age (years), male sex (yes/no), foreign born (yes/no), date of death or emigration, smoking (yes/no), BMI ( $\text{kg}/\text{m}^2$ ), overnight fast (hours),

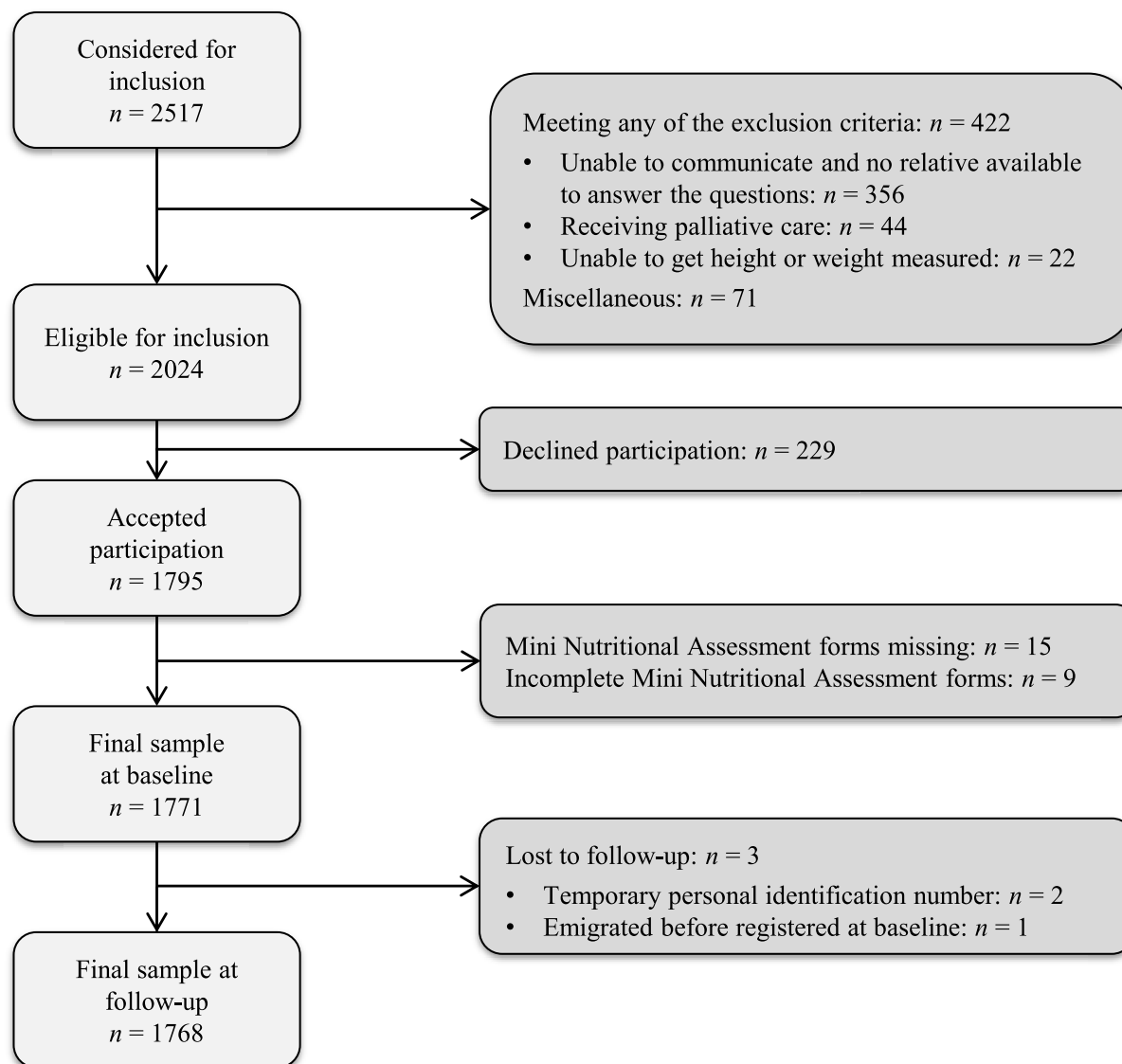


Fig. 1. Flow chart over recruitment process with reasons for exclusions and loss to follow-up.

