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Original Article

Predictors for achieving protein and energy requirements in undernourished hospital patients

Eva Leistra[a,b,*], Floor Willeboordse[a], Marian A.E. van Bokhorst – de van der Schueren[a,b], Marjolein Visser[b,c,d], Peter J.M. Weijs[a], Annelie Haans – van den Oord[e], Jan Oostenbrink[f], Anja M. Evers[b], Hinke M. Kruizenga[a,b,c]

[a] Department of Nutrition and Dietetics, Internal Medicine and the EMGO Institute for Health and Care Research, VU University Medical Center, PO Box 7057, 1007 MB Amsterdam, The Netherlands
[b] Dutch Malnutrition Steering Group, Nicolaas Witsenkade 13hs, 1017 ZR Amsterdam, The Netherlands
[c] Department of Health Sciences, Faculty of Earth and Life Sciences, VU University, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands
[d] Department of Epidemiology and Biostatistics, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands
[e] Department of Dietetics, Franciscus Hospital, PO Box 999, 4700 AZ Roosendaal, The Netherlands
[f] Department of Information Technology, Franciscus Hospital, PO Box 999, 4700 AZ Roosendaal, The Netherlands

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SUMMARY

Background & aims: Providing sufficient protein an energy is considered crucial in the treatment of undernutrition. Still, the majority of undernourished hospital patients have a suboptimal protein and energy intake. The aim of this study was to investigate predictors for achieving protein and energy requirements on the fourth day of admission in undernourished hospitalized patients.
Methods: 830 adult undernourished patients (SNAQ $\geq$ 3) were retrospectively included. Intake requirements were defined as $\geq$1.2 g protein per kg bodyweight and $\geq$100% of the energy requirement based on calculated resting energy expenditure according to Harris & Benedict + 30%. Logistic regression analyses were performed to investigate predictors for achieving the requirements.
Results: Protein and energy intake had been recorded for 610 patients, of whom 25.6% had sufficient protein and energy intake. Protein requirements were less commonly met than energy requirements. Complete case analyses ($n = 575$) showed that negative predictors for achieving the protein and energy requirements were: nausea (OR = 0.18; 95%CI = 0.06–0.53), cancer (0.57; 0.35–0.93), acute infections (0.63; 0.37–1.01) and higher BMI (0.84; 0.79–0.89). Positive predictors were: a higher age (1.01; 1.00–1.03), chronic lung disease (3.76; 2.33–6.07) and receiving tube feeding (3.89; 1.56–9.73).
Conclusion: Only one in four undernourished hospital patients meets the predefined protein and energy requirements on the fourth day of admission. Nausea, cancer, acute infections, BMI, age, chronic lung disease and tube feeding were identified as predictors for achieving protein and energy intake.

1. Introduction

Disease related undernutrition is a common problem in hospitalized patients, with a prevalence rating between 25 and 40%.[1–7] Causes for disease related undernutrition are reduced intake, changes in metabolism, or abnormal losses due to malabsorption, leading to a deficiency or imbalance of protein, energy and other nutrients.[6,8] Undernutrition is associated with increased morbidity and mortality in acute and chronic diseases, impairment of recovery, prolonged length of stay, and increased treatment costs.[6,9,10]

The standard treatment of undernutrition is aimed at achieving optimal protein and energy intake, according to a patient's requirements, in order to reduce the effects of catabolism and minimize the loss of body protein mass.[11] The adequate level of protein intake for hospitalized patients is currently defined as 1.2–1.7 g/kg bodyweight per day.[11–13] The adequate level of energy intake is generally assessed by using the estimated resting energy expenditure (REE) of Harris and Benedict[14] with an additional factor of 30% for either activity or disease.[11,15]

Data on nutritional intake of undernourished patients are scarce. A study of Dupertuis et al. (2003) showed that 43% of hospitalized patients, independent of nutritional status, did not

* Corresponding author. Department of Nutrition and Dietetics, VU University Medical Center Amsterdam, PO Box 7057, 1007 MB Amsterdam, The Netherlands. Tel.: +31 20 444 3410; fax: +31 20 444 4143.
E-mail address: e.leistra@vumc.nl (E. Leistra).

