

Original article

The nutritional strategy: Four questions predict morbidity, mortality and health care costs



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SUMMARY

Background: Nutritional care for hospital in-patients is potentially important but challenging.

Objective: To investigate the association between nutritional status and clinical outcomes.

Methods: Eight prevalence surveys were performed at Haukeland University Hospital, Norway, during 2008–2009. In total 3279 patients were classified as being at nutritional risk or not according to the Nutritional Risk Screening (NRS 2002) tool. The initial four questions of NRS 2002 assess dietary intake, weight loss, body mass index (BMI) and illness severity.

Results: The overall prevalence of nutritional risk was 29%. Adjusted mean days for hospitalisation was 8.3 days for patients at nutritional risk and 5.0 days for patients not at risk ($p < 0.001$). In adjusted models, patients at nutritional risk had increased one-year mortality (OR 4.07, 95% CI 2.90–5.70), morbidity (OR 1.59, 95% CI 1.18–2.13), and were 1.24 (95% CI 1.16–1.32) times more likely to have had a new admission during the three previous years and the one subsequent year, compared to patients not at risk. A 'positive' response to the initial four questions was associated with increased risk of morbidity and mortality. Patients with a reduced dietary intake during the last weeks had OR 1.72 (95% CI 1.03–2.85) for one-year mortality. Patients with a positive answer on all the initial four questions had ten times increased risk for mortality the following year, OR 13.0 (95% CI 4.52–37.6).

Conclusion: The four initial questions of the NRS 2002 robustly identify nutritional risk and were strong predictors of hospitalisation, morbidity and most importantly mortality among hospitalised patients. Thus, these simpler and short questions are robust indicators for subsequent poor outcomes.

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1. Introduction

Optimal nutrition is an essential part of health. Nevertheless poor nutrition is a common clinical problem in patients in European hospitals.^{1,2} Loss of appetite and weight loss are associated with reduced muscle mass,³ increased morbidity and loss of function even after only one week of illness.⁴ Nutritional treatment,

such as protein- and energy-enriched food and oral supplements, have been shown to improve nutritional status,³ prevent loss of body mass and function⁴ and reduce inflammation,⁵ morbidity and mortality^{6–8} in hospitalised patients. Even during a short hospital stay, individualised nutritional care to malnourished patients reduces morbidity and mortality.⁹ Implementation of clinical routines which include nutritional evaluation, optimised food composition and monitoring of dietary intake have been shown to increase nutritional intake.¹⁰ The additional costs of this nutritional care are modest.¹¹

Better nutritional practice to improve patient care is emphasised in international and national health care guidelines.^{12,13} However, the process of structured nutrition care is a challenge in many

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hospitals, and routines are not well implemented.^{14–16} A survey of nutritional practice in Norwegian hospitals showed poor practice and lack of knowledge among nurses and physicians.¹⁶ It has been suggested that a general increase of number of forms and report requirements in the hospital as well as time-consuming procedures for nutritional assessment may contribute to this poor practice.^{15,16}

To address this problem, Haukeland University Hospital introduced a strategy called “Good nutritional practice” in 2006 and recommended nutritional evaluation of all patients at admission.¹⁵ Several methods were considered to identify patients at risk of malnutrition and the NRS 2002 (Nutritional Risk Screening) was chosen.¹² The full NRS 2002 survey includes four simple questions (yes/no) and a scoring procedure for the same questions. Controlled trials have shown that this nutritional evaluation can identify patients who are more likely to benefit from nutritional support.¹⁷ Thus, the aim of this study was to measure if poor nutritional status assessed by NRS 2002, and which components of the assessment, if any, were associated with morbidity, mortality and the use of hospital services during a one-year follow-up in a university hospital.

2. Methods

2.1. Study design

This prospective observational study was conducted at the second largest hospital in Norway; Haukeland University Hospital, as well as the local hospitals Voss Hospital, Hagavik Orthopaedic Hospital and Nordås Rehabilitation Centre. In repeated point prevalence surveys carried out every three months starting January 2008, patients were evaluated according to nutritional risk. Data on the use of in-hospital services and mortality were obtained from the patient administrative electronic database.

2.2. Procedures

The NRS 2002 is designed to identify patients at nutritional risk. The evaluation starts with four initial questions:

Is BMI <20.5 kg/m²?

Has the patient lost weight within the last weeks?

Has the patient had a reduced dietary intake during the last weeks?

Is the patient severely ill?

