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Original article

"More2Eat" in patients at nutritional risk during hospital stay lowers the risk of three-month mortality

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SUMMARY

Background & aims: Malnutrition is a common problem among hospitalized patients due to increased nutrient requirements and reduced food intake or uptake of nutrients. The aim of this prospective cohort study was to investigate the association of nutritional risk status (at or not at risk by NRS-2002) as well as energy and protein intake, use of oral nutritional supplements (ONS) and snack meals in at risk patients during hospitalization and adverse outcomes (length of stay (LOS), readmissions and mortality) at three-months follow-up.

Methods: Data were collected at baseline and at three-months follow-up in patients hospitalized at 31 units at a Danish University Hospital. Diet records were performed at baseline by using the nurses' quartile nutrition recording methods. Data about disease and clinical outcomes were collected from electronic medical records at baseline and three-months follow-up.

Results: A total of 318 patients were included. Patients at nutritional risk (n = 149, 47%) had higher risk of longer LOS (≥20 days (OR = 4.24 [1.81;9.95] and ≥30 days OR = 2.50 [1.22;5.14])), having one readmission (OR = 1.86 [1.15;3.01]) and death (OR = 2.56 [1.27;5.20]) compared to patients not at nutritional risk (n = 169, 53%). A longer LOS was associated with patients who achieved ≥75% of energy and protein requirements, consumed snack meals incl. and excl. oral nutritional supplements. Readmissions in patients at nutritional risk during the three-months were not associated with food intake during the index hospitalization. Mortality was observed in 43 of the 318 (13.5%) hospitalized patients. A lower mortality was associated with increased energy and protein intake in patients at nutritional risk.

Conclusions: The results of this study indicate a longer LOS, higher readmission rate and increased mortality in patients at nutritional risk compared to patients not at risk. Patients at nutritional risk had lower risk of three-month mortality and longer LOS during index hospitalization with increased energy and protein intake. Readmissions in patients at nutritional risk were not affected by food intake. The association of nutritional risk with poorer outcomes indicates that good nutritional care including constant attention to food-intake during hospitalization can be beneficial regarding mortality.

1. Introduction

Disease, as well as treatment, can lead to malnutrition due to increased requirements and reduced intake or uptake of nutrients [1]. Malnutrition is associated with negative consequences for the individual patient as well as for the community [2–4]. Nutritional risk or malnutrition are found in 12–60% of hospitalized patients [3,5–10]; however, the prevalence of patients at nutritional risk vary according to disease diagnosis and health-care settings [11]. In 2009–2010, a multi-modal nutrition care intervention study was

Abbreviations: ONS, Oral nutritional supplements; LOS, Length of stay; ID, Identification number; OR, Odds ratio; IRR, Incidence rate ratio; 95% CI, 95% confidence interval; RR, Relative risk; STROBE, STrengthening the Reporting of OBservational studies in Epidemiology.

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performed at Aalborg University Hospital and found 48–50% of inpatients to be at nutritional risk [12]. This quasi-experimental study improved the frequency of nutrition screening and increased the number of patients reaching at least 75% of energy and protein requirements by 19–20% [12]. In recent years, it seems as though focus on nutrition care in hospitals has decreased as recently published studies reveal lower frequency of nutrition screening and poorer nutritional routines [10,13]. There can be many reasons for this such as increased pressures on hospitals and health care providers particularly since COVID-19. A way to improve nutrition care is by increased focus on drafting and implementing guidelines. The Danish Health Authority published an updated guideline for handling disease-related malnutrition in 2022, emphasizing and focusing on nutrition risk screening and good nutritional practice in patients identified at risk of malnutrition [14]. In order to prepare for a successful implementation and evaluation of nutritional care practice at Danish hospitals, we found that an update on the situation regarding prevalence, food intake and adverse outcomes of hospital malnutrition in a large Danish university hospital was necessary.

Therefore, the *aim* of this More2Eat study was to investigate the association of nutritional risk status (at or not at risk measured by NRS-2002) as well as energy and protein intake, use of oral nutritional supplements (ONS) and snack meals in at risk patients during hospitalization and adverse outcomes (length of stay (LOS), readmissions and mortality) at three-months follow-up.

2. Material and methods

The study design was an observational prospective cohort study with data collected at baseline and at three-month follow-up. Data were collected through diet recording and electronic medical records.

2.1. More2Eat study

The More2Eat study was performed at a hospital, which have implemented the “More2Eat model” as to provide the best opportunities for a constant development and implementation of evidence-based nutrition practice across the hospital by using a “complex interventions approach” [15]. The model uses both a top-down approach and a bottom-up approach. The hospital and the departments are subject to national and local guidelines. An example of a top-down approach is the guidelines regarding the prevalence of screened patients, which should be at least 80% of patients with an expected minimum LOS at 48 h. The bottom-up approach includes development and improvement of practice in the individual unit based on individual needs such as education, development projects, materials and setting goals, all directed towards achieving full implementation and maintenance of the overall national and local guidelines.

2.2. Setting and population

Data collected at baseline was performed as a single day assessment of patients hospitalized at a Danish University Hospital with 562 beds. The study population included patients hospitalized at 31 different medical and surgical units, excluding psychiatric, pediatric, maternity and intensive care units. The included units have different organizational and logistical structures regarding number of physicians, dietitians and staff nurses as well as numbers of beds.