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achieve their minimal protein and energy needs (defined as 0.8 g/kg bodyweight per day and Harris & Benedict[16]) and that 70% did not reach their recommended needs (defined as 1.2 or 1.0 g/kg day (for patients $\leq$ or $>$ 65 years) and Harris & Benedict[16] $+$ 10%).[17] First results of the multinational Nutrition Day survey showed that 60% of all patients admitted to the hospital did not eat their full regular meals on the measurement day, and that these patients were considered to be at increased risk of acquiring a significant protein-energy deficit within a few days.[18]

It is still unknown which factors influence the chance of sufficient protein and energy intake. Therefore, the objective of this study was to investigate predictors for achieving protein and energy requirements in undernourished hospital patients.

2. Materials and methods

2.1. Subjects

This study was conducted in the Franciscus Hospital, a general hospital in Roosendaal, The Netherlands. At admission to the hospital, patients were routinely screened with the Short Nutritional Assessment Questionnaire (SNAQ).[19] All patients admitted to the hospital in 2008 who were screened as undernourished (SNAQ score $\geq$ 3) at hospital admission were retrospectively included in this study. Patients below the age of 18 years or with a hospital stay of less than four days were excluded.

2.2. Data collection

Data was retrospectively derived from the dietetic registration records and represents routine care. Data on protein and energy intake was collected using a structured intake list filled in by an educated nutrition assistant or a trained nurse. When a patient had consumed anything in addition to the hospital menu this was documented precisely by the nutrition assistant. Daily intake was calculated by a dietician and was recorded in the dietetic registration record and discussed with the patient. Protein and energy intakes were calculated, respectively in grams and kilocalories based on the NEVO Dutch Food Consumption Table 2006[20] and the Directives for Sizes and Weights.[21] The intake list was recorded on both the third and fourth day of hospital admission to check for inconsistencies. In case of uncertainty about a patient's intake, the dietician always contacted the patient and the nutritional assistant for further intake analyses. The calculated intake on the fourth day was used in these analyses. If this was missing, the reported intake on the third day of admission was used ($n = 20$). Other general and medical information, anthropometric data and information on additional nutrition during the first days of hospital stay was obtained from either electronic or written hospital records, by using a structured case record form.

This study was approved by the ethical review board of the VU University Medical Center. Because all Dutch hospitals annually have to report on the number of undernourished patients who were optimally treated to the Dutch Health Care Inspectorate, data on intake were already collected. Data were coded and stored anonymously.

2.3. Criteria for sufficient protein and energy intake

The criteria for sufficient protein and energy intake were based on the most commonly used requirements for protein and energy. In The Netherlands, optimal protein intake is currently defined as 1.2–1.7 g/kg bodyweight per day.[11–13] The cut-off point for sufficient protein intake was set at at least 1.2 g/kg as described by the performance indicator defined by the Dutch Health Care Inspectorate.[22] For obese patients, protein requirements were adjusted to a BMI of 27, as recommended in the Dutch perioperative guidelines.[22,23] Energy requirements were based on the estimated resting energy expenditure (REE) of Harris and Benedict[14] plus an additional factor of 30% to correct for activity and/or disease.[11,15,23] An intake of 100% or more of this requirement was defined as sufficient.