A patient is “not at risk” if BMI is ≥ 20.5 kg/m², food intake is normal, weight has not been declining and the current illness is not severe (i.e. no increased stress metabolism). If at least one of these criteria is met, the evaluation proceeds by giving 0–3 score in relation to BMI, recent weight loss and food intake during the previous weeks. Further, stress metabolism is evaluated with 0–3 score according to illness category. Finally, patients aged 70 years and older get one extra point. A total score ≥ 3 , defined as “at nutritional risk”, indicates that these individuals should receive individualised nutritional care.¹²

At 8 a.m. on the registration day, information on patient’s name, date of birth, gender and hospital ward was exported to a dedicated database. The nurses performed the nutritional evaluation and registration of the data. The head nurses who were responsible for the digital registration were given a time-limited password and had seven hours to perform the registration. This procedure has previously been described.¹⁵

2.3. Variables

The use of in-hospital services, morbidity and mortality were compared between patients identified to be at nutritional risk by

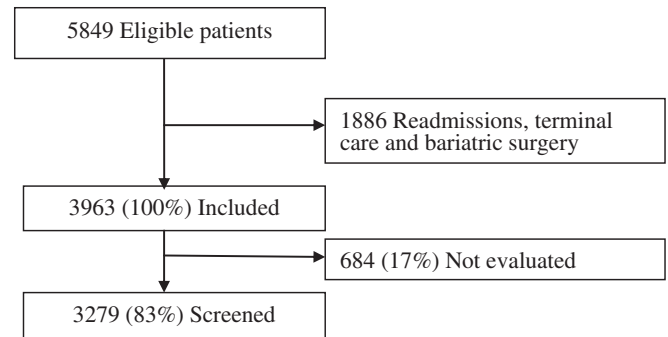


Fig. 1. Flow-chart.

the NRS 2002, as well as separately by the four initial screening questions. Morbidity was assessed as number of ICD-10 diagnosis codes at discharge. The use of in-hospital services was measured as length of stay (LOS), number of subsequent admissions and the total number of days in hospital from inclusion and until the end of year one. Mean number of admissions, irrespective of cause, during the three previous years and the one following, were also recorded. These data were also obtained for patients whose nutritional screening was incomplete.

2.4. Participating hospital units

Both medical and surgical inpatient departments and intensive care units participated in the surveys with the exception of departments of obstetrics, paediatrics and psychiatry. After a pilot study in three units, the first point prevalence survey was performed in 14 units in January 2008. The subsequent surveys included 51 units, from 2 to 31 beds. The present study included all hospitalised patients evaluated during eight surveys conducted during 2008 and 2009 ($n = 5949$). Patients who participated in two or more surveys are included with data from the first registration only. Patients admitted for bariatric surgery, day only admissions and foreign patients without a Norwegian personal identification number were excluded ($n = 1220$). Other exclusion criteria were terminal care and age below 18 years ($n = 666$). Through the eight surveys of 3963 eligible patients, 3279 (83%) had their nutritional survey fully completed. There is no information available for why 684 (17%) patients were not assessed (Fig. 1).

2.5. Statistical analyses

Statistical analyses were performed by using SAS (Statistical Analysis System) version 9.2 (SAS Institute, Inc., Cary, North Carolina) and R version 2.15.1 (The R Foundation for Statistical Computing, www.r-project.org). Continuous variables were reported as mean \pm SEM and categorical variables as prevalence (%) \pm SEM. The chi-square test was used to test for difference in prevalence of categorical variables, while Mann–Whitney U test was used to test for difference in medians of continuous variables. One-way analysis of variance was used to test for difference in means of continuous variables.

In hospital-based cross-sectional studies, patients with longer hospital stays are more often likely to be sampled than patients with shorter stays.¹⁸ This oversampling of long-term stayers, i.e. length biased sampling, may influence the means and prevalence of exposures and outcomes as well as the effect estimates of exposure-outcome associations.¹⁸ In order to account for this length bias, individual sampling weights were incorporated into the analyses by giving more weights to patients with shorter

Table 1
Population characteristics according to nutritional status and the NRS 2002 criteria.