Patients were included if they were ≥18 years of age, willing to participate, able to give written informed consent and speak or have a relative that could speak Danish or English. Furthermore, patients had to be able to participate in at least two main meals on the day of baseline data collection. Patients were excluded if they were fasting or discharged before having the possibility to eat two meals at the hospital on the day of baseline data collection, were isolated due to infections or COVID-19, cognitively unable to understand the given information and give written informed consent, dying or were admitted after attempt to suicide.

2.3. Data collection

The data collection consisted of 24 h diet recording, nutritional risk screening and medical record data, which was collected using the electronic medical record systems Clinical Suite (Provider: CSC, year of creation: 2009, lasted version: 21) and NordEPJ (Provider: Systematic, year of creation: 2022, lasted version: 37.1.4.5). All data were double checked by two researchers from the research team. Each unit and the individual patient were assigned with a specific identification number (ID) for anonymization.

2.3.1. Baseline: data collection

Baseline data was collected one single day at each unit between November 3rd (2021) and January 26th (2022) by one to three experienced data collectors from the research team. The data collection lasted from 7 AM to 7 AM the next morning. The data collection research teams were present at the units from 7 AM until 10 PM, while the unit staff collected data on food intake as well as use of enteral and parenteral nutrition from 10 PM until 7 AM next morning. One data collector visited the unit the next morning to collect the diet records and clarify missing data with patients when relevant.

On the morning of the data collection day, non-eligible patients were identified by a staff nurse from each unit according to the exclusion criteria. Thereafter, the data collectors informed eligible patients and included patients after written informed consent was signed. Measurement of body weight was conducted if not completed the previous one week and height if not done the past one year. All patients were screened for nutritional risk using the NRS-2002 screening tool [16].

2.3.1.1. Food intake and requirements at baseline. Monitoring food intake was conducted using the nurses' quartile nutrition recording methods [17]. When a meal or drink was served, the type and quantity was registered manually on paper. When the meal was completed, the quantity of the food and drink consumed was recorded manually. This applied to main meals as well as to snack meal and caloric drinks during the 24 h of data collection. The use of parenteral and enteral nutrition was registered on the diet record paper, including product name and amount provided. Furthermore, any case of partial fasting during the day of data collection was registered. Registering of food intake was conducted by the research team, unit staff nurses and patients themselves (supervised by the research team).

The total consumption of energy (kcal) and protein (grams) were calculated by using the Hospital dietary calculation software program “Dietary Calculator 2” (Provider: The hospital's own development department within Digitization and IT and local dieticians, year of creation: 2011, lasted version from 2022: 1.7.5948.26452), which is based on the hospital's menu recipes and meals and drink portions served. When a meal was not sufficiently noted in the dataset, we estimated the intake by dividing the two eaten main meals with two and including the result as the third meal. This method was used in 12 patients. Energy requirement was estimated using the Harris–Benedict equation and applied with an activity factor of 1.1 (bedridden patients) or 1.3 (not bedridden patients) [18]. Protein requirement was calculated using

1.3 g protein/kg body weight/day [19–22]. In case of overweight (BMI ≥ 30), the patients' ideal body weight corresponding to BMI=25 was used to estimate energy and protein requirements.

2.3.1.2. Electronic medical records at baseline. The medical data were collected using the patients' electronic medical records (Clinical Suite). Information collected included demographic data, hospitalization diagnosis, medical plan, nutritional status and nutritional plan. In this publication the following information was used:

- Demographics: sex, age, hospitalization diagnosis, co-morbidities the patient had at inclusion and the patient's mobility (whether the patient was bedridden or not bedridden).
- Nutritional status: weight (kg), height (cm) and BMI (kg/m^2).

The hospitalization diagnoses were categorized and the co-morbidities were based on the nutritionDay Worldwide methods [23].

2.3.2. Three-month follow-up: data collection

The three-month follow-up data were collected from February 3rd (2022) to April 26th (2022) and was based on the patients' electronic medical records (NordEPJ). Information collected at three-months follow-up were:

- LOS at index hospitalization; hereunder, the dates of admission and discharge.
- Readmissions during the three-months follow-up if the patients were discharged. Elective admissions during the three-month follow up period were not included as readmissions in the data collection.
- Mortality date during the index hospitalization or during the three-months follow-up.

2.4. Data analysis

Research Electronic Data Capture was used for data management and STATA version 17 (64-hit to Windows) was used to perform the data analysis. Descriptive statistics were presented as number of fill-in replies (N) and percent (%) regarding categorical variables. The Shapiro-Wilk test was used to assess normality of continuous variables. Median and range values were calculated in non-normality continuous variables.

The outcome variables include LOS, readmissions and mortality. The exposure variables included consumption of ≥75% of energy and protein requirements, nutritional risk, consuming ONS and snacks meals during the index hospitalization and finally the patients' hospitalization diagnosis.

Mann–Whitney test, Chi^2-test as well as simple logistic regression analysis were used to analyze the difference between those at nutritional risk and those not at risk and calculate odds ratio (OR). To investigate the associations between patients' diagnosis, food intake and nutritional risk regarding readmissions and mortality, piecewise exponential Poisson regression analyzes were performed to calculate incidence rate ratio (IRR) as well as confidence interval (95% CI). Poisson regression analyzes were performed to investigate the association between LOS and the exposure variables, where relative risk (RR) was calculated with 95% CI. To perform Poisson regression analyses, the time from inclusion to the three-months follow-up was chosen. A 0.05 significant level was chosen for the regression analyzes. Multiple regression analyzes were performed adjusted for age, sex and numbers of co-morbidities.