2.4. Patient related factors

To obtain insight into reasons for reaching sufficient intake, we studied patient related factors that possibly influence protein and energy intake. Next to general patient characteristics (age, gender) we included anthropometric data (bodyweight (kg), height (cm), and BMI (kg/m^2)). Furthermore, patients' underlying diseases were registered (cancer, gastrointestinal diseases, chronic lung diseases, kidney diseases, nervous disorders, psychological disorders, acute infections or other diseases).[24–27] In addition, data was collected on factors influencing nutritional intake, i.e. chemotherapy, surgery, nausea, diarrhea and swallowing problems during the first four days of admission. Moreover, data on the use of sip feeding, tube feeding and parenteral nutrition during the first four days of admission was recorded. Finally we recorded absolute SNAQ score, hypothesizing that a higher SNAQ score would reflect a more complex patient.[28]

2.5. Statistical analyses

Descriptive statistics were used to analyze patient characteristics. Characteristics of the patients with known and missing data on protein and energy intake were compared by chi-square tests for categorical variables and Student's *t*-tests for continuous variables. Percentages of patients who achieved the requirements on the fourth day of admission were calculated.

Further analyses were performed with patients having complete data on protein and energy intake as well as possible predictors. Differences between those who met and those who did not meet the protein and energy requirements were compared by chi-square tests (categorical variables) and Student's *t*-tests (continuous variables). To identify predictors for achieving adequate protein and energy intake, a prediction model was made with optimal protein and energy intake as dependent variable, using multivariate backward logistic regression analysis. The diagnostic accuracy of the prediction model was assessed in a ROC curve, whereby the area under the curve (AUC) shows the predicted probability of the model. A p-value of $<$0.05 was considered to be statistically significant for descriptive statistics and $<$0.10 was considered to be statistically significant for the logistic regression analyses. Data were analyzed using SPSS version 15.0 for Windows.

3. Results

3.1. Patient characteristics

In 2008, 7960 (71%) of all 11231 patients admitted to the Franciscus Hospital were screened with the SNAQ. A total of 1180 (15%) were found to be undernourished. Of these, 830 patients with a hospital stay of four days or more were included in the study. Mean age was 69.0 ($\pm$14.4) years and 50% of the patients were male. Of all patients, 320 (38.6%) had a malignant disease, 215 (25.9%) had an acute infection, and 161 (19.4%) had a chronic lung disease (primarily COPD). Older patients ($\geq$65 years) more often had multiple diseases than did younger patients (39.7% vs. 23.7%; $p < 0.001$).

Protein and energy intake had been reported for 610 (73.5%) out of 830 patients (Fig. 1). Comparing patients with complete data on protein and energy intake to patients with missing data, we