	All subjects	Nutritional status		<i>P</i> ^a
		At nutritional risk	Not at nutritional risk	
Total	3279 (100)	952 (29.0)	2327 (71.0)	
	Median [range]	Median [range]	Median [range]	
Age, yr	66 [18–99]	72 [18–99]	64 [18–98]	<0.001
BMI, kg/m ²	24.7 [11.0–55.6]	20.2 [11.0–44.5]	25.8 [18.5–55.6]	<0.001
	n (%)	n (%)	n (%)	
Sex, male	1646 (50.2)	443 (46.5)	1203 (51.7)	
Age, >70 year	1389 (42.5)	532 (55.9)	860 (37.0)	<0.001
<i>Four initial questions^a</i>				
Is BMI <20.5 kg/m ² ?	549 (16.7)	522 (54.8)	22 (0.7)	
Has the patient lost weight within the last weeks?	639 (19.5)	546 (57.4)	93 (2.8)	
Has the patient had a reduced dietary intake last weeks?	772 (23.5)	652 (68.5)	120 (3.7)	
Is the patient severely ill?	419 (12.8)	339 (35.6)	80 (2.4)	
BMI, kg/m ²				
≥20.5, 0 score	2658 (81.0)	418 (44.4)	2240 (98.9)	
≥18.5–<20.5, 2 score	305 (9.3)	279 (29.6)	26 (1.1)	
<18.5, 3 score	244 (7.4)	244 (25.9)	0	
Dietary intake, %				
>75%, 0 score	362 (11.0)	188 (28.3)	174 (73.1)	
50–75%, 1 score	255 (7.8)	195 (29.3)	60 (25.2)	
25–50%, 2 score	170 (5.2)	167 (25.1)	3 (1.3)	
<25%, 3 score	116 (3.5)	115 (17.3)	0	
Weight loss, %				
<5%, 0 score	456 (13.9)	297 (50.8)	159 (84.6)	
5–<10%, 1 score	171 (5.2)	144 (24.6)	27 (14.4)	
10–<15%, 2 score	91 (2.8)	89 (15.2)	2 (1.1)	
≥15%, 3 score	55 (1.8)	55 (9.4)	0	
Illness score				
0 score	127 (3.9)	73 (7.7)	54 (22.5)	
1 score	679 (20.7)	524 (55.0)	155 (64.6)	
2 score	247 (7.5)	216 (22.7)	31 (12.9)	
3 score	139 (4.2)	139 (14.6)	0	

^a The chi-square test was used to test for difference in prevalence of categorical variables, while Mann–Whitney *U* test was used to test for differences in medians of continuous variables.

hospital stays, analogous to those described by Nowell et al.¹⁹ Patients with the longest hospital stay (250 days) were given a weight of 1, while those with the shortest stay (1 day) were given a weight of 250. The generalised form of weights is $\text{weight} = 250/\text{LOS}$.

The associations of nutritional risk and the four introductory questions with mortality (1 year) and morbidity were assessed using logistic regression models. The estimated odds ratios (OR) with the corresponding 95% confidence intervals (CI) were reported crude and after accounting for the individual sampling weights described above, using PROC SURVEYLOGISTIC in SAS. Analyses of mortality were further adjusted for age (continuous), gender (male, female), height (continuous), emergency admission (yes, no), month for inclusion (quarter), number of days from admission to inclusion (continuous), and number of diagnoses (continuous). Analyses of morbidity were adjusted for the same variables except for the number of diagnoses.

The associations of nutritional risk and the four introductory questions with LOS, hospital stay (1 year) and admissions (4 years) were examined using linear regression models. Since the dependent variables were positively skewed, log-transformation was performed to better meet the assumption of normally distributed residuals in the regression models. After model fitting, the estimated slope coefficient *B* was interpreted on the anti-log scale, $\exp(B)$, rather than on the linear scale. This means that for a one unit increase in the independent variable the expected value of the dependent variable changed by the factor of $\exp(B)$. The estimated $\exp(B)$ with the corresponding 95% CI were reported crude and after accounting for the above mentioned sampling weights, using PROC SURVEYREG in SAS. Analyses of LOS and hospital stay (1 year)

were adjusted for age (continuous), gender (male, female), height (continuous), emergency admissions (yes, no), time of year at inclusion (quarter), and number of diagnoses (continuous). Analyses of admission (4 years) were adjusted for the same variables as well as for number of days from admission to inclusion (continuous).

Estimation of hospital costs was based on a mean daily cost for patients ready to leave the hospital of US\$ 860²⁰ and the mean number of days in hospital over one year.

To handle missing values in multiple regression models, we used the method of list-wise deletion. All *p*-values were two-sided, and values below 0.05 were considered statistically significant.

2.6. Ethics

The study was part of a quality improvement project and was therefore exempted from review by the Regional Committee for Medical and Health Research Ethics. The Norwegian Data Inspectorate and the hospital research board approved the study. The patients were not subject to any experimental interventions and thus were not asked to provide informed consent.

3. Results

3.1. Patients' characteristics

A total of 3963 patients were included in eight point prevalence surveys during 2008 and 2009. Among these, the NRS 2002 assessment was completed for 3279 (83%). Of these, 952 (29%) patients were classified as being at nutritional risk (Table 1).