BMI groups were divided according to World Health Organizations definition, weight (kg) divided by height multiplied by height (m^2) [24]. LOS was divided into groups and not used as a continuous variable, to avoid results to be affected by outliers as only few of the patients had longer LOS over 30 days.

2.5. Ethical considerations

The North Jutland protection agency approved this study (ID 2021-097). The study was put forward to the regional ethic committee, which found that no full application was necessary due to the Danish legislation. The study was compliant to the Helsinki declaration.

The study design and the reporting in this article was done with respect for STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) Checklist of items that should be included in reports of cohort studies [25].

3. Results

The study included 318 out of 354 eligible patients, resulting in a 0.90 inclusion rate. No patients withdrew their consent during the three-month follow-up period (Fig. 1).

3.1. Demographics

Of the 318 included patients, median age was 72 (range 18–98) and 56% were male. Median BMI was 26.8 kg/m^2 (14.3–55.5 kg/m^2). The three most frequent diagnoses were “diseases of bones, muscles and connective tissue” (15.1%), “diseases of the circulatory organs” (13.8%) and “infections” (12.9%). Demographics can be seen in Table 1.

Among the included patients, 55.4% achieved at least 75% of energy requirement and the median value of energy intake was 1448.5 kcal (range 102.0–3655.0 kcal) corresponding to 18 kcal/kg. In addition, 30.2% achieved at least 75% of protein requirement and the median value of protein intake was 55.5 g (range 2.0–165.0 g) corresponding to 0.7 g/kg. Furthermore, 21.4% and 61.6% of the included patients received ONS and snack meals. Among all the patients who received ONS, the ONS contributed to 23.4% in relation to the patients' energy intake, and 29.9% in relation to the patients' protein intake.

3.2. Clinical outcomes in the overall population

The median LOS of the index hospitalization was 10 days (range 1–266 days). A non-significant longer median LOS during the index hospitalization was found in patients in the age-group 50–59 years of age (12 days, p = 0.647), male (11 days, p = 0.112), obese (11 days, p = 0.243) and with 5–6 co-morbidities (25 days, p = 0.259).

A minimum of one readmission were observed in 34.9% (n = 106) during the three-months follow-up, of these 61.3% (n = 65) of the patients had one readmission, 16.0% (n = 17) had two readmissions, 13.2% (n = 14) had three readmissions and 9.4% (n = 10) had more than three readmissions. The highest frequency of readmissions was found in patients with cancers (n = 12, 57.1%) and hematological diseases (n = 13, 72.2%). Although not significant, a tendency towards a higher readmission frequency was seen in the 50–59-year-old followed by the ≥70 year old's (n = 21, 43.8% and n = 59, 35.5%, p = 0.395) and those with BMI <18.5 (n = 6, 50.0%, p = 0.100).

A total of 13.5% (n = 43) patients died; 13 patients died during the index hospitalization and 30 patients died during the three-months follow-up. Patients with cancers and hematological