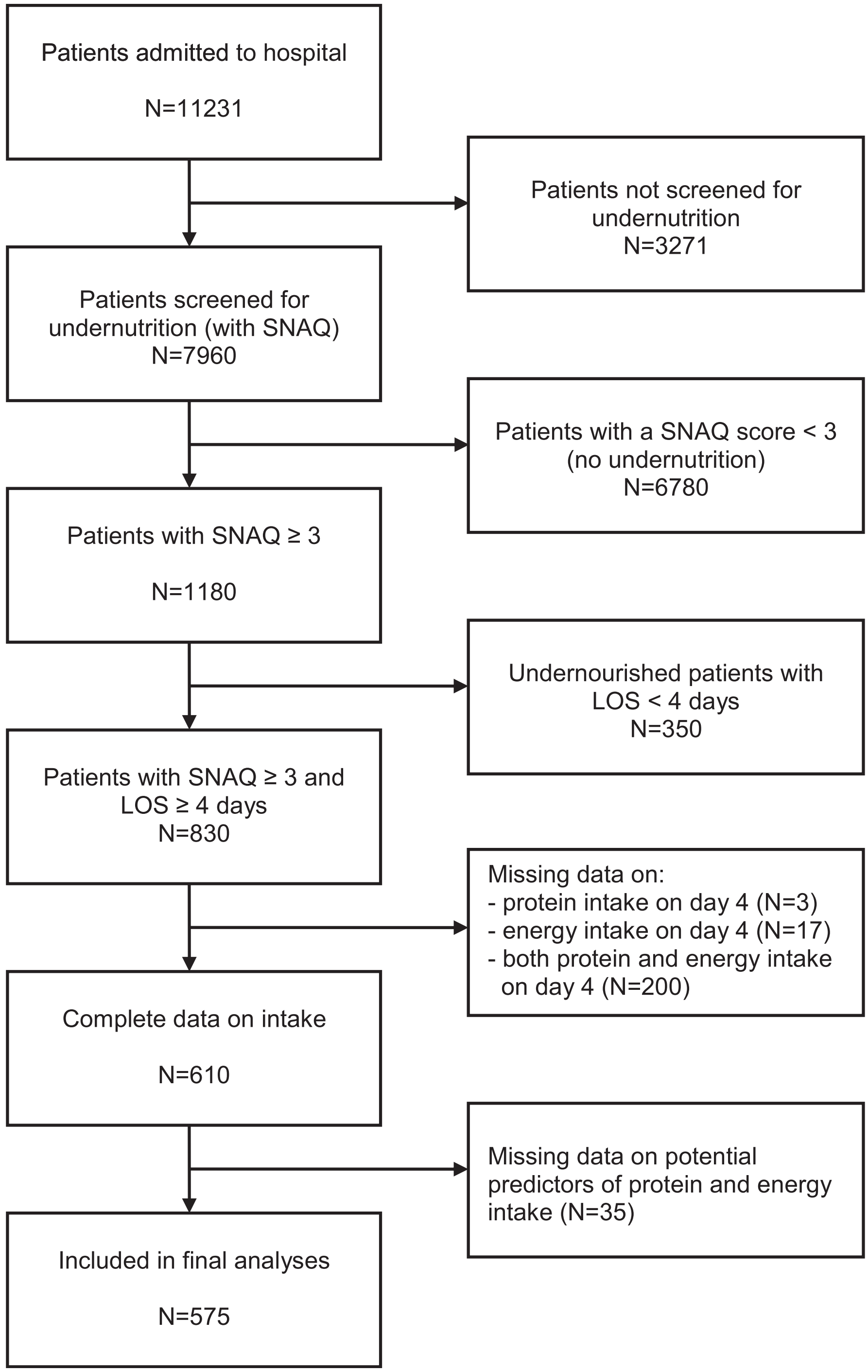

Fig. 1. Flowchart.

observed that patients with a known intake were more likely to have a chronic lung disease (21.5% vs. 13.6%, $p = 0.012$), and were less likely to have psychological disorders (3.8% vs. 7.3%; $p = 0.035$), acute infections (24.1% vs. 30.9%, $p = 0.048$), or to use sip feeding (28.5% vs. 38.6%. $p = 0.060$). Only one patient received parenteral nutrition, therefore this parameter was not used in the analyses.

3.2. Protein and energy intake

Energy requirements were met significantly more often than protein requirements ($p < 0.001$). Of the 610 patients with known intake, 156 patients (25.6%) had both sufficient protein and energy intake on the fourth day of admission, 16 patients (2.6%) had sufficient protein intake only and 82 patients (13.4%) had sufficient energy intake only (Fig. 2). More than half of the patients (58.4%) did not meet the predefined requirements for either protein or energy. Of all patients who met the protein requirements ($n = 172$), 90.7% also met the energy requirements, and of those who met the energy requirements ($n = 238$), 65.5% also met the protein requirements.