number of eating episodes, number of medical diagnoses, number of medications taken, current living situation (living alone, cohabiting, or living in a nursing home), meal provision (cooks independently, meals on wheels, at the nursing home, or at restaurants; multiple answers possible), and the Charlson Comorbidity Index (CCI) [21], as well as the following specific medical diagnosis groups, classified using *International Statistical Classification of Diseases and Related Health Problems*, 10th Revision (ICD-10) codes, which were deemed potentially associated with malnutrition and had a prevalence of >1% in the study sample: diabetes mellitus (E10–E14), cerebrovascular disease (I60–I69), pneumonia (J12–J18), chronic obstructive pulmonary disease (COPD; J44), rheumatoid arthritis (M05–M06), and renal failure (N17–N19). The diagnosis dementia or Alzheimer's disease (F00–F03, G30), which was found among 33 (1.9%) of the patients, was not included in the study since it was covered by question E, *Neuropsychological problems*, of the MNA instrument.

Age was calculated as the time from date of birth to date of inclusion in the VNAS study. Overnight fast was defined as the time between the last eating episode in the evening and the first eating

episode the following morning, while number of eating episodes was defined as how often the patient usually ate breakfast, lunch, dinner, and between-meal and evening snacks. CCI was constructed using ICD-10 coding according to Quan et al. [22] and weights from Charlson et al. [21].

## 2.5. Outcome

Time-to-death (TTD) from any cause, with a maximum follow-up time of 10 years, was used as outcome. TTD was calculated as the time from date of inclusion in the VNAS study to date of death or censoring, whichever came first. Individuals were considered censored if they were unregistered from the PR due to emigration or other reasons, or if they were still alive 10 years after the date of inclusion in the VNAS study.

## 2.6. Ethical considerations

The VNAS study has been approved by the Uppsala Ethical Review Board (approval no.: 2007-323) and the Swedish Ethical

Review Agency (approval no.: 2022-05734-02). All participants gave written informed consent before entering the study. For 23 participants who were unable to communicate, participation in the study was approved by a next-of-kin, who also assisted in answering the MNA questions and the study-specific questionnaire together with the patient. Patients assessed as malnourished or at risk of malnutrition according to the MNA instrument were informed about their nutritional status but did not get any additional interventions as part of the study, only the routine interventions at the hospital.

## 2.7. Statistical analyses

Categorical data are presented as frequencies and percentages,  $n$  (%), while ordinal, discrete, and continuous data are given as means with accompanying standard deviations (SDs). Tests of differences between the three NAS groups were performed using Pearson's  $\chi^2$ -test for categorical data, Kruskal–Wallis rank-sum test for ordinal, discrete, and continuous data, and log-rank test for time-to-event data. For cases where the  $\chi^2$ -approximation for Pearson's  $\chi^2$ -test might be incorrect,  $P$ -values were computed by Monte Carlo simulations using 100 000 replications. A graphical presentation of the survival probability for the three NAS groups over the 10-years follow-up period is given by a Kaplan–Meier plot.

Adjusted and unadjusted Cox regression models with all independent variables included in the models as piecewise variables with change points at 2, 4, 6, and 8 years were used to examine how long the observed NAS at baseline was associated with ACM. For these models, the three-category NAS was the risk factor of main interest, with the well-nourished group used as reference category.

All variables that did not contribute directly or indirectly to the MNA score were used as confounders: age (years), male sex (yes/no), foreign born (yes/no), smoking (yes/no), overnight fast  $\geq 12$  h (yes/no), eating episodes  $\geq 4$  (yes/no), number of diagnoses (yes/no), diabetes mellitus (yes/no), cerebrovascular disease (yes/no), pneumonia (yes/no), COPD (yes/no), rheumatoid arthritis (yes/no), and renal failure (yes/no). The results are presented as hazard ratios (HRs) with accompanying 95% confidence intervals (CIs), separately for the five follow-up periods 0 to  $\leq 2$  years,  $>2$  to  $\leq 4$  years,  $>4$  to  $\leq 6$  years,  $>6$  to  $\leq 8$  years, and  $>8$  to  $\leq 10$  years. For both adjusted and unadjusted Cox regression analyses, the proportional hazards assumption was tested for each explanatory variable using the Grambsch–Therneau test [23]. In none of the cases was the proportional hazards assumption rejected. All statistical analyses were performed in R  $\geq 4.2.0$  (R Foundation for Statistical Computing, Vienna, Austria), with two-sided  $P$ -values  $<0.05$  considered statistically significant.