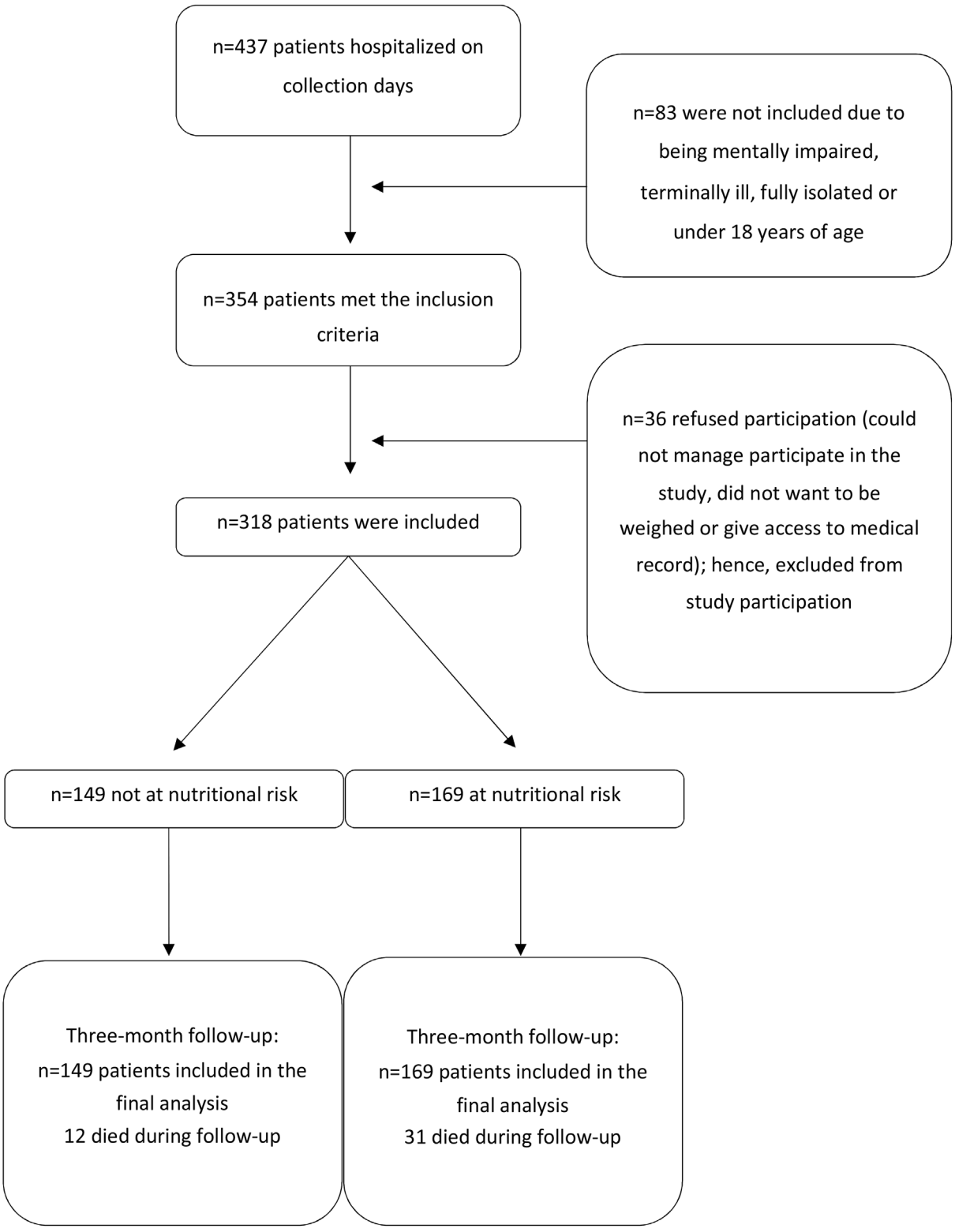

Fig. 1. Flow chart of recruitment and three-month follow-up.

diseases had a higher frequency of mortality within the three-month follow-up (n = 6, 26.1% and n = 6, 31.6%, p = 0.049). Furthermore, a tendency towards higher frequency of three-month mortality was observed in the 70–79 year old's (n = 19, 19.2%, p = 0.114) and those with BMI <18.5 (n = 5, 35.7%, p = 0.052).

3.3. Clinical outcomes associated nutritional risk profile

A longer LOS was observed in patients at nutritional risk compared to patients not at nutritional risk (p < 0.001, see Table 2). One patient was still admitted during the follow-up period, and the

Table 1
Demographics of included patients.

Variable	N = 318 (%)
Sex, man	179 (56.3)
Age, years (median (range))	72 (18–98)
BMI, kg/m^2 (median (range))	26.8 (14.3–55.5)
Hospitalization diagnosis	
Infection	41 (12.9)
Cancer	23 (7.2)
Diseases of bones, muscles and connective tissue	48 (15.1)
Diseases of the blood and blood-forming organs	19 (6.0)
Diseases of the urinary and genital organs	23 (7.2)
Diseases of the nervous system	36 (11.3)
Diseases of the circulatory organs	44 (13.8)
Respiratory diseases	30 (9.4)
Diseases of the digestive organs	36 (11.3)
Other[a]	18 (5.8)
Number of comorbidities	
0	43 (13.5)
1–2	192 (60.5)
3–4	73 (22.9)
5–6	10 (3.1)

[a] Others: Skin and subcutaneous tissue disorders, Endocrine and nutritional disorders as well as metabolic disorders, Mental disorders and behavioral disorders, Symptoms and abnormal findings not classified elsewhere, Lesions and poisoning and certain other consequences, Factors affecting the state of health.

patient is not included in the analysis regarding LOS. Patients at nutritional risk had a significantly higher OR for a 20–29 day LOS during the index hospitalization (n = 30 vs. n = 8, OR = 4.24 [1.81;9.95]) and ≥30 days LOS (n = 31 vs. n = 14, OR = 2.50 [1.22;5.14]) compared to patients not at nutritional risk. A higher risk of readmissions was found in patients at nutritional risk compared to patients not at risk (n = 65 vs. n = 41, OR = 1.86 [1.15;3.01]). Patients who died during their index hospitalizations or were admitted during the entire three-month period were excluded in the analysis regarding readmissions (n = 14). No difference was found in regard to more than one readmission between patients at or not at risk. A higher three-month mortality rate was found in patients at nutritional risk compared to patients not at risk (n = 31 vs. n = 12, OR = 2.56 [1.27;5.20]).

The Kaplan–Meier plot show that patients at nutritional risk had higher risk of mortality compared to patients not at nutritional risk (Fig. 2).

3.4. Clinical outcomes in patients at nutritional risk

3.4.1. LOS at index hospitalization

A longer LOS was found in patients at nutritional risk achieving ≥75% of energy requirement (RR = 1.59 [1.49–1.70]), achieving ≥75% of protein requirement (RR = 1.36 [1.27–1.45]), as well as receiving snack meals incl. and excl. ONS (RR 1.38 [1.26–1.51] and RR 1.60 [1.47–1.74]) during the index hospitalization. Some significant differences were found between LOS and diagnosis; see Table 3.

3.4.2. Three-month readmissions

No significant risk differences were found between readmission and the exposure variables, but a tendency towards higher IRR for readmission during the follow-up period among the patients with cancer [95% CI = 0.46;2.41], hematology diseases [95% CI = 0.62;4.05], urinary diseases [95% CI = 0.53;3.36] and diseases of the circulatory organs [95% CI = 0.55;3.49] (see Table 4). Patients who died during the index hospitalization or never discharged were not included in the analysis.