For 575 patients both protein and energy intake, as well as all possible predictors were reported. In Table 1, patient characteristics

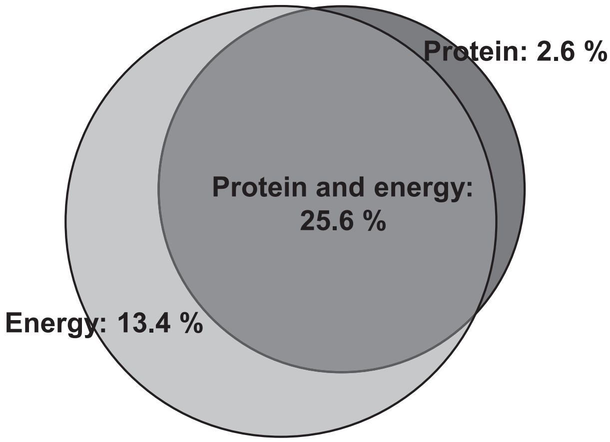

Fig. 2. Percentage of undernourished patients with adequate protein and/or energy intake.

of the undernourished patients are shown for both protein and energy requirements achieved, as well as protein requirements achieved, and energy requirements achieved. Patients using sip feeding or tube feeding and those with chronic lung diseases achieved the protein and energy requirements more often. Patients with higher BMI, younger age, cancer, patients experiencing nausea and patients undergoing surgery reached the requirements less often. Similar associations were found when looking solely at achieving the protein requirements or achieving the energy requirements.

3.3. Predictors for achieving protein and energy requirements

Backward logistic regression analysis provided predictors for achieving the protein and energy requirements (Table 2). Negative predictors for achieving the protein and energy requirements were: nausea (OR = 0.18; 95%CI = 0.06–0.53), cancer (0.57; 0.35–0.93), acute infection (0.63; 0.37–1.01) and having a higher BMI (0.84 per point BMI (kg/m^2); 0.79–0.89). Having a higher age (1.01 per year; 1.00–1.03), having a chronic lung disease (3.76; 2.33–6.07) and receiving tube feeding (3.89; 1.56–9.73) were found to be positive predictors for achieving the nutritional requirements. Sip feeding was significantly related to achieving the requirements in the univariate chi-square tests, but did not reach statistical significance in the prediction model.

The ROC curve for this prediction model showed an AUC of 0.791 (0.749–0.832; $p < 0.001$), indicating that achieving the protein and energy requirements at day 4 can be moderately explained by this model.

4. Discussion

The aim of this study was to investigate predictors for achieving protein and energy requirements in undernourished hospitalized patients. Of all patients with known intake, only one in four had a protein and energy intake meeting their requirements at the fourth day of admission. Moreover, we observed that protein requirements were less commonly met than energy requirements. This emphasizes the specific attention that should be paid to protein intake in the treatment of undernutrition.

The results are in line with previous studies of Dupertuis et al.[17] and Hiesmayr et al.,[18] even though these studies used slightly different criteria to measure intake and requirements. The rather small percentage of patients with sufficient protein and energy intake might be explained by the day of evaluation. In The Netherlands, there is consensus on evaluating a patient's intake on the fourth day of admission,[22] as mean length of hospital stay is decreasing rapidly. An early evaluation will contribute to more rapid intervention and gives the opportunity to change the nutritional treatment if necessary. Although we realize that possibly not all undernourished patients will be optimally fed within these first four days, we think that a higher percentage should be feasible.

Nausea was found to be the most important dichotomous predictor for not achieving the protein and energy requirements. Prevention or treatment of nausea and vomiting has been described earlier, for instance in the ERAS protocol,[29] where it is advised, based on consensus guidelines,[30] to avoid emetogenic drugs and use antiemetics in patients with (a risk for) postoperative nausea and vomiting. More research is needed to assess how nausea can be treated in order to improve intake, and how antiemetics can contribute to the treatment of undernourished patients.

A second negative predictor of achieving the requirements was cancer. One could suggest that patients suffering from cancer also experience nausea, however, post-hoc adding an interaction term for cancer and nausea to the final model did not reach statistical significance ($p = 0.686$) showing that both are independent predictors. Cancer is associated with malaise complaints, such as anorexia, taste and smell alterations, fatigue, but also pain and anxiety, all associated with decreased intake.[27] In this study 37% of the patients were suffering from cancer and only one in six of these patients had sufficient protein and energy intake on the fourth day of admission, indicating that this is an important risk group to target.