## 3. Results

The 1768 participants were at a mean (SD) age of 78.1 (7.8) years at baseline, with a majority ( $n = 990$ , 56.0%) being females. They were followed-up for a mean (SD) time of 5.6 (3.8) years, or 9941 person-years of follow-up.

### 3.1. Participant characteristics

Demographic, nutritional, and clinical characteristics for the 1768 participants are given in Table 1 according to observed NAS. The three NAS groups differed significantly for most of the

**Table 1**  
Demographic, nutritional, and clinical characteristics for the  $n = 1768$  participants according to observed nutritional assessment status.

Variable	Well-nourished $n = 586$	At risk of malnutrition $n = 997$	Mal-nourished $n = 185$	P-value <sup>c</sup>	Missing $n$ (%)
Age (years), mean (SD)	75.8 (7.3)	78.9 (7.7)	81.1 (8.1)	<b>&lt; 0.001*</b>	0 (0.0)
Male sex, $n$ (%)	275 (46.9)	427 (42.8)	76 (41.1)	0.198 <sup>†</sup>	0 (0.0)
Foreign born, $n$ (%)	98 (16.7)	146 (14.6)	19 (10.3)	0.094 <sup>†</sup>	0 (0.0)
Smoking, $n$ (%)	58 (9.9)	107 (10.7)	32 (17.4)	<b>0.016<sup>†</sup></b>	2 (0.1)
BMI (kg/m <sup>2</sup> ), mean (SD) <sup>a</sup>	27.3 (3.9)	25.9 (4.8)	21.7 (4.9)	<b>&lt; 0.001*</b>	2 (0.1)
Overnight fast $\geq 12$ h, $n$ (%)	422 (72.1)	804 (80.7)	160 (86.5)	<b>&lt; 0.001<sup>†</sup></b>	2 (0.1)
Eating episodes $\geq 4$ , $n$ (%)	351 (59.9)	490 (49.1)	68 (36.8)	<b>&lt; 0.001<sup>†</sup></b>	0 (0.0)
Number of diagnoses, mean (SD)	2.7 (1.5)	3.2 (1.7)	3.7 (1.9)	<b>&lt; 0.001*</b>	0 (0.0)
Number of medications, mean (SD) <sup>a</sup>	3.5 (3.0)	5.1 (3.4)	6.2 (3.9)	<b>&lt; 0.001*</b>	0 (0.0)
Living situation, $n$ (%) <sup>a</sup>				<b>&lt; 0.001<sup>†</sup></b>	1 (0.1)
– Cohabiting	358 (61.1)	454 (45.6)	40 (21.6)		
– Living alone	220 (37.5)	484 (48.6)	105 (56.8)		
– Nursing home	8 (1.4)	58 (5.8)	40 (21.6)		
Meal provision, $n$ (%) <sup>a,b</sup>					5 (0.3)
– Cooks independently	559 (95.6)	835 (84.1)	122 (65.9)	<b>&lt; 0.001<sup>†</sup></b>	
– Meals on wheels	22 (3.8)	121 (12.2)	33 (17.8)	<b>&lt; 0.001<sup>†</sup></b>	
– Nursing home	6 (1.0)	42 (4.2)	31 (16.8)	<b>&lt; 0.001<sup>†</sup></b>	
– Restaurant	17 (2.9)	55 (5.5)	10 (5.4)	<b>0.049<sup>†</sup></b>	
Diabetes mellitus, $n$ (%)	77 (13.1)	186 (18.7)	27 (14.6)	<b>0.013<sup>†</sup></b>	0 (0.0)
Cerebrovascular disease, $n$ (%)	81 (13.8)	155 (15.5)	23 (12.4)	0.430 <sup>†</sup>	0 (0.0)
Pneumonia, $n$ (%)	12 (2.0)	41 (4.1)	8 (4.3)	0.074 <sup>†</sup>	0 (0.0)
COPD, $n$ (%)	15 (2.6)	51 (5.1)	14 (7.6)	<b>0.007<sup>†</sup></b>	0 (0.0)
Rheumatoid arthritis, $n$ (%)	8 (1.4)	21 (2.1)	10 (5.4)	<b>0.005<sup>#</sup></b>	0 (0.0)
Renal failure, $n$ (%)	13 (2.2)	26 (2.6)	14 (7.6)	<b>&lt; 0.001<sup>†</sup></b>	0 (0.0)
CCI score, mean (SD) <sup>a</sup>	0.9 (1.4)	1.1 (1.4)	1.3 (1.8)	<b>0.002*</b>	0 (0.0)
Deceased at follow-up, $n$ (%)					
– 2 years follow-up	88 (15.0)	264 (26.5)	103 (55.7)	<b>&lt; 0.001<sup>‡</sup></b>	0 (0.0)
– 4 years follow-up	142 (24.2)	442 (44.3)	133 (71.9)	<b>&lt; 0.001<sup>‡</sup></b>	0 (0.0)
– 6 years follow-up	201 (34.3)	567 (56.9)	153 (82.7)	<b>&lt; 0.001<sup>‡</sup></b>	0 (0.0)
– 8 years follow-up	254 (43.3)	673 (67.5)	166 (89.7)	<b>&lt; 0.001<sup>‡</sup></b>	0 (0.0)
– 10 years follow-up	297 (50.7)	757 (75.9)	174 (94.1)	<b>&lt; 0.001<sup>‡</sup></b>	0 (0.0)