3.4.3. Three-month mortality

At three-months follow-up, an association between energy intake and probability of mortality was found among patients at nutritional risk (illustrated in Fig. 3A). A lower probability was found with increasing energy sufficiency; 24% probability of mortality with an energy intake of approximately 50% of energy requirement, 19% probability of mortality with an energy intake of approximately 75% of energy requirement, while a 15% probability of mortality was found in patients reaching 100% of energy requirement. Likewise, an association was found between protein intake and probability of mortality among patients at nutritional risk (illustrated in Fig. 3B). A lower probability was found with increasing protein sufficiency; 20% mortality in patients with a protein intake of approximately 50% of protein requirement, 15% probability of mortality in patients reaching 75% of protein requirement, and 12% probability of mortality was seen in patients reaching 100% of protein requirement.

A lower risk of mortality within the three-month follow up was found in at nutritional risk patients who achieved the 75% of energy requirement (IRR = 0.36 [0.16;0.78]) during the index

Table 2
Association between mortality and readmissions during the three-month follow-up and length of stay during index hospitalization regarding patients at nutritional risk or not at nutritional risk.

Variable	Nutritional risk		p-value	OR [95% CI]
	At risk, N (%) = 169	Not at risk, N (%) = 149		
Length of index hospitalization (n = 168, n = 149)			<0.001*	
1–2 days	8 (5)	16 (12)		0.57 [0.23;1.41]
3–9 days	61 (36)	69 (46)		1
10–19 days	38 (22)	42 (28)		1.02 [0.59;1.79]
20–29 days	30 (18)	8 (5)		4.24 [1.81;9.95]*
30 days and over	31 (19)	14 (9)		2.50 [1.22;5.14]*
Readmissions (n = 156, n = 148)			0.011*	
No	91 (29)	107 (72)		1
Yes	65 (38)	41 (28)		1.86 [1.15;3.01]*
Number of readmissions (n = 65, n = 41)			0.375	
1	38 (58)	27 (66)		1
2	13 (20)	4 (10)		2.31 [0.68;7.86]
≥3	14 (14)	10 (12)		0.99 [0.39;2.57]
Mortality			0.007*	
No	138 (82)	137 (92)		1
Yes	31 (18)	12 (8)		2.56 [1.27;5.20]*

*$p < 0.05$.

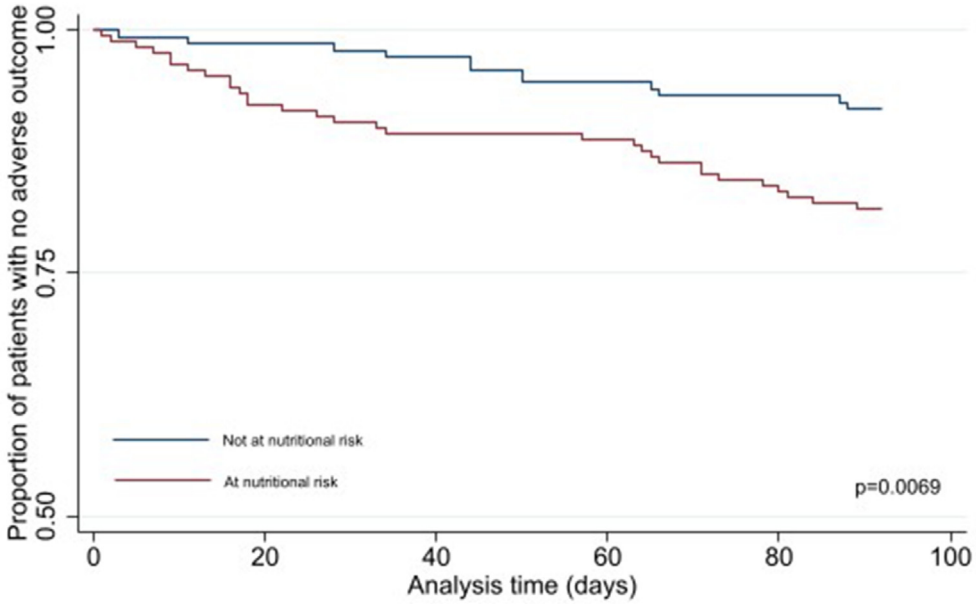

Fig. 2. Mortality in patients at nutritional risk and not at nutritional risk (Kaplan Meier plot).

Table 3
Associations between length of stay among patients at nutritional risk and achieving 75% of energy and protein requirements, diagnosis, received ONS and snack meals during hospitalization, respectively.

Patients at nutritional risk (n = 168)	$Median_{Length\ of\ stay\ (days)}$ (range)	Unadjusted		Adjusted[b]	
		RR	95% CI	RR	95% CI
Achieving 75% of energy requirement					
Yes	15 (2–266)	1.57	1.47;1.68*	1.59	1.49;1.70*
No	12 (1–120)	1	Ref.	1	Ref.
Achieving 75% of protein requirement					
Yes	11 (2–266)	1.32	1.23;1.41*	1.36	1.27;1.45*
No	13 (1–185)	1	Ref.	1	Ref.
ONS					
Yes	17 (2–82)	1.01	0.94;1.08	1.04	0.96;1.11
No	11 (1–266)	1	Ref.	1	Ref.
Snack meals					
No	8 (2–120)	1	Ref.	1	Ref.
Snack meals incl. ONS	17 (2–82)	1.34	1.23;1.47*	1.38	1.26;1.51*
Snack meals excl. ONS	14 (1–266)	1.59	1.47;1.73*	1.60	1.47;1.74*
Diagnosis					
Infection	16 (4–91)	1	Ref.	1	Ref.
Cancer	8.5 (3–27)	0.47	0.40;0.55*	0.40	0.34;0.47*
Diseases of bones, muscles and connective tissue	15 (2–145)	1.11	0.99;1.25	1.16	1.03;1.30*
Diseases of the blood and blood-forming organs	8 (3–32)	0.46	0.37;0.56*	0.49	0.40;0.60*
Diseases of the urinary and genital organs	24 (4–77)	1.14	0.99;1.31	1.05	0.91;1.21
Diseases of the nervous system	20 (2–185)	1.40	1.25;1.58*	1.45	1.29;1.64*
Diseases of the circulatory organs	8 (1–36)	0.58	0.49;0.69*	0.64	0.54;0.75*
Respiratory diseases	13.5 (2–58)	0.92	0.80;1.05	0.85	0.74;0.98*
Diseases of the digestive organs	14 (4–266)	1.25	1.11;1.39*	1.23	1.09;1.38*
Other[a]	10.5 (2–87)	0.95	0.81;1.11	0.88	0.75;1.04