The most important dichotomous positive predictor for achieving the requirements is the use of tube feeding during the first four days of hospital stay. Use of tube feeding increases the chance of optimal intake on the fourth day of admission by more than four times. Since only 5% of the population received tube feeding, this should be confirmed in a larger study, though, our results support that for undernourished patients with an expected low intake during a longer period, tube feeding should always be considered, taking into account the risk of developing refeeding syndrome.[31]

We also found that patients with chronic lung diseases were more likely to achieve the protein and energy requirements. We have no plausible explanation for this finding. Patients with chronic lung diseases had a mean lower bodyweight (64.0 ± 14.9 vs. 68.0 ± 13.9; $p = 0.006$), making it easier to achieve optimal intake levels, but as BMI was present in the final model, the association was independent of bodyweight. Another explanation might be the chronic aspect of this disease. Patients usually have a history of hospital admissions, and visits to the outpatient clinic or general practitioner, where they already may have had nutritional advice and/or support.

Up to now, studies on treatment of undernutrition mainly focused on old and frail undernourished patients, hypothesizing that these patients would have more difficulties in achieving sufficient protein and energy during their hospital stay. In contradiction, this study has shown that younger patients and patients with a higher BMI need as much attention, when it comes to achieving the nutritional goals. Patients with a higher BMI or a lower age will have higher absolute protein and energy requirements, which lower the chances of achieving these requirements on the fourth day of admission. We observed that undernourished patients with a BMI ≥ 25 received sip feeding significantly less often than patients with a lower BMI (14.1% vs. 35.2%; $p < 0.001$), which indicates less awareness for undernutrition in overweight patients. We thus concluded that there should be more awareness by health care professionals that undernutrition can be prevalent in patients with high bodyweight and younger age as well.

Table 1
Characteristics of undernourished hospital patients by protein and/or energy intake.