Notes: BMI, Body Mass Index; CCI, Charlson Comorbidity Index; COPD, Chronic obstructive pulmonary disease; MNA, Mini Nutritional Assessment; SD, standard deviation. Significant  $P$ -values are given in **bold**. <sup>a</sup> Contributed directly or indirectly to the MNA score. <sup>b</sup> Multiple answers possible. <sup>c</sup>  $P$ -values from Kruskal–Wallis rank-sum test<sup>\*</sup>, Pearson's  $\chi^2$ -test<sup>†</sup>, and log-rank test<sup>‡</sup>. <sup>#</sup>  $P$ -values computed by Monte Carlo simulation.

characteristics, with the largest difference often being between the groups of malnourished and well-nourished patients. The malnourished patients were thus the oldest at a mean (SD) age of 81.1 (8.1) years ( $P < 0.001$ ), had the lowest BMI at mean (SD) 21.7 (4.9) kg/m<sup>2</sup> ( $P < 0.001$ ), were the most frequent smokers ( $n = 32$ , 17.4%;  $P = 0.016$ ), the most likely to have an overnight fast  $\geq 12$  h ( $n = 160$ , 86.5%;  $P < 0.001$ ), the least likely to have  $\geq 4$  eating episodes ( $n = 68$ , 36.8%;  $P < 0.001$ ), and had the highest mean (SD) number of diagnoses and medications at 3.7 (1.9) and 6.2 (3.9), respectively ( $P < 0.001$  for both). In contrast to this, the well-nourished patients were the youngest at a mean (SD) age of 75.8 (7.3) years, had the highest BMI at mean (SD) 27.3 (3.9) kg/m<sup>2</sup>, were the least frequent smokers ( $n = 58$ , 9.9%), the least likely to have an overnight fast  $\geq 12$  h ( $n = 422$ , 72.1%), the most likely to have  $\geq 4$  eating episodes ( $n = 351$ , 59.9%), and had the lowest mean (SD) number of diagnoses and medications at 2.7 (1.5) and 3.5 (3.0), respectively.

### 3.2. Long-term associations with ACM

A Kaplan–Meier plot of the survival probability for the three NAS groups over the 10-years follow-up period is given in Fig. 2. The risk of early death differed significantly between the three groups ( $P < 0.0001$ ). The median survival was just under two years for malnourished patients, five years for patients at risk of malnutrition, and ten years for well-nourished patients. The number and percentage of deceased at 2, 4, 6, 8, and 10 years of follow-up are given in Table 1. Notably, the risk of death differed significantly between the three NAS groups at all time-points (all  $P < 0.001$ ). At 10 years of follow-up, 174 (94.1%) malnourished patients, 757 (75.9%) patients at risk of malnutrition, and 297 (50.7%) well-nourished patients had died.