*$p < 0.05$.
ONS = Oral nutritional supplement.
[a] Others: Skin and subcutaneous tissue disorders, Endocrine and nutritional disorders as well as metabolic disorders, Mental disorders and behavioral disorders, Symptoms and abnormal findings not classified elsewhere, Lesions and poisoning and certain other consequences, Factors affecting the state of health.
[b] Adjusted for age, sex and co-morbidity.

hospitalization (see Table 5). Compared to patients hospitalized with infectious disease, patients with digestive diseases had higher risk for mortality within the three-months follow-up (IRR = 4.98 [1.20;20.65]).

4. Discussion

The present study found a longer LOS, higher three-month readmission rate and increased mortality in patients at nutritional risk compared to patients not at risk. Worse clinical outcome in hospitalized patients at nutritional risk is supported by previous studies both in Danish settings and internationally [6,10,26,27]. These findings suggest that NRS-2002 is a sensitive screening tool in regard to mortality, LOS and readmissions in the hospital setting regardless of medical diagnosis.

Findings from the present study show that patients at nutritional risk had higher risk of mortality compared to patients not at risk. Based on Fig. 2, it must be assumed that the proportion of

Table 4
Associations between patients at nutritional risk with a readmission and achieving 75% of energy and protein requirements, hospitalization diagnosis, received ONS and snack meals during hospitalization, respectively.

Patients at nutritional risk (n = 156)	$N_{Readmissions}$ n = 65	Unadjusted		Adjusted[b]	
		IRR	95% CI	IRR	95% CI
Achieving 75% of energy requirement					
Yes	32 (49.2)	0.85	0.52;1.38	0.81	0.50;1.32
No	33 (50.8)	1	Ref.	1	Ref.
Achieving 75% of protein requirement					
Yes	21 (32.3)	1.01	0.60;1.69	1.02	0.60;1.71
No	44 (67.7)	1	Ref.	1	Ref.
ONS					
Yes	18 (27.7)	1.01	0.59;1.75	1.07	0.62;1.86
No	47 (72.3)	1	Ref.	1	Ref.
Snack meals					
No	16 (24.6)	1	Ref.	1	Ref.
Snack meals incl. ONS	18 (27.7)	1.21	0.62;2.37	1.17	0.59;2.31
Snack meals excl. ONS	31 (47.7)	1.32	0.73;2.42	1.15	0.61;2.18
Diagnosis					
Infection	13 (20.0)	1	Ref.	1	Ref.
Cancer	11 (16.9)	1.29	0.58;2.89	1.05	0.46;2.41
Diseases of bones, muscles, and connective tissue	5 (7.7)	0.47	0.17;1.31	0.50	0.18;1.41
Diseases of the blood and blood-forming organs	7 (10.8)	1.38	0.55;3.45	1.59	0.62;4.05
Diseases of the urinary and genital organs	7 (10.8)	1.45	0.58;3.63	1.33	0.53;3.36
Diseases of the nervous system	3 (4.6)	0.34	0.10;1.18	0.35	0.10;1.24
Diseases of the circulatory organs	7 (10.8)	1.17	0.47;2.93	1.38	0.55;3.49
Respiratory diseases	4 (6.2)	0.49	0.16;1.49	0.45	0.15;1.38
Diseases of the digestive organs	7 (10.8)	0.82	0.33;2.05	0.85	0.33;2.16
Other[a]	1 (1.4)	0.21	0.03;1.61	0.19	0.03;1.51

*$p < 0.05$.
ONS = Oral nutritional supplement.
[a] Others: Skin and subcutaneous tissue disorders, Endocrine and nutritional disorders as well as metabolic disorders, Mental disorders and behavioral disorders, Symptoms and abnormal findings not classified elsewhere, Lesions and poisoning and certain other consequences, Factors affecting the state of health.
[b] Adjusted for age, sex, and co-morbidity.