	All	Both protein and energy			Only protein			Only energy		
		Insufficient	Sufficient[c]	*p*	Insufficient	Sufficient[c]	*p*	Insufficient	Sufficient[c]	*p*
N patients	575	430	145		414	161	–	350	225	
Sex, male[a]	282 (49.0%)	215 (50.0%)	67 (46.2%)	0.429	209 (50.5%)	73 (45.3%)	0.268	174 (49.7%)	108 (48.0%)	0.688
Age[b]	68.9 ± 14.3	68.2 ± 14.7	71.1 ± 12.9	**0.037**	68.5 ± 14.5	70.2 ± 13.7	0.197	67.1 ± 14.9	71.8 ± 12.8	**0.000**
Age ≥ 65 years[a]	380 (66.1%)	278 (64.7%)	102 (70.3%)	0.210	271 (65.5%)	109 (67.7%)	0.610	216 (61.7%)	164 (72.9%)	**0.006**
SNAQ score ≥ 5[a]	231 (40.2%)	171 (39.8%)	60 (41.4%)	0.732	165 (39.9%)	66 (41.0%)	0.803	142 (40.6%)	89 (39.6%)	0.808
BMI (kg/m^2)[b]	23.4 ± 4.5	24.1 ± 4.5	21.3 ± 3.8	**0.000**	24.2 ± 4.4	21.4 ± 3.9	**0.000**	24.3 ± 4.7	22.0 ± 3.8	**0.000**
BMI < 18.5[a]	60 (10.4%)	32 (7.4%)	28 (19.3%)	**0.000**	29 (7.0%)	31 (19.3%)	**0.000**	26 (7.4%)	34 (15.1%)	**0.003**
BMI ≥ 25[a]	177 (30.8%)	158 (36.7%)	19 (13.1%)	**0.000**	156 (37.7%)	21 (13.0%)	**0.000**	135 (38.6%)	42 (18.7%)	**0.000**
BMI ≥ 30[a]	43 (7.5%)	41 (9.5%)	2 (1.4%)	**0.001**	39 (9.4%)	4 (2.5%)	**0.005**	37 (10.6%)	6 (2.7%)	**0.000**
Cancer[a]	215 (37.4%)	179 (41.6%)	36 (24.8%)	**0.000**	173 (41.8%)	42 (26.1%)	**<0.001**	156 (44.6%)	59 (26.2%)	**0.000**
Gastrointestinal disease[a]	50 (8.7%)	36 (8.4%)	14 (9.7%)	0.635	35 (8.5%)	15 (9.3%)	0.742	30 (8.6%)	20 (8.9%)	0.895
Chronic lung disease[a]	126 (21.9%)	63 (14.7%)	63 (43.4%)	**0.000**	60 (14.5%)	66 (41.0%)	**<0.001**	48 (13.7%)	78 (34.7%)	**0.000**
Kidney disease[a]	21 (3.7%)	17 (4.0%)	4 (2.8%)	0.507	16 (3.9%)	5 (3.1%)	0.663	9 (2.6%)	12 (5.3%)	***0.085***
Nervous disorder[a]	52 (9.0%)	39 (9.1%)	13 (9.0%)	0.970	38 (9.2%)	14 (8.7%)	0.856	29 (8.3%)	23 (10.2%)	0.429
Psychological disorder[a]	22 (3.8%)	15 (3.5%)	7 (4.8%)	0.467	15 (3.6%)	7 (4.3%)	0.684	13 (3.7%)	9 (4.0%)	0.862
Acute infection[a]	137 (23.8%)	110 (25.6%)	27 (18.6%)	***0.089***	107 (25.8%)	30 (18.6%)	***0.068***	86 (24.6%)	51 (22.7%)	0.601
Other disease[a]	157 (27.3%)	125 (29.1%)	32 (22.1%)	0.102	118 (28.5%)	39 (24.2%)	0.301	102 (29.1%)	55 (24.4%)	0.217
Chemotherapy[a]	34 (5.9%)	28 (6.5%)	6 (4.1%)	0.295	27 (6.5%)	7 (4.3%)	0.321	24 (6.9%)	10 (4.4%)	0.231
Surgery[a]	25 (4.3%)	20 (4.7%)	5 (3.4%)	0.539	20 (4.8%)	5 (3.1%)	0.362	17 (4.9%)	8 (3.6%)	0.455
Sip feeding[a]	165 (28.7%)	110 (25.6%)	55 (37.9%)	**0.004**	106 (25.6%)	59 (36.6%)	**0.009**	92 (26.3%)	73 (32.4%)	0.111
Tube feeding[a]	28 (4.9%)	13 (3.0%)	15 (10.3%)	**0.000**	13 (3.1%)	15 (9.3%)	**0.002**	11 (3.1%)	17 (7.6%)	**0.016**
Nausea[a]	70 (12.2%)	66 (15.3%)	4 (2.8%)	**0.000**	65 (15.7%)	5 (3.1%)	**0.000**	61 (17.4%)	9 (4.0%)	**0.000**
Diarrhea[a]	43 (7.5%)	35 (8.1%)	8 (5.5%)	0.299	33 (8.0%)	10 (6.2%)	0.471	32 (9.1%)	11 (4.9%)	***0.058***
Swallowing problems[a]	25 (4.3%)	17 (4.0%)	8 (5.5%)	0.425	17 (4.1%)	8 (5.0%)	0.649	17 (4.9%)	8 (3.6%)	0.455

Bold numbers indicate significance.
Bold italic numbers indicate a trend toward significance.
[a] n (%).
[b] Mean ± SD.
[c] Sufficient protein is defined as ≥1.2 g/kg bodyweight (weight adjusted when BMI > 27); sufficient energy intake is defined as ≥100% of the REE according to Harris and Benedict 1984[14] plus an additional factor of 30% to correct for activity and/or disease.[11,15]

Even though screening and treatment of undernutrition have become performance indicators for all Dutch hospitals,[22] 29% of patients were not screened at hospital admission and 26.5% had no data on intake. Therefore, we cannot exclude selection and information bias. Still, as this study represents routine care, it is unique that so much data is available on protein and energy intake.