Results from Cox regression analyses of the association between NAS and TTD during the five separate follow-up periods are given in Table 2. During all the five periods, being malnourished or at risk of malnutrition was significantly associated with an increased risk of early death, compared with being well-nourished (reference

category), in unadjusted as well as adjusted analyses. In the unadjusted analyses, the HRs for the ARM compared with the WN group varied between a low of 1.89 during the period 0 to  $\leq 2$  years and a high of 2.48 during the period  $>2$  to  $\leq 4$  years (both  $P < 0.001$ ), with the corresponding values for the MN compared the WN group being 4.94 during the period 0 to  $\leq 2$  years and 3.28 during the period  $>4$  to  $\leq 6$  years (both  $P \leq 0.001$ ). The results were somewhat more stable in the adjusted analyses, with a low of 1.45 during the period  $>4$  to  $\leq 6$  years ( $P = 0.021$ ) and a high of 1.91 during the period  $>2$  to  $\leq 4$  years ( $P < 0.001$ ) for the ARM compared with the WN group, with the corresponding values for the MN compared the WN group being 2.25 during the period  $>4$  to  $\leq 6$  years ( $P = 0.003$ ) and 3.69 during the period 0 to  $\leq 2$  years ( $P < 0.001$ ). An overview of the results for the adjusted Cox regression analyses are given in Fig. 3.

## 4. Discussion

The main finding of the present study was that MNA-assessed nutritional status, after adjusting for important confounders, was an independent predictor of long-term mortality in older adults admitted to hospital. Moreover, our study found that MNA predicted ACM during all five separate follow-up periods up to 10 years after MNA was measured. These findings imply that older patients who are malnourished or at risk of malnutrition according to MNA are at risk of both short- and long-term (up to 10 years) increased mortality.

### 4.1. Results in perspective

Several studies have described MNA-assessed nutritional status as an independent predictor of mortality in different settings, such as free-living people [11], community-dwelling older adults receiving home care [3], geriatric outpatients [12], in a nursing home setting [10], and among elderly in specific disease groups [24]. However, limitations are often small sample sizes and/or short follow-up periods.