Table 2
Clinical outcome according to nutritional risk status ($n = 3279$).

	Mortality (1 year)	Morbidity ^a	LOS ^b	Hospital stay (1 year)	Admissions (4 years) ^c	Hospital costs (1 year) ^d
	% ± SEM	% ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM
Observed estimates						
All subjects	18.9 ± 0.68	44.7 ± 0.87	18.2 ± 0.41	27.2 ± 0.54	4.17 ± 0.07	23 392 ± 464.4
At nutritional risk	37.3 ± 1.57	61.8 ± 1.58	22.7 ± 0.74	33.7 ± 1.00	4.74 ± 0.14	28 982 ± 860.0
Not at nutritional risk	11.3 ± 0.66	37.8 ± 1.01	16.4 ± 0.48	24.5 ± 0.63	3.94 ± 0.08	21 070 ± 541.8
<i>p</i> Value ^e	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Corrected estimates ^f						
All subjects	12.5 ± 0.82	24.9 ± 1.06	5.68 ± 0.12	12.3 ± 0.36	4.16 ± 0.14	10 578 ± 309.6
At nutritional risk	30.8 ± 2.42	40.0 ± 2.54	8.32 ± 0.37	17.9 ± 0.82	5.70 ± 0.42	15 394 ± 705.2
Not at nutritional risk	8.03 ± 0.79	21.2 ± 1.15	5.03 ± 0.12	11.0 ± 0.39	3.78 ± 0.14	9460 ± 335.4
<i>p</i> Value ^d	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

SEM, standard error of mean.

^a Morbidity was transformed to a categorical variable defined by >4 diagnoses.^b LOS is length of current stay in days.^c Number of admissions was recorded the three previous and one following year.^d Hospital costs estimates were based on a mean daily cost of 860 US\$ and the hospital stay (1 year).^e *p* value for difference between nutritional risk groups; chi-square test for categorical variables, 1-way analysis of variance for continuous variables.^f Estimates were corrected for length bias using sampling weights as described in the methods.

Compared to patients not at nutritional risk, patients at nutritional risk were older (mean age 67.9 vs. 61.7 years, $p < 0.001$), had lower BMI (mean 21.4 vs. 26.9 kg/m², $p < 0.001$) and had 36% more days in hospital during the one-year follow-up (mean 34 vs. 25 days, $p < 0.001$). Patients, ($n = 683$) with incomplete assessment and who were therefore not classified as being or not being at nutritional risk, were intermediate between the two above groups with mean age 64.9 years, 25.3 kg/m² BMI and 27 hospital days.

3.2. Clinical outcomes

The one-year mortality rate was 37% among patients at nutritional risk compared with 11% among those not at risk (OR 4.65, 95% CI 3.87–5.58). These results did not change importantly after

accounting for sampling weights and further adjusting for age, gender, height, emergency admissions, quarter of inclusion, number of days from admission to inclusion and number of diagnoses (Tables 2 and 3).

Greater morbidity, measured as more than seven diagnoses, was near 5 times more common among patients at nutritional risk compared to patients not at risk. Compared to patients not at risk, twice as many patients at nutritional risk had more than four diagnoses (OR 2.66, 95% CI 2.28–3.11). These results did not change essentially and was still significant after corrections and adjustments (Tables 2 and 3).

Hospital stays of three weeks or longer were observed in 39.6% of the patients at nutritional risk vs. 22.3% of those not at risk ($p < 0.001$). Similarly only 11.4% of the patients at nutritional risk vs.

Table 3
One-year mortality and morbidity according to nutritional risk identified with the NRS 2002 and its four initial questions ($n = 3279$).