An important limitation of this study is the retrospective data collection. Even though we performed a structured data extraction, we could have missed data because they were not registered during the patients' hospital stay. This might have influenced the final model, which therefore should be treated with some caution. Moreover, missing data on intake could not be verified due to the retrospective character of the study. Having included those patients with missing data could probably have changed the results, either in a positive or a negative way. If all patients without data on intake had had a sufficient protein and energy intake, the percentage of patients meeting the requirements would be 32%. In contrast, if all missing patients would have had an insufficient intake, the percentage of patients with adequate intake would only be 19%.

Table 2
Determinants for both protein[a] and energy[b] intake.

	OR	95%CI	*p*
Constant	5.666	–	0.043
Nausea	0.177	0.060–0.526	0.002
Cancer	0.566	0.347–0.924	0.023
Acute infection	0.633	0.369–1.085	0.096
BMI	0.844	0.797–0.894	0.000
Age	1.014	0.999–1.030	0.071
Chronic lung disease	3.760	2.331–6.065	0.000
Tube feeding	3.889	1.555–9.727	0.004

[a] Protein intake is defined as ≥1.2 g/kg compared to <1.2 g/kg (weight adjusted when BMI > 27).
[b] Energy intake is defined as ≥100% compared to <100% of calculated requirements.

Hence, this does not change the conclusion that intake remains a major problem in undernourished hospital patients.

Another limitation of the retrospective data collection was that we only had data on characteristics reported in the medical or dietetic records, but not on other factors related to intake, such as missing a meal or in-between meal snacks on the first four days of admission, organizational factors, or how patients evaluate their appetite.

A last point of discussion is the fact that optimal protein intake in undernourished patients is still the subject of much discussion. A recent study of Sauerwein and Serlie (2010) recommends a protein intake of 1.5 g/kg/day as optimal amount for non-critically ill patients.[32] If we had used this criterion in our sample, only 12% would have met their protein requirement.

The ROC curve for our prediction model showed an AUC of 0.791 indicating that achieving the protein and energy requirements can be moderately predicted by this model of patient related factors. Organizational factors may also be of major importance for a patient's intake, and would certainly improve the prediction model. Several studies described organizational factors that could be associated with undernutrition, like lack of nutritional training and sufficient education amongst all staff groups, confusion regarding nutritional responsibility, failure to record weight and height, lack of adequate staff to assist with serving and feeding and no clearly defined responsibilities in planning and managing nutritional care.[33,34] These factors will make it more difficult to achieve optimal protein and energy intake levels, and should be targeted as well. In this study, no organizational factors have been studied, but most of them are suspected to contribute to the poor intakes in this study as well.

5. Conclusions

The present study shows that only one out of four undernourished hospital patients meets the predefined protein and energy requirements on the fourth day of admission. A major finding was the result that protein requirements were less commonly met than energy requirements, emphasizing the importance of focusing on adequate protein intake in the treatment of undernutrition. Although this study has some methodological shortcomings, results suggest that nausea, cancer, acute infections, higher BMI, higher age, chronic lung disease, and tube feeding are all predictors for achieving requirements. Based on these findings, we advise to (1) target patients with cancer and acute infections, (2) create awareness among hospital personnel of the fact that undernutrition can be prevalent in patients with higher BMI or younger age as well, (3) use tube feeding when low intake is expected and (4) treat nausea effectively. Future intervention studies should focus on how treatment can be improved to increase food intake and nutrition therapy in undernourished patients.

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Statement of authorship

Author contributions to the manuscript are as follows: EL and HMK were responsible for the study design. EL was responsible for data collection, data analysis and writing the manuscript. FW participated in most of