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Malnutrition risk and its association with adverse outcomes in a Belgian cohort of community-dwelling adults aged 80 years and over

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Abstract:	<p>Objectives: To investigate the prevalence of malnutrition risk and its association with adverse outcomes in a Belgian cohort of community-dwelling adults aged ≥ 80 years, a worldwide growing age-group. Methods: In the BELFRAIL cohort, malnutrition risk was evaluated with the Mini Nutritional Assessment (MNA total score < 24) and prealbumin levels (< 20 mg/dl). Agreement between them was assessed with Kohen's kappa coefficient. Association of malnutrition risk with first unplanned hospitalization (3.0 $\pm$ 0.25 years follow-up) and mortality (5.1 $\pm$ 0.25 years follow-up) was investigated with survival analysis and Cox multivariate regression. Results: Out of 567 BELFRAIL participants, 556 (98.1%) had MNA data and 545 (96.1%) prealbumin levels. Sixty-eight (12.2%) were at risk of malnutrition based on MNA and 69 (12.7%) based on prealbumin, with very poor agreement between them (Kappa=0.024, 95% CI -0.064, 0.112). For both MNA and prealbumin, participants with malnutrition risk had lower scores on physical and cognitive performance tests. They had no higher risk for first hospitalization compared to those without malnutrition risk, but higher risk for all-cause mortality even after adjustment for multimorbidity, inflammation, physical and mental functioning (HR 1.35 95%CI 0.92-1.97 for MNA; HR 1.46; 95%CI 1.01-2.12 for prealbumin). Conclusion: Malnutrition risk based on MNA or prealbumin was low in a Belgian cohort of community-dwelling adults 80 years and older. Physical and cognitive performance was lower in those with malnutrition risk, but malnutrition risk was not independently associated with hospitalization and mortality (except for malnutrition risk by prealbumin). Further research needs to investigate the best tool to assess malnutrition risk in this age group.</p>	
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Malnutrition risk and its association with adverse outcomes in a Belgian cohort of community-dwelling adults aged 80 years and over

ABSTRACT

Objectives: To investigate the prevalence of malnutrition risk and its association with adverse outcomes in a Belgian cohort of community-dwelling adults aged ≥ 80 years, a worldwide growing age-group.

Methods: In the BELFRAIL cohort, malnutrition risk was evaluated with the Mini Nutritional Assessment (MNA total score <24) and prealbumin levels (<20 mg/dl). Agreement between them was assessed with Kohen's kappa coefficient. Association of malnutrition risk with first unplanned hospitalization (3.0 $\pm$ 0.25 years follow-up) and mortality (5.1 $\pm$ 0.25 years follow-up) was investigated with survival analysis and Cox multivariate regression.

Results: Out of 567 BELFRAIL participants, 556 (98.1%) had MNA data and 545 (96.1%) prealbumin levels. Sixty-eight (12.2%) were at risk of malnutrition based on MNA and 69 (12.7%) based on prealbumin, with very poor agreement between them (Kappa=0.024, 95% CI -0.064, 0.112). For both MNA and prealbumin, participants with malnutrition risk had lower scores on physical and cognitive performance tests. They had no higher risk for first hospitalization compared to those without malnutrition risk, but higher risk for all-cause mortality even after adjustment for multimorbidity, inflammation, physical and mental functioning (HR 1.35 95%CI 0.92-1.97 for MNA; HR 1.46; 95%CI 1.01-2.12 for prealbumin).

Conclusion: Malnutrition risk based on MNA or prealbumin was low in a Belgian cohort of community-dwelling adults 80 years and older. Physical and cognitive performance was lower in those with malnutrition risk, but malnutrition risk was not independently associated with hospitalization and mortality (except for malnutrition risk by prealbumin). Further research needs to investigate the best tool to assess malnutrition risk in this age group.