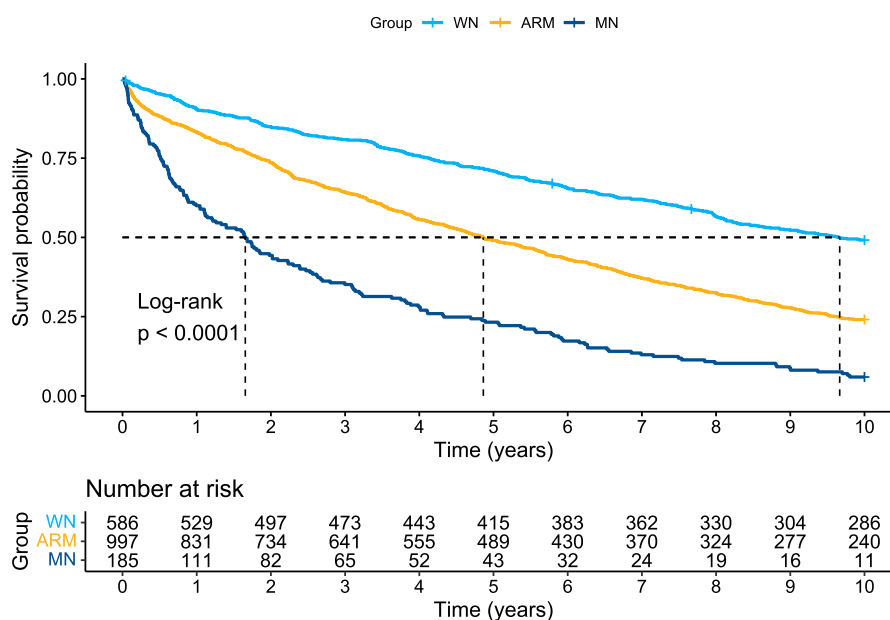
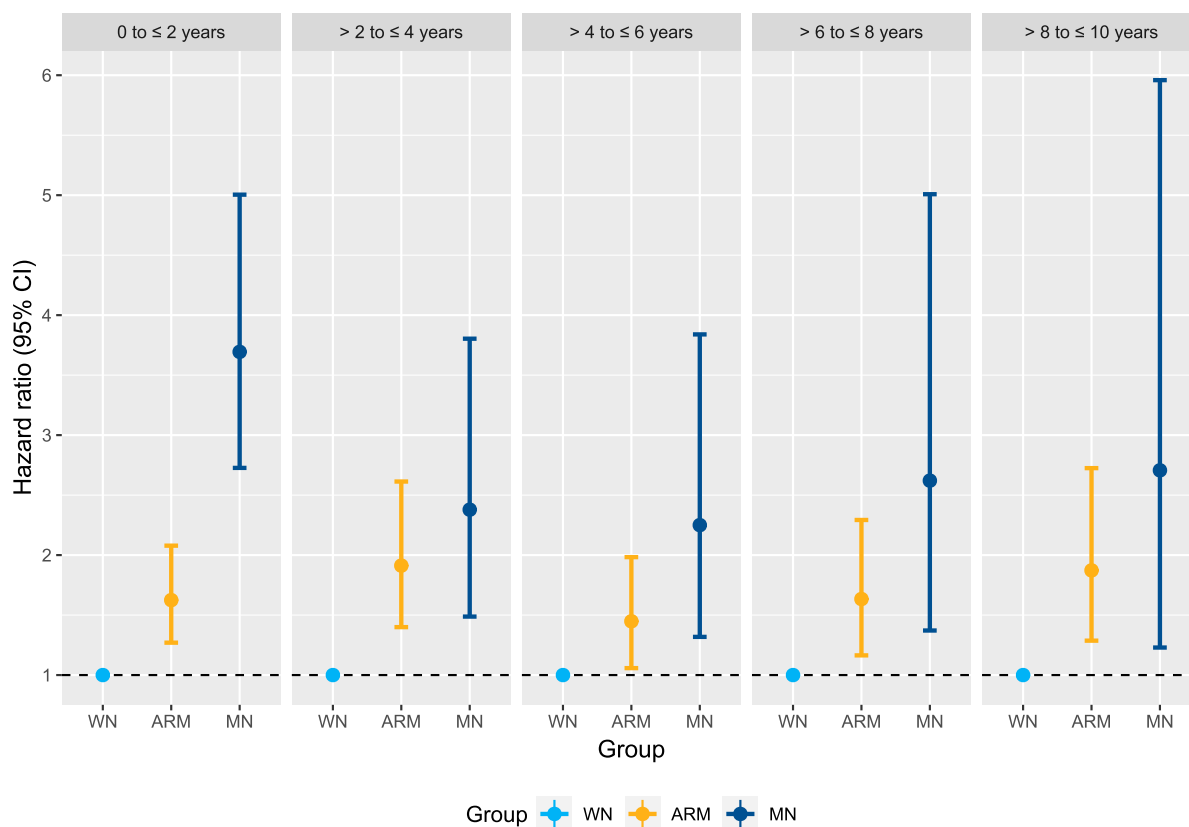


Fig. 2. Survival probability for the three nutritional assessment status groups well-nourished (WN), at risk of malnutrition (ARM), and malnourished (MN) over the 10-years follow-up period.

**Table 2**  
Results of Cox regression analyses for associations between nutritional assessment status and time to death during different follow-up periods.