Nutritional risk factors	<i>n</i>	Mortality (1 year)			Morbidity ^a		
		Crude odds ratio (95% CI) ^b	Adjusted odds ratio (95% CI) ^c	Adjusted odds ratio (95% CI) ^d	Crude odds ratio (95% CI) ^b	Adjusted odds ratio (95% CI) ^c	Adjusted odds ratio (95% CI) ^e
NRS 2002 ^f							
At nutritional risk	952	4.65 (3.87, 5.58)	5.01 (3.76, 6.92)	4.07 (2.90, 5.70)	2.66 (2.28, 3.11)	2.48 (1.94, 3.18)	1.59 (1.18, 2.13)
Four initial questions, model 1 ^g							
Is BMI <20.5 kg/m ² ? (yes)	549	1.67 (1.32, 2.11)	2.04 (1.34, 3.10)	2.15 (1.34, 3.46)	1.31 (1.06, 1.61)	1.28 (0.93, 1.75)	1.16 (0.80, 1.69)
Has the patient lost weight within the last weeks? (yes)	639	1.22 (0.89, 1.66)	1.08 (0.65, 1.80)	1.24 (0.74, 2.08)	1.05 (0.82, 1.36)	0.96 (0.64, 1.46)	1.04 (0.65, 1.66)
Has the patient had a reduced dietary intake in the last weeks? (yes)	772	2.37 (1.76, 3.19)	2.32 (1.43, 3.77)	1.72 (1.03, 2.85)	1.85 (1.46, 2.35)	1.89 (1.29, 2.76)	1.27 (0.83, 1.94)
Is the patient severely ill? (yes)	419	2.34 (1.82, 3.00)	3.88 (2.60, 5.77)	3.54 (2.25, 5.57)	1.81 (1.44, 2.28)	1.75 (1.23, 2.50)	1.65 (1.08, 2.50)
Four initial questions, model 2 ^h							
At least one question answered with yes	1174	4.18 (3.48, 5.03)	4.46 (3.29, 6.04)	3.95 (2.85, 5.47)	2.17 (1.88, 2.51)	1.85 (1.47, 2.32)	1.40 (1.08, 1.83)
Four initial questions, model 3 ⁱ							
Only 1 question answered with yes	427	3.10 (2.40, 4.01)	3.12 (2.00, 4.86)	3.05 (1.92, 4.85)	1.61 (1.31, 1.98)	1.33 (0.95, 1.86)	1.10 (0.75, 1.62)
Exactly 2 questions answered with yes	342	3.62 (2.76, 4.75)	3.85 (2.46, 6.01)	3.12 (1.94, 5.03)	2.18 (1.73, 2.75)	2.10 (1.46, 3.03)	1.50 (0.98, 2.29)
Exactly 3 questions answered with yes	315	5.91 (4.53, 7.70)	6.74 (4.36, 10.4)	6.24 (3.84, 10.1)	2.70 (2.11, 3.45)	2.33 (1.61, 3.37)	1.68 (1.11, 2.55)
All 4 questions answered with yes	73	10.3 (6.37, 16.7)	18.1 (8.22, 40.0)	13.0 (4.52, 37.6)	5.92 (3.37, 10.4)	6.21 (2.63, 14.7)	3.46 (1.48, 8.11)

^a Morbidity was transformed to a categorical variable defined by >4 diagnoses.^b Estimate of odds ratio by logistics regression models.^c Estimate of odds ratio after accounting for sampling weights as described in the methods.^d Estimate of odds ratio after accounting for sampling weights and adjusted for age, gender, height, emergency admissions, month for inclusion, number of days from admission to inclusion, and number of diagnoses.^e Estimate of odds ratio after accounting for sampling weights and adjusted for age, gender, height, emergency admissions, month for inclusion, and number of days from admission to inclusion.^f NRS 2002: Patients at nutritional risk (yes) were compared with patients who were not at nutritional risk (no).^g Model 1: Patients with a positive answer (yes) on one question were compared with those with a negative answer (no) on that question. All four questions were simultaneously entered into the regression model, i.e. mutually adjusted for each other.^h Model 2: Patients with at least one positive answer (yes) on the four questions were compared with those with a negative answer (no) on all four questions.ⁱ Model 3: Patients with a positive answer (yes) on one or more questions were compared with those with a negative answer (no) on all four questions.

Table 4
Hospitalisations according to nutritional risk identified with the complete NRS 2002 and its four initial questions ($n = 3279$).