Keywords: malnutrition; adults aged 80 years and over; mini nutritional assessment; prealbumin; adverse outcomes

INTRODUCTION

The population of older adults aged 80 years and older is steadily increasing worldwide and by 2050 is expected to comprise 20% of the older adult population worldwide and 10.6% of older adults in Belgium [1]. Malnutrition (usually referring to undernutrition) is common in older adults and associated with adverse outcomes such as disability, hospitalization, lower quality of life and mortality [2-5] [6-9]. Although there is no gold standard definition and assessment method for malnutrition, a global consensual two-step approach for its diagnosis in clinical settings has been recently endorsed: first screening for malnutrition risk (identification of “at risk” status) with a validated screening tool, then assessment for diagnosis and staging [10].

Several tools for malnutrition screening have been developed in different settings and populations of older adults. Out of ten screening tools used in community-dwelling older adults, the short form of the Mini Nutritional Assessment (MNA-SF), which was developed in the late 80s to identify malnutrition in older patients admitted to a general surgical ward, had the best performance (sensitivity: 98%, specificity: 94% using physician assessment of clinical nutritional status as a gold standard) [11]. The MNA is recognized and used worldwide as a nutritional status screening tool for older adults in different settings [12,13]. Studies of MNA in community-dwelling older adults are limited compared to those in other settings such as hospital, outpatient, rehabilitation or nursing homes [12,13]. In a recent systematic review, the pooled estimate prevalence of malnutrition (MNA score ≤ 17) in 58 studies of community-based older adults was 3.1% (95% CI 2.3-3.8), while the prevalence of risk of malnutrition (MNA score 17-23.5) was 26.5% (95% CI 22.4-32.7) [13]. In Belgium, the recently published findings of the NutriAction II study report a high and stable (over 5 years) prevalence of malnutrition and its risk (57% in 2008 and 56% in 2013) based on MNA-SF (score ≤ 11) among community and nursing home older adults [14]. In both the younger and older (nonagenarians) subpopulations in NutriAction I, MNA-SF had high sensitivity (97% and 98%, respectively), but low specificity (52% and 44%, respectively) [15]. Studies on predictive value of malnutrition screening tools for adverse outcomes in older adults are still limited in number and quality and none to our knowledge focuses on adults aged 80 years and older [7].

Beside screening tools such as MNA, several biochemical markers have been used and evaluated for malnutrition detection in older adults [16-19]. In a recent systematic review, concentrations of hemoglobin, total cholesterol, total protein, albumin and pre-albumin were statistically significantly lower in (mainly hospitalized) older adults at risk of malnutrition based on MNA, even in presence of inflammation [19]. Prealbumin (transthyretin) is one of the serum markers of risk of malnutrition that could be useful especially in non-acute settings [19-22] It has been advocated as a nutritional marker and a routine screening tool in older adults [17,23].

While MNA is widely used, to our best knowledge, there are no comparative studies on malnutrition risk based on MNA and prealbumin in community-dwelling adults especially those aged 80 years and older. This study aims to investigate the prevalence of malnutrition risk based on MNA and prealbumin and its association with adverse outcomes in a prospective cohort of community-dwelling adults aged 80 and older in Belgium.

METHODS

Study design and population

BELFRAIL is a prospective, population-based cohort study of community-dwelling adults aged 80 and over living in Belgium. The protocol of the study has been already published [24]. Briefly, between November 2008 and September 2009, 567 adults aged 80 and over were randomly recruited in 29 general practices in Wallonia, Flanders and Brussels. Only those in palliative care, in medical emergency or with severe dementia (known mini mental status exam score <14) were excluded. Participants had a standardized extraction of data from their medical records and examination by their general practitioner, as well as a home-based comprehensive geriatric assessment by a trained clinical research assistant that included MNA and laboratory tests. Data on mortality and hospitalization were collected prospectively from the general practitioners until 3.0 ± 0.25 years for hospitalization and 5.1 ± 0.25 years for mortality. The study protocol was approved by the Biomedical Ethics Committee of the Université Catholique de Louvain (UCL), Belgium (B40320084685) and all participants gave written consent.