Follow-up period (years)	Nutritional assessment status	Unadjusted <sup>a</sup>			Adjusted		
		HR	95% CI	P-value	HR	95% CI	P-value
0 to ≤2	Well-nourished	Ref.			Ref.		
	At risk of malnutrition	1.89	1.48–2.40	< <b>0.001</b>	1.62	1.26–2.08	< <b>0.001</b>
	Malnourished	4.94	3.72–6.57	< <b>0.001</b>	3.69	2.72–5.01	< <b>0.001</b>
>2 to ≤4	Well-nourished	Ref.			Ref.		
	At risk of malnutrition	2.48	1.82–3.37	< <b>0.001</b>	1.91	1.39–2.62	< <b>0.001</b>
	Malnourished	4.09	2.61–6.41	< <b>0.001</b>	2.38	1.48–3.81	< <b>0.001</b>
>4 to ≤6	Well-nourished	Ref.			Ref.		
	At risk of malnutrition	1.77	1.29–2.41	< <b>0.001</b>	1.45	1.05–1.99	<b>0.021</b>
	Malnourished	3.28	1.97–5.44	< <b>0.001</b>	2.25	1.31–3.84	<b>0.003</b>
>6 to ≤8	Well-nourished	Ref.			Ref.		
	At risk of malnutrition	1.95	1.39–2.72	< <b>0.001</b>	1.63	1.16–2.30	<b>0.005</b>
	Malnourished	3.64	1.98–6.69	< <b>0.001</b>	2.62	1.37–5.01	<b>0.004</b>
>8 to ≤10	Well-nourished	Ref.			Ref.		
	At risk of malnutrition	2.13	1.47–3.09	< <b>0.001</b>	1.87	1.28–2.73	<b>0.001</b>
	Malnourished	3.47	1.62–7.38	<b>0.001</b>	2.71	1.22–5.96	<b>0.013</b>

Notes: CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio; Ref., reference category. Significant P-values are given in **bold**. <sup>a</sup> Results based on n = 1768 (100.0%) participants with 1228 (69.5%) events. <sup>b</sup> Adjusted for age, male sex, foreign born, smoking, overnight fast ≥ 12 h, eating episodes ≥ 4, number of diagnoses, diabetes mellitus, cerebrovascular disease, pneumonia, COPD, rheumatoid arthritis, and renal failure. Results based on n = 1765 (99.8%) participants with 1225 (69.4%) events.



**Fig. 3.** Hazard ratios with 95% confidence intervals (CIs) for adjusted Cox regression analyses of the associations between nutritional assessment status (WN, well-nourished; ARM, at risk of malnutrition; MN, malnourished) and time to death during different follow-up periods.

Using a relatively small (n = 309) sample size of older adults receiving home care, Kiesswetter et al. found that MNA predicted one-year mortality with HRs (95% CIs) of 8.75 (2.45–31.18) for malnourished participants and 5.05 (5.53–16.58) for those at risk of malnutrition [3]. In our study with 1768 participants, the HR (95% CI) in the 0 to ≤ 2 years follow-up period was 3.69 (2.72–5.01) for malnourished patients and 1.62 (1.26–2.08) for those at risk of malnutrition. The authors in the aforementioned study argue that

longer observation periods are needed for prediction of mortality using MNA [3].

In a 10-years follow-up study conducted in Sweden during the years 1999–2009, Lundin et al. examined a free-living female population, again with a relatively small sample (n = 351), of whom only one was diagnosed with malnutrition. During the 10-year follow-up period, women at risk of malnutrition were more than twice as likely to die, HR (95% CI) 2.36 (1.25–4.46) [11]. In a 9-year

retrospective cohort study of 96 nursing home residents reported by Ozturk et al., malnutrition assessed with the MNA-short form (MNA-SF) was found to be significantly associated with an increased risk of early death both for those being malnourished (HR 4.84; 95% CI 1.92–12.22) and those being at risk of malnutrition (HR 3.91; 95% CI 1.89–8.09) [10]. In the present study, the HR (95% CI) in the >8 to ≤10 years follow-up period was 2.71 (1.22–5.96) for malnourished patients and 1.87 (1.28–2.73) for those at risk of malnutrition.