Nutritional risk factors	n	LOS ^a			Hospital stay (1 year)			Admissions (4 years) ^b		
		Crude exp(B) (95% CI) ^c	Adjusted exp(B) (95% CI) ^d	Adjusted exp(B) (95% CI) ^e	Crude exp(B) (95% CI) ^c	Adjusted exp(B) (95% CI) ^d	Adjusted exp(B) (95% CI) ^e	Crude exp(B) (95% CI) ^c	Adjusted exp(B) (95% CI) ^d	Adjusted exp(B) (95% CI) ^f
NRS 2002 ^g										
At nutritional risk	952	1.65 (1.53–1.78)	1.53 (1.33, 1.75)	1.30 (1.13, 1.48)	1.70 (1.58, 1.84)	1.93 (1.66, 2.23)	1.57 (1.35, 1.82)	1.24 (1.16, 1.32)	1.51 (1.34, 1.70)	1.34 (1.19, 1.51)
Four initial questions, model 1 ^h										
Is BMI < 20.5 kg/m ² ? (yes)	549	1.03 (0.93, 1.14)	1.02 (0.87, 1.20)	0.97 (0.84, 1.12)	1.05 (0.95, 1.16)	1.24 (1.04, 1.48)	1.17 (0.99, 1.39)	1.14 (1.04, 1.24)	1.30 (1.09, 1.54)	1.26 (1.07, 1.48)
Has the patient lost weight within the last weeks? (yes)	639	1.16 (1.02, 1.31)	0.98 (0.79, 1.21)	0.99 (0.82, 1.18)	1.14 (1.01, 1.29)	1.01 (0.79, 1.29)	1.02 (0.80, 1.30)	1.02 (0.93, 1.13)	1.03 (0.87, 1.22)	1.04 (0.88, 1.24)
Has the patient had a reduced dietary intake in the last weeks? (yes)	772	1.32 (1.17, 1.48)	1.53 (1.25, 1.87)	1.38 (1.15, 1.64)	1.38 (1.24, 1.55)	1.65 (1.28, 2.11)	1.47 (1.16, 1.86)	1.12 (1.02, 1.23)	1.10 (0.94, 1.30)	1.04 (0.88, 1.22)
Is the patient severely ill? (yes)	419	1.41 (1.26, 1.59)	1.42 (1.16, 1.75)	1.20 (0.99, 1.46)	1.47 (1.32, 1.64)	1.94 (1.55, 2.42)	1.54 (1.23, 1.93)	1.13 (1.02, 1.24)	1.53 (1.27, 1.85)	1.36 (1.12, 1.64)
Four initial questions, model 2 ⁱ										
At least one question answered with yes	1174	1.53 (1.42, 1.65)	1.44 (1.27, 1.62)	1.25 (1.11, 1.40)	1.63 (1.51, 1.76)	1.85 (1.61, 2.14)	1.60 (1.39, 1.84)	1.25 (1.17, 1.32)	1.48 (1.32, 1.65)	1.38 (1.24, 1.54)
Four initial questions, model 3 ^j										
Only 1 question answered with yes	427	1.32 (1.18, 1.47)	1.23 (1.03, 1.47)	1.12 (0.95, 1.33)	1.41 (1.26, 1.57)	1.57 (1.27, 1.95)	1.41 (1.17, 1.71)	1.21 (1.11, 1.32)	1.51 (1.26, 1.81)	1.42 (1.20, 1.68)
Exactly 2 questions answered with yes	342	1.56 (1.39, 1.76)	1.51 (1.24, 1.85)	1.32 (1.10, 1.59)	1.66 (1.48, 1.88)	1.77 (1.43, 2.19)	1.54 (1.24, 1.91)	1.23 (1.12, 1.35)	1.38 (1.19, 1.61)	1.29 (1.12, 1.50)
Exactly 3 questions answered with yes	315	1.66 (1.47, 1.88)	1.60 (1.29, 2.00)	1.34 (1.12, 1.62)	1.88 (1.68, 2.11)	2.59 (2.08, 3.22)	2.10 (1.69, 2.61)	1.36 (1.23, 1.50)	1.63 (1.38, 1.93)	1.46 (1.23, 1.75)
All 4 questions answered with yes	73	2.41 (1.94, 2.98)	2.57 (1.64, 4.01)	1.74 (1.15, 2.62)	2.15 (1.75, 2.65)	2.75 (1.60, 4.70)	1.73 (1.00, 2.98)	1.17 (0.97, 1.41)	1.32 (0.91, 1.92)	1.04 (0.70, 1.56)

^a LOS is length of current stay in days.

^b Number of admissions was recorded the 3 previous and 1 following years.

^c Estimate of exp(B) by linear regression models.

^d Estimate of exp(B) after accounting for sampling weights as described in the methods.

^e Estimate of exp(B) after accounting for sampling weights and adjusted for age, gender, height, emergency admissions, month for inclusion, and number of diagnoses.

^f Estimate of exp(B) after accounting for sampling weights and adjusted for age, gender, height, emergency admissions, month for inclusion, number of diagnoses, and number of days from admission to inclusion.

^g NRS 2002: Patients at nutritional risk (yes) were compared with patients who were not at nutritional risk (no).

^h Model 1: Patients with a positive answer (yes) on one question were compared with those with a negative answer (no) on that question. All four questions were simultaneously entered into the regression model, i.e. mutually adjusted for each other.

ⁱ Model 2: Patients with at least one positive answer (yes) on the four questions were compared with those with a negative answer (no) on all four questions.

^j Model 3: Patients with a positive answer (yes) on one or more questions were compared with those with a negative answer (no) on all four questions.