Nutritional status

Risk of malnutrition was assessed both with MNA and serum levels of prealbumin. MNA consists of two parts: the screening and the assessment [25]. The screening part includes body mass index (BMI) and questions regarding decline of food intake, weight loss in the past 3 months, mobility, psychosocial stress or acute disease in past 3 months and neuropsychological problems. The screening score ranges from 0 to 14 where 11-14 is considered normal nutritional status, 8-11 is risk of malnutrition and 0-7 is malnutrition. If the screening score is ≤ 11 then the assessment part is implemented that consists of 12 items including mid-arm and calf circumferences and questions about feeding, self-assessment of nutrition and general health, taking more than 3 prescription drugs, independent living and pressure sores/skin ulcers. The assessment score ranges from 0-16. Based on the scores of the screening and assessment parts of MNA, a malnutrition indicator score is calculated and if < 17 is considered as malnutrition, 17-23.5 as risk for malnutrition and 24-30 as normal nutritional status [25]. In the BELFRAIL cohort the screening part of MNA was applied for all the participants. For the participants from the

northern part of Belgium, the assessment part of MNA was applied only for those with a screening score of ≤ 11 . In the rest of the BELFRAIL cohort, the assessment part of the MNA was applied for all participants no matter the score of the screening part. In this study we considered two nutritional status groups: those with malnutrition or risk of malnutrition (if the full MNA score was < 24) and those with normal nutritional status or no risk for malnutrition (if full MNA score was 24-30). Participants from the north with an MNA screening score >11 , but without full MNA score were considered as having normal nutritional status /no risk for malnutrition.

The prealbumin was measured in fasting serum with the UniCel® DxC 800 Synchron (Beckman-Coulter, Brea, USA). Based on prealbumin levels, the nutritional status categories were at risk of malnutrition (prealbumin $< 20\text{mg/dl}$) and without risk of malnutrition (prealbumin $\geq 20\text{ mg/dL}$) [20] .

Outcomes

Time to all-cause death and first unplanned hospitalization were used as outcomes. The general practitioners prospectively reported the date and cause of hospitalization (until 3.0 ± 0.25 years) and death (until 5.1 ± 0.25 years) through detailed follow-up questionnaires.

Other variables

Multimorbidity was recorded as the sum of the following list of diseases reported from the general practitioners (simple disease count): angina pectoris, episodes of atrial fibrillation, cardiomyopathy, known valvular disease, myocardial infarct, transient ischaemic attack, stroke, peripheral arterial disease, hypertension, lipid disorders, episodes of decompensated heart failure, osteoporosis, thyroid disease, depression, respiratory disease (chronic obstructive pulmonary disease or asthma), cancer, Parkinson's disease, arthrosis, arthritis, diabetes, locomotor sequela of stroke and renal failure [26].

The cognitive functioning was assessed with the mini-mental state examination (MMSE) and a score of ≤ 24 was considered as cognitive impairment [24]. The 15-item Geriatric

Depression Scale (GDS-15) was used to screen for depression with a score of ≥ 5 indicating risk of depression [24]. Physical performance was tested with a battery of tests that consisted of measured times of walking 3 meters and return, sitting and standing from a chair, putting on and taking off a cardigan and maintaining balance in a tandem stand. The summary physical performance test (PPT) score ranges from 0-14 and low physical performance was defined as being in the lowest sex-specific quartile of the total score [24]. Grip strength was measured as the highest of three attempts at maximal squeeze with the dominant hand using a JAMAR® Plus digital handheld dynamometer [24]. Activities of daily living (ADL) were assessed by asking participants for difficulties in carrying out six activities: climbing stairs, walking 5 min outdoors without resting, getting up and sitting down in a chair, dressing and undressing oneself, using own or public transportation, and cutting one's own toenails. The responses varied from 1 = "No I cannot" to 5 = "Yes, without difficulty" with a summed score ranging between 6 and 30 [24].

Haemoglobin levels were measured in whole blood with Sysmex XE-2100 automated haematology analyser (Milton Keynes, UK). The ultra-sensitive C-reactive protein (usCRP) levels were measured in serum using UniCel® DxC 800 Synchron (Beckman-Coulter, Brea, USA) and levels were considered high if > 0.3 mg/dl [24].

Statistical analysis

The comparison of baseline characteristics between the two groups of malnutrition status based on MNA or prealbumin were tested with the independent Student's t test for parametric variables, Mann-Whitney U test for non-parametric and Pearson's chi-square test for categorical ones. Kaplan-Meier curves for all cause mortality and first hospitalization were plotted for the two groups of nutritional status based on MNA and prealbumin, using log-rank test for comparison. Cox proportional hazards regression analysis was used to estimate the hazard ratios (HR) with corresponding 95% confidence interval (95%CI) for mortality and hospitalization of the group at risk for malnutrition based on MNA or prealbumin adjusting for potential confounders in two steps: first adjustment for age, sex and disease count then additional adjustment for high usCRP, high GDS-15, low MMSE and low PPT. The group of participants without risk of

malnutrition based on MNA or prealbumin was used as reference. Models were checked for the proportional hazard assumption. Cohen's Kappa coefficient was used to assess the level of agreement between malnutrition risk based on MNA and prealbumin. A two-tailed probability value $p < 0.05$ was considered statistically significant. All statistical analyses were performed with IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Baseline characteristics and nutritional status of the study population

Out of the 567 participants of the BELFRAIL cohort, 556 (98.1%) had MNA scores and 545 (96.1%) had prealbumin levels. They were comparable with the whole BELFRAIL cohort with a mean age of 84.7 ± 3.7 years, 32.7% male and only 10.1% institutionalized (Table 1). There were only 8 participants (1.4%) with malnutrition based on MNA and 60 (10.8%) at risk of malnutrition. The participants with malnutrition or at risk of malnutrition (grouped together as malnutrition risk) based on MNA ($n=68$; 12.2%) or prealbumin ($n=69$; 12.7%) had lower MMSE and PPT scores, grip strength and hemoglobin levels. Those with malnutrition risk based on MNA had also lower BMI, ADL score and prealbumin, higher GDS-15 score and were more often institutionalized compared to those without risk of malnutrition. Those with malnutrition risk based on prealbumin were older, more often females and with higher levels of usCRP than those without malnutrition risk (Table 1).

Only 10 participants were identified with malnutrition risk by both MNA and prealbumin and the agreement was very poor with a Kappa coefficient of 0.024 (95% CI -0.064, 0.112).

Association of malnutrition risk with adverse outcomes

Hospitalization

During 3.0 ± 0.25 years follow-up, half of BELFRAIL participants (51.4%) were hospitalized at least once (Table 1). Kaplan-Meier survival curves show no significantly higher hospitalization for those with malnutrition risk based on either MNA (log rank test $p=0.068$) or prealbumin (log rank test $p=0.058$) compared to those without risk (Figure 1).

Mortality

At 5.1 ± 0.25 years of follow-up, 242 BELFRAIL participants (42.7%) had died (Table 1). The Kaplan-Meier curves show a statistically significant higher survival for those without malnutrition risk compared to those with malnutrition risk based on either MNA (log rank test $p<0.001$) or prealbumin (log rank test $p=0.001$) (Figure 2). Participants with malnutrition risk based on either MNA or prealbumin had higher risk of all-cause mortality even after adjustment for age, sex and multimorbidity (HR 1.69; 95%CI 1.21-2.38 for MNA

and 1.72, 95%CI 1.21-2.45 for prealbumin). After additional adjustment for high usCRP, low MMSE, low PPT and high GDS-15, only the HR for malnutrition risk based on prealbumin remained statistically significant (HR 1.46; 95%CI 1.01-2.12). (Table 2)

DISCUSSION

In a Belgian cohort of community dwelling adults aged 80 and older, malnutrition risk based on MNA (12.2%) or prealbumin (12.7%) was low, not associated with hospitalization but only with 5 years all-cause mortality (even after adjustment for multimorbidity, inflammation, physical and mental status).

Although malnutrition has been extensively studied in the older adult population including the community-based setting, very few studies are available for adults older than 80 years and none has used both a screening questionnaire such as MNA and a biomarker such as prealbumin [15]. The prevalence of malnutrition risk in our study is lower than in previous research in Belgium, yet these studies differ in settings or screening tool [14,27]. In a recent systematic review, 31 studies conducted in community settings in Europe had a pooled malnutrition prevalence based on MNA of 2.1% (95% CI 1.2-3.0) and risk of malnutrition of 23.4% (95%CI 18.5-28.3) [13]. These differences in prevalence of malnutrition risk are expected as our study population included community-dwelling older adults over 80 years old with low institutionalization compared to previous studies, and independently (home-) living older adults have been shown to have lower prevalence of malnutrition risk [13,28,29]. Additionally, the survival selection effect and potential for reverse epidemiology are features of adults over 80 years old [30,31]. Hence the need for more specific studies on malnutrition risk and its screening in this growing age group.

In our cohort of adults aged 80 years and over we found that malnutrition risk was associated with lower physical and cognitive functioning as participants with malnutrition risk based on both MNA and prealbumin had lower scores of PPT, grip strength and MMSE. Additionally, those with malnutrition risk by MNA had also more functional disability (lower ADL score) and were more at risk of depression (higher GDS-15 score). This is in line with previous research in Belgium that has shown malnutrition based on MNA-SF to be associated with functional disability and impaired mobility [14]. In a recent systematic review, malnutrition based on MNA was found to be associated with physical frailty in community-dwelling older adults [4]. In a Dutch study of geriatric outpatients, malnutrition based on MNA was associated with impaired mobility, ADL disability and

depression, but not with cognitive impairment [5]. Malnutrition (mainly based on MNA) is associated with poorer quality of life in older adults and nutritional interventions have been shown to improve both physical and mental components of quality of life [2]. As malnutrition often co-occurs with sarcopenia in older adults, the malnutrition-sarcopenia syndrome has been proposed as the future of nutritional screening and assessment [32,33]. In our study, those with malnutrition risk by either MNA or prealbumin had lower grip strength compared to those with normal nutritional status. Further research on the association of malnutrition, sarcopenia and frailty is necessary esp. in adults aged 80 and over as these conditions often coexist, increase the risk for adverse outcomes and appropriate interventions can reduce this risk [4,32,34]. Even though the prevalence of malnutrition risk in our cohort of community-dwelling adults aged 80 years and over was not high, its association with measures of physical and mental functioning shows the importance of screening for and identifying those at risk of malnutrition as appropriate nutritional interventions may prevent further disability and adverse outcomes [2,35].

In regard to association of malnutrition risk by MNA or prealbumin with adverse outcomes, in our cohort we did not find a statistically significant association with first, unplanned hospitalization in 3 years follow-up. This is similar to findings in the Danish part of the SENECA study on nutrition of older adults in Europe, where older adults (70-75 years old) with malnutrition risk (MNA<24) did not have higher rates of hospitalization [36]. Yet a recent study with community-dwelling older adults in Canada showed malnutrition was an independent predictor of risk of acute hospitalization, but malnutrition was defined using a different tool (SCREEN) not MNA [6]. As in previous research, we also found an association of malnutrition risk with all-cause mortality at 5 years old [6-9]. There are very few studies on the predictive value of malnutrition based on MNA for adverse outcomes with a moderate quality of evidence for prediction of mortality risk [7]. In our study, the higher risk for 5 years mortality of the participants with malnutrition risk based on MNA was not statistically significant after adjustment for multimorbidity, physical and mental function and inflammation, so future quality studies are needed for the predictive ability of malnutrition based on MNA for adverse outcomes esp. in independent home-living older adults [7]. Until then, the use of MNA for identifying malnutrition risk in this group of older adults is questionable [7,28].

Only malnutrition risk based on prealbumin in our cohort was an independent predictor of mortality. We could not find other studies that have investigated the association of malnutrition based on prealbumin with mortality in community-dwelling older adults. Prealbumin has been shown to be a good short-term prognosis marker in hospitalized patients with malnutrition [17,20]. It is suggested not only as a marker of malnutrition risk, but also of sarcopenia, thrombovascular risk, and has a role in memory preservation, normal cognition and prevention of neurodegeneration [20,22,23,37]. Yet levels of prealbumin are influenced by many non-nutritional factors including age and acute phase responses such as trauma, infection, inflammation or malignancy, and its use to identify malnutrition risk in acute health care settings is controversial and should be done with caution [19-21]. In our study in non-acute settings, even after adjustment for inflammation based on usCRP levels, the group with malnutrition risk based on prealbumin <20 mg/dl had a higher risk for mortality. Further research on nutritional status assessment using prealbumin either alone or in combination with anthropometric measurements and/or dietary assessment is needed for older adults in non-acute settings such as those living in community [19]. This could be particularly relevant in the very old adults where malnutrition and sarcopenia frequently co-exist and prealbumin is recently suggested as a biomarker of sarcopenia [17,32,33,37]. Additionally, the prealbumin cut-off to define malnutrition risk is still to be determined in older adults taking into consideration a 'normal' age-related decline [19,20,37].

Strengths and limitations

This study has several strengths. It is a prospective study of a representative community-dwelling population aged 80 years and older in Belgium, with standardized comprehensive geriatric assessment that allowed investigation of malnutrition based on MNA and prealbumin with adjustment for several confounders such as multimorbidity, physical performance, affective and cognitive status, and inflammation, as well as assessment of association with 3 years hospitalization and 5 years mortality. One of the weaknesses of this study is that as the number of participants with malnutrition by MNA was very low, they were combined together with those at risk of malnutrition. Additionally, for a part of participants only the MNA screening scores were available as the MNA assessment part was applied only if screening scores were low. Yet, this is in

compliance with the guideline on implementation of MNA and previous research has shown a very good sensitivity and specificity of the screening score (MNA-SF) against the total MNA score [38,39].

Conclusion

In a community-dwelling cohort of adults 80 years and older in Belgium, malnutrition risk based on MNA or prealbumin was low yet those with malnutrition risk had poorer physical and mental functioning. Only malnutrition risk based on prealbumin was independently associated with mortality at 5 years follow-up. There is a need for more research on the assessment of nutritional status in the community-dwelling independent very old adults that would benefit from a combination of both anthropometric and/or dietary assessment and biomarkers such as prealbumin. This is important in light of the worldwide growing population of adults 80 years and over, the impact of malnutrition in their quality of life and risk of adverse outcomes, and the availability of potentially beneficial interventions.

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Table 1: Baseline characteristics of the BELFRAIL study population and the nutritional status groups based on MNA and prealbumin