Notably, none of the abovementioned studies used a hospital setting. In fact, there are few and insufficient studies about the effect of MNA-assessed malnutrition on long-term mortality in a hospital setting. When studying patients admitted to hospital, neither Vischer et al. using 1- and 4-years follow-up [8], nor Jiang et al. using 3-years follow-up [9], found significant associations between NAS and ACM. Vischer et al. [8] argued that the likeliest explanation for their findings was that MNA is not suitable for providing prognostic information in a hospital setting, having a high co-morbidity load and mortality rate, due to a strong competing influence of acute medical conditions on mortality predictions. However, the present study included patients from internal medicine wards (40%), surgical wards (38%), and orthopaedic wards (22%), with a mean of 3.1 diagnoses and 5.4 different medications. Moreover, the mortality rate was high; at 10-years follow-up 94.1% of the malnourished patients, 75.9% of patients at risk of malnutrition, and 50.7% of the well-nourished patients had died. This suggests that MNA is in fact a suitable tool to use for mortality prediction in older adults in a hospital setting. Even though the instrument originally was developed for assessing nutritional status in older adults, it has been shown to also detect frailty status. This increases its usefulness in clinical practice as two common geriatric syndromes can be assessed simultaneously and raises the question whether frailty status assessed with the MNA also is associated with ACM [25].

A possible explanation for the association between MNA and ACM is the patients' underlying diseases. However, in a previous prospective cohort study, we found that malnourished older adults as well as those at risk of malnutrition had a consistently higher risk of early death compared with well-nourished older adults, regardless of the cause of death [5]. This emphasizes that malnutrition and risk of malnutrition by themselves are important risk factors for early death. Moreover, the association between the separate items of the MNA and mortality has also been explored in a previous study. This study demonstrated that the items food intake, independent living, having >3 prescription drugs, fluid intake, and self-assessed health status were all independently associated with ACM among older adults [1].

Pooled data from 990 older adults at risk of malnutrition from nine randomized controlled trials (RCTs) investigating the effect of nutritional interventions on energy intake and body weight have shown that dietary counselling combined with oral nutritional supplements (ONS) is more effective than dietary counselling or ONS used alone [26]. The use of ONS improved subjective health-related quality of life in malnourished older adults in a multi-centre RCT in Sweden [27]. Moreover, a recent nationwide population-based cohort study of 69 934 hospitalised patients with malnutrition demonstrated that receiving nutritional support in routine care decreased in-hospital mortality [28]. However, the treatment effect on mortality is inconsistent, with other studies showing no beneficial effects of nutritional intervention (dietary counselling, ONS, or both) on mortality [29,30], provided that survival is the aim of the treatment. Further research in this area is needed to determine if nutritional support also can enhance survival.

#### 4.2. Strengths and limitations

The main strength of the present study was that it used a longer follow-up period than any previous study of older adults admitted to hospital. Another unique feature was that it focused on how long the association with ACM persisted, divided over five different time periods. Yet another strength was the large sample, indicated by the small confidence interval of the HR (Table 2). A limitation of the study was that the results cannot be generalized to free-living people or those in nursing homes, as only 5% of our study population was living in nursing homes before being admitted to hospital. Moreover, 24 of the 33 patients diagnosed with dementia or Alzheimer's disease answered the questions by themselves, which is a source of uncertainty regarding the correctness of these answers. Finally, patients admitted to hospital during weekends or holidays were not included in the study, which may have resulted in a selection bias.

#### 5. Conclusions and clinical implications

The present study found that malnutrition and risk of malnutrition was associated with increased long-term mortality among older adults admitted to hospital. Moreover, the study showed that the increased mortality rate persisted over time, being significant at all the five time periods. Thus, MNA proved to be a useful tool for predicting long-term mortality in a hospital setting. These results highlight the importance of finding patients with a poor nutritional status early. In clinical practice, medical staff should screen the patients admitted to hospital with the MNA to identify those with malnutrition and risk of malnutrition to allow timely nutritional interventions to improve the nutritional status before it is too late. The MNA can be used to provide long-term prognostic information to rule out those at low risk of mortality and therefore in less need of further assessment and intervention, such that HCPs can focus the resources on those in actual need of nutritional support.

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#### Conflict of interest

The authors declare no conflicts of interest.

#### Author contributions

**Lisa Söderström:** Conceptualization, Methodology, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Project administration. **Andreas Rosenblad:** Conceptualization, Methodology, Software, Formal analysis, Data Curation, Writing – Original Draft, Writing – Review & Editing. All the authors reviewed and commented on the manuscript.

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