22.4% of the patients not at risk had a short hospital stay, i.e. less than four days ($p < 0.001$). Patients at risk were 1.24 (95% CI 1.16–1.32) times more likely as those not at risk to have been admitted during the previous 3 years and the one subsequent year and 1.70 (95% CI 1.58–1.84) more likely for hospitalisation (Table 4). These results did not change materially after accounting for sampling weights and adjusting for age, gender, height, emergency admissions, quarter for inclusion, number of days from admission to inclusion and number of diagnoses.

3.3. Costs of in-hospital services

Hospital cost was 60% higher for patients at nutritional risk compared to patients not at risk, (US\$ 15 394 vs. 9460, ($p < 0.001$)) (Table 2).

3.4. NRS 2002 and the four initial questions

The four initial questions of NRS 2002 were strongly associated with increased risk for mortality even after accounting for length of stay sampling weights and adjustment for age, gender, height, emergency admissions, month for inclusion, number of days from admission to inclusion and number of diagnoses (Tables 3 and 4). The adjusted OR for one-year mortality increased progressively with more 'positive' responses to the four question: 3.05 (95% CI 1.92–4.85), 3.12 (95% CI 1.94–5.03), 6.24 (95% CI 3.84–10.1) and 13.0 (95% CI 4.52–37.6) for patients with a positive answer to one, two, three or all four of the initial questions, respectively (Table 3).

The question regarding reduced dietary intake in the previous weeks was associated with 2.37 (95% CI 1.76–3.19) times more likely for mortality the following year, and 1.85 (95% CI 1.46–2.35) for increased morbidity compared to patients not at nutritional risk. Severe illness was associated with 2.34 (95% CI 1.82–3.00) increased likelihood for mortality the following year and 1.81 (95% CI 1.44–2.28) for increased morbidity (Table 3).

The risk for mortality was similar when using the full NRS 2002 and the initial screening only, i.e. patients with a positive answer on one random initial question had OR 4.18 (95% CI 3.48–5.03) for one-year mortality compared to 4.65 (95% CI 3.87–5.58) among patients identified with the full NRS 2002 (Table 3). Of note, the predictive value of these questions was not driven by the question relating to prior ill-health as, interestingly, three of the four questions were alone effective in predicting the adverse morbidity and mortality outcomes (Table 3). The associations with increased mortality was still significant after accounting for sampling weights and adjustment for age, gender, height, emergency admissions, quarter for inclusion, number of days from admission to inclusion and number of diagnoses (Tables 3 and 4). Compared to the more complex scoring questions of the complete NRS 2002, the four initial questions identified all the patients at nutritional risk and 91% of the patients not at risk. Thus, these initial questions only incorrectly 'over-identified' 9% of the patients to be at nutritional risk. Using the full survey did not result in any material improvement in the prediction of subsequent adverse outcomes.

4. Discussion

In this study we evaluated the nutritional state and outcome of 3279 hospitalised patients with a wide variety of diseases in a university hospital. "Nutritional risk" was identified in 29% according to NRS 2002. Nutritional risk, but also its four initial questions were associated with increased morbidity, hospitalisation and importantly mortality. The risk for mortality over the following year was 10-fold increased for patients with a 'positive' answer to all four of these questions compared to patients not at

nutritional risk. Patients with a reduced dietary intake during the prior weeks had a 4-fold-increased risk for one-year mortality. Of relevance to clinical implementation, the association with adverse outcome was similar for patients identified with the four initial screening questions versus the more time-consuming comprehensive screening tool NRS 2002.

The strength of the present study is that the surveys were performed in all adult somatic health departments in the second largest hospital in Norway, and that it was mandatory to participate. This allowed us to analyse several outcomes from a large number of patients from different medical specialities. Length bias may occur in prevalence surveys where individuals spend various lengths of time. This was facilitated by correcting for length-bias, i.e. patients with shorter hospital stays were giving more weight. The relatively low number of potential subjects "not registered" reduces the risk for systematic bias. Moreover, the patients with missing nutritional assessment had baseline data intermediate between those at nutritional risk and not at risk, as were their morbidity and mortality outcomes. The main outcome, mortality, is robust and easy to investigate. However, our secondary outcome, morbidity, might be influenced by different practice in the hospital and the fact that they are not entirely prospective measured. A limitation is that due to the nature of the study, any underlying reasons for the poor nutrition are not known. Age, gender, height, emergency admissions, month for inclusion, number of days from admission to inclusion and number of diagnoses were potential risk factors for nutritional risk that were adjusted for. As numbers of diagnoses determine roughly 60 per cent of the hospital reimbursement, this could bias towards more diagnoses being recorded. However, the hospital administrations, for several years, have focused on correct and not to overuse of diagnoses.