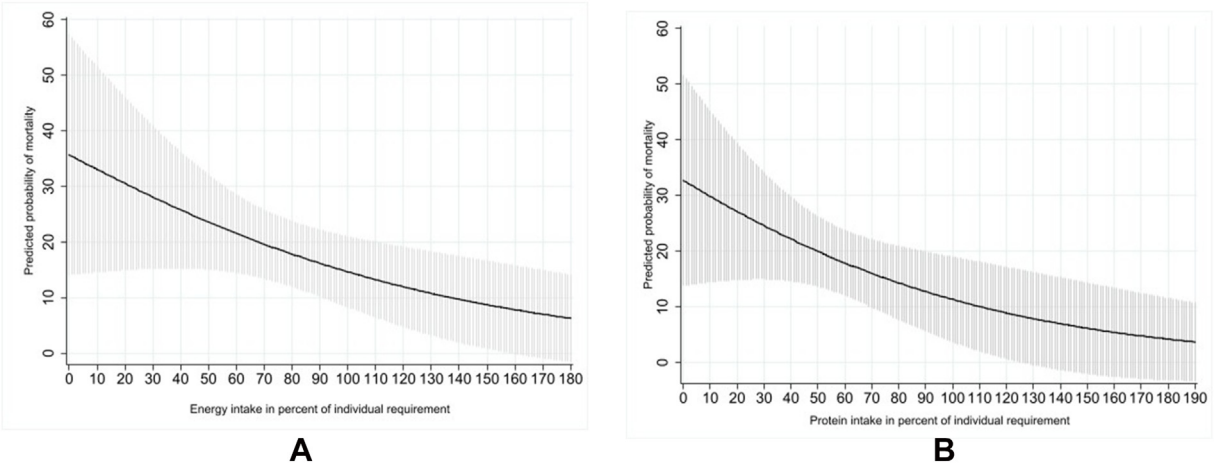

Fig. 3. Predicted probability of mortality at three-month follow-up among patients at nutritional risk regarding: A) Energy intake in percent of individual requirement as well as 95% CI and B) protein intake in percent of individual requirement as well as 95% CI.

patients with mortality will continue to increase after the three-month follow-up period, which is supported by the literature [6]. Findings from the present study show that patients at nutritional risk reaching at least 75% of energy and protein requirements were associated with a longer LOS, lower risk of three-month mortality, but not readmissions. The use of ONS and snack meals during hospitalization was associated to longer LOS among patients at nutritional risk. The positive association between longer LOS and achieving 75% of energy and protein requirements as well as use of ONS and consuming ONS and snack meals may be explained by the fact, that patients who had increased attention to nutrition by the health professionals and thus received ONS and snacks were more ill and at greater risk of longer stay. Therefore, these patients may have easier to achieve attention to energy and protein requirements during hospitalization. Use of ONS and consuming snack meals during hospitalization was not significantly associated to mortality or readmissions at three-months follow up. These findings are supported by a recent Danish study where no association was found between reaching 75% of energy and protein intake and mortality and readmissions at a 30-day follow up period [10]. Furthermore, in a RCT study following patients with individual dietetic support after hospitalization, a non-significant increase of readmissions was seen at 30 days and 16 weeks for the intervention group [28]. This was seen as an intervention “bias”. In a large study

Table 5
Associations between mortality among patients at nutritional risk regarding achieving 75% of energy and protein requirements, diagnosis, received ONS and snack meals during hospitalization, respectively.

Patients at nutritional risk (n = 169)	$N_{Mortality}$ n = 31	Unadjusted		Adjusted[b]	
		IRR	95% CI	IRR	95% CI
Achieving 75% of energy requirement					
Yes	9 (29.0)	0.36	0.17;0.78*	0.36	0.16;0.78*
No	22 (71.0)	1	Ref.	1	Ref.
Achieving 75% of protein requirement					
Yes	8 (25.8)	0.73	0.32;1.62	0.76	0.34;1.71
No	23 (74.2)	1	Ref.	1	Ref.
ONS					
Yes	13 (41.9)	1.86	0.91;3.79	1.89	0.92;3.86
No	18 (58.1)	1	Ref.	1	Ref.
Snack meals					
No	11 (35.5)	1	Ref.	1	Ref.
Snack meals incl. ONS	13 (41.9)	1.24	0.56;2.77	1.26	0.56;2.85
Snack meals excl. ONS	7 (22.6)	0.44	0.17;1.13	0.43	0.16;1.16
Diagnosis					
Infection	3 (9.7)	1	Ref.	1	Ref.
Cancer	4 (12.9)	2.04	0.46;9.10	2.13	0.46;9.90
Diseases of bones, muscles and connective tissue	6 (19.4)	2.38	0.60;9.52	2.73	0.68;11.05
Diseases of the blood and blood-forming organs	3 (9.7)	2.54	0.51;12.61	3.71	0.72;19.12
Diseases of the urinary and genital organs	3 (9.7)	2.61	0.53;12.96	2.20	0.44;11.04
Diseases of the nervous system	0 (0.0)	–	–	–	–
Diseases of the circulatory organs	3 (9.7)	2.18	0.44;10.81	2.44	0.49;12.13
Respiratory diseases	1 (3.2)	0.53	0.06;5.10	0.54	0.06;5.25
Diseases of the digestive organs	7 (22.5)	3.45	0.89;13.36	4.98	1.20;20.65*
Other[a]	1 (3.2)	0.91	0.10;8.79	1.14	0.11;11.77

*$p < 0.05$.
ONS = Oral nutritional supplement.
[a] Others: Skin and subcutaneous tissue disorders, Endocrine and nutritional disorders as well as metabolic disorders, Mental disorders and behavioral disorders, Symptoms and abnormal findings not classified elsewhere, Lesions and poisoning and certain other consequences, Factors affecting the state of health.
[b] Adjusted for age, sex and co-morbidity.

reporting data from NutritionDay based on 9959 patients from 601 units at 245 different American hospitals, supports increased 30-day mortality in patients with insufficient food intake [29]. Likewise, in the large European EFFORT study, unselected hospitalized patients identified at nutritional risk receiving a protocolized nutritional support found a mean intake of >75% of energy and protein requirements on day three. Furthermore, the study found lower 30-day mortality and lower non-elective readmissions after discharge compared to nutritional risk patients not receiving protocolized nutritional support [30]. Although patients in the current study did not receive protocolized nutritional support by the hospital dietitians, the findings support that reaching at least 75% of energy and protein requirements matters in relation to three-month mortality. However, studies suggest that comprehensive nutrition intervention is needed to impact readmission rates [30–32].