Variables	Total BELFRAIL population (n=567)	MNA (n=556)			Prealbumin (n=545)		
		At risk of malnutrition (n=68)	Normal nutritional status (n=488)	P value	At risk of malnutrition (n=69)	Normal nutritional status (n=476)	P value
Age (years)	84.7 ± 3.7	85.6 ± 3.6	84.6 ± 3.7	0.05 ^a	95.9 ± 4.1	84.6 ± 3.6	0.005 ^a
Sex (men)	211 (37.2)	19 (27.9)	189 (38.7)	0.08 ^c	16 (23.1)	187 (39.3)	0.01 ^c
BMI (kg/m ²)	27.4 ± 4.9	23.7 ± 5.0	27.9 ± 4.6	0.000 ^a	26.3 ± 4.9	27.6 ± 4.9	0.05 ^a
Disease count	4 [3,5]	4.5 [3,6]	4 [2,5]	0.10 ^b	4 [3,6]	4 [3,5]	0.49 ^b
Institutionalized	57 (10.1)	17 (25)	36 (7.4)	0.000 ^c	7 (10.1)	48 (10.1)	0.99 ^c
ADL	25 [21,27]	20 [14,25]	25 [21,27]	0.000 ^b	23 [20,27]	25 [21,27]	0.08 ^b
MMSE	28 [25,29]	26 [20,28]	28 [26,29]	0.000 ^b	27 [23,28]	28 [26,29]	0.003 ^b
GDS-15	2 [1,4]	3.5 [2,6]	2 [1,4]	0.000 ^b	2 [2,4.75]	2 [1,4]	0.64 ^b
PPT	9 [5,11]	6.5 [4,9.79]	9 [6,12]	0.002 ^b	8 [4,11]	9 [5,12]	0.03 ^b
Grip strength	20.9 [15.8,27.1]	16.5 [12.6,20.2]	21.5 [16.7,27.4]	0.000 ^b	17.6 [14.4,23.2]	21.2 [16.3,27.9]	0.003 ^b
Hemoglobin	13.3 ± 1.4	12.7 ± 1.3	13.4 ± 1.4	0.000 ^a	12.9 ± 1.27	13.4 ± 1.4	0.009 ^a
usCRP(mg/dl)	0.19 [0.08,0.41]	0.20 [0.07,0.48]	0.18 [0.08,0.40]	0.76 ^b	0.48 [0.13,1.15]	0.17 [0.08,0.35]	0.000 ^b
Prealbumin(mg/dl)	25.9 ± 6.3	24.4 ± 5.9	26.1 ± 6.3	0.03 ^a	17.4 ± 2.6	27.2 ± 5.7	0.000 ^a
Death	242 (42.7)	42 (61.8)	193 (39.5)	0.001 ^c	39 (56.5)	193 (40.5)	0.01 ^c
First hospitalization	288 (51.4)	37 (56.9)	246 (50.8)	0.36 ^c	39 (56.5)	236 (50.3)	0.34 ^c

MNA: mini nutritional assessment; BMI: body mass index; ADL: activities of daily living; MMSE: mini mental status examination; GDS-15 : 15 item geriatric depression scale; PPT: physical performance tests; usCRP: ultra sensitive C reactive protein; n=number of participants; ^a p value based on Student's t-test for independent samples; ^b p value based on Chi-square test; ^c p value based on Mann-Whitney U test.

Table 2: Association of risk of malnutrition based on MNA and prealbumin with all-cause mortality at 5 years follow-up

Variables	Malnutrition risk based on MNA (n=556) Hazard Ratio (95% Confidence Interval)			Malnutrition risk based on prealbumin (n=545) Hazard Ratio (95% Confidence Interval)		
	Unadjusted	Model 1	Model 2	Unadjusted	Model 1	Model 2
Malnutrition risk	1.97(1.41-2.75)	1.69(1.21-2.38)	1.35 (0.92-1.97)	1.78(1.25-2.49)	1.72(1.21-2.45)	1.46(1.01-2.12)
Age		1.10(1.07-1.14)	1.07(1.04-1.11)		1.10(1.07-1.14)	1.07(1.03-1.11)
Sex (male)		1.14(0.87-1.49)	1.17(0.88-1.56)		1.17(0.89-1.54)	1.21(0.91-1.62)
Disease count		1.12(1.07-1.19)	1.13(1.06-1.19)		1.14(1.08-1.21)	1.13(1.07-1.20)
High hsCRP			1.50(1.14-1.98)			1.41(1.06-1.87)
Low PPT			1.50(1.12-2.01)			1.55(1.16-2.07)
Low MMSE			2.23(1.65-3.02)			2.27(1.68-3.07)
High GDS-15			0.92 (0.66-1.27)			0.93(0.67-1.29)

MNA: mini nutritional assessment; at risk of malnutrition: if MNA <24 or prealbumin < 20 mg/dl; High hsCRP: high sensitivity C reactive protein > 0.3 mg/dl; Low PPT: physical performance test score in the lowest sex-specific quartile; Low MMSE: mini mental status examination score <24; High GDS-15:15 item geriatric depression score ≥5

Figure 1: Kaplan-Meier survival curves for 5-years mortality and 3-years hospitalization for nutrition status groups based on MNA and prealbumin
MNA: Mini nutritional assessment