The prevalence of nutritional risk, 29.0% identified by NRS 2002 and 35.5% identified by the four initial questions, are both within the range of what has been reported during the last 15 years from studies of hospital populations using comprehensive assessment instruments as the NRS 2002²¹ or the Subjective Global Assessment (SGA).^{2,22–26} However, reduced food intake and loss of weight was even more common in the European multicentre study Nutrition Day ($n = 16\,455$) than in this study (49% vs. 19.5% and 51% vs. 23.5%, respectively).²⁷

Malnutrition adversely impacts every organ system in the body with potentially serious consequences,²⁸ thus also the length of hospitalisation.^{1,2,29}

The cost of undernutrition in the United Kingdom (UK) National Health Service has been estimated to be £13 billion annually, i.e. twice the estimated annual health care costs for obesity.²⁸ In the present study, the hospital costs were estimated to be 60% higher in the following year for patients at nutritional risk, simply due to increased hospitalisations. Moreover, this is likely to be an underestimate as any increased treatment costs were not included. Accurate diagnosis and coding for malnutrition could positively change the patients' Diagnosis Related Groups (DRG) to one with a higher weighting. This would correctly reflect the resources the hospital spends on these patients as 45% of malnourished patients are found to be hospitalised longer than recommended under the DRG.² In some countries, this would increase the amount of reimbursement the hospital received.

Undernutrition is clearly associated with increased use of scarce health care resources. Predicting outcome in hospitals can be important for several reasons, as identifying high-risk patients will impact in decision-making.³⁰ From the data on the present and previous studies, early nutritional care may be crucial to improve outcomes and health care costs. Thus, recognising nutritional problems at admission could help optimise the patient's treatment. There is evidence that nutritional information may change evaluation and

intervention. In UK and Denmark, nutritional evaluation by admission is mandatory.³¹ Nevertheless, in Denmark only 24% of the patients were screened, and only 8% received the mandatory nutritional risk screening without procedural errors.¹⁴ Nutritional evaluation is neither routine in clinical practice in situations and locations in which health care personnel state they consider that it is important.^{14,16} Difficult and time-consuming procedures and lack of a gold standard for nutritional evaluation have been proposed as the main reasons for this inconsistency.^{14,15} Comparing different assessment tools, wide discrepancies in prevalence of malnutrition can be found.³² The results from the current study are critically important, as patients identified by four simple questions regarding poor nutrition, have essentially the same strong association with adverse outcomes as patients identified with more complex and time consuming procedures.

Optimal assessment of patients' nutritional status requires clinical judgment and should, ideally, include direct observation, food questionnaires and examination of the patient's physical, functional and mental status as well as identification of symptoms affecting nutritional status. However, when high turnover of patients makes this impractical, simplified admission procedures are required.

The scoring part of the NRS 2002 questionnaire is the time consuming part and that in which mistakes or miss-assignments are most common.¹⁴ The findings of this study indicate that the four introductory questions allow a rapid and robust identification of patients in need for nutritional care, and all the patients at nutritional risk would still be identified.

The question regarding severity of illnesses was associated with increased risk for mortality, morbidity, prolonged hospitalisation and new admissions. Although, some screening tools have excluded this question,³¹ we argue that this question is a strong risk factor for morbidity and mortality and thus is highly relevant. However, it should be emphasised that, according to guidelines, illness severity reflects increased nutritional requirement rather than prognostic severity.¹²

In conclusion, the four initial screening questions of the NRS 2002 were strong predictors of hospitalisation, morbidity and mortality among hospitalised patients. The four simple questions are robust indicators of poor subsequent outcomes and substantially greater health care costs and can cost-effectively identify individuals who would benefit from focussed nutritional interventions.

Clinical trial registry

Not relevant. The study was part of a quality improvement project and was therefore exempted from review by the Regional Committee for Medical and Health Research Ethics. The Norwegian Data Inspectorate and the hospital research board approved the study. The patients were not asked to provide informed consent and were not subject to any experimental interventions.

Statement of authorship

RJT, GST, ABG participated in developing the nutritional strategy, conception, design and conduction of the research.

RJT, AHR and RMN had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. RJT drafted the manuscript and had primary responsibility for final content.

All the authors participated in the interpretation of the data, contributed to write the manuscript and the final approval of the submitted version.

Conflict of interest

The sponsors of this study had no role in the study design, data collection, data analyses, data interpretation, or writing the report. The authors, the Kavli Research Centre for Ageing and Dementia and The Western Norway Regional Health Authority have no conflicts of interest to declare.

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