The lack of impact of ONS and snack meals in three-month mortality and readmissions are partially disputed in a previous study in unselected hospitalized patients [32,33]. In a large American observational study, close to a 40% lower 30-day readmission rates was found in adult malnourished inpatients at any general and surgical wards using ONS compared to non-ONS users [32]. Use of ONS and snack meals are important mediators to improve energy and protein intake in patients at nutritional risk, as studies have shown that patients at nutritional risk consume less from meals than their not-at-risk counterparts [34]. However, ONS provision does not necessarily contribute to a higher energy and protein intake [34]. Monitoring food intake is therefore necessary to detect insufficient intake despite provision of ONS and to provide nutritional care tailored the individual patient. The lack of clinical impact of ONS and snack meals in the current study may be related to lack of nutritional monitoring to identify patients in need of an altered nutritional plan to secure sufficient energy and protein intake. Conducting good interdisciplinary nutritional practice including screening, nutrition plan and monitoring has previously shown to improve patients' energy and protein intake in hospitalized patients, providing the foundation for improving clinical outcomes for patients at nutritional risk [12].

A 75% cut off of energy and protein requirements in hospital has never exactly been associated with clinical outcomes, but only with the maintenance of weight [35]. Regardless, there is no question that food intake is at some cut off level associated with clinical outcomes. In a former study we found that mortality was higher in patients receiving less than 50% of their daily requirements, concerning energy and protein [36]. The EFFORT study found an association between food intake and clinical outcomes; however, not providing cut-offs for energy and protein sufficiency [30]. In the present study, patients achieving 100% of energy and protein requirements have 15% and 12% probability of mortality respectively, which may indicate that patients still have an increased probability of mortality even though they reach the target of ≥75% of requirements, as illustrated in Fig. 3A and B. Therefore, it can be discussed whether the energy and protein individual requirements are estimated correctly or perhaps the requirements among inpatients should be calculated in a different way depending on the specific disease or by indirect calorimetry [30].

In the present study, patients at nutritional risk had significant longer LOS compared to patients not at nutritional risk and especially in LOS ≥20 days. Previous studies supports these findings [8,9,37]. A study found that a decrease in nutritional status and a weight loss >5% was associated with longer LOS [9]. In the present study we do not have the opportunity to investigate whether the patients' nutritional status will be better or worse during their hospitalization. Furthermore, in the present study we found an association between achieving 75% of energy and protein requirements and longer LOS among patients at nutritional risk.

Another Danish study from 2010 found no association between reduced food intake equivalent to <50% due energy and protein requirements and LOS [36].

4.1. Strengths and limitations

A strength of the current study is the broad inclusion criteria and thus its generalizability. Only 10% of the eligible patients declined participation; hence, the study population represents a wide range of medical and surgical hospitalized patients. The high inclusion rate may be due to the low patient burden, as it included physically data collection for one day only and the follow-up data was collected using the electronic patient journals. Furthermore, the included patients in the present study represent patients with different LOS, ranging from newly hospitalized to long-term inpatients.

Another important strength of this study concerns the data collection at baseline. The baseline data collection was conducted by a trained research team allowing for reliable prospective data on food intake of all included patients. Prospective data collection concerning food intake is time consuming and often left out or rely on ward staff to be collected. All collected data, including data from the patient electronic journals were double checked by two researchers from the research team, further strengthening the study's validity.

As time-to-event data were collected it was possible to perform a survival analysis in the form of a piecewise exponential Poisson regression analyzes, which give more detailed analyzes and strengthens the study.

The lack of associations between readmissions and partly mortality in relation to energy and protein intake, use of ONS and snack meals with or without ONS may be due to the low mortality rate to secure powerful data on these associations. Another limitation to the study was the lack of nutritional information during the three-month follow-up period eliminating the possibility to assess the impact of prolonged nutritional information on readmission and mortality rates. Further studies should assess the impact of good nutrition care both during and after discharge.

5. Conclusion

This prospective cohort study revealed significant association between patients at nutritional risk and increased risk of mortality and readmissions as well as longer LOS of index hospitalization compared to patients not at risk. The results of this study indicate an association between food intake and predicted three-month mortality among patients at nutritional risk. No associations were found between food intake among patients at nutritional risk and readmissions. Snack meals and ONS contributed to achieving nutritional requirements. As a curiosum we found that patients achieving 75% of energy and protein requirements and snack meals with and without ONS had longer LOS during their index hospitalization. The high prevalence of patients at nutritional risk with associated risk of poorer outcome indicate that good nutritional care including constant attention to food-intake during hospitalization is beneficial regarding mortality.

Author contributions

SM: Investigation, Formal analysis, Validation, Writing - Original Draft, Writing - Review & Editing. RT: Conceptualization, Methodology, Investigation, Validation, Writing - Review & Editing. LBS: Conceptualization, Methodology, Investigation, Resources, Validation, Writing - Review & Editing. HHR: Conceptualization, Methodology, Validation, Writing - Review & Editing. MH: Conceptualization, Methodology, Investigation, Resources, Validation, Writing - Review & Editing, Supervision.

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Declaration of competing interest

No conflict of interest to declare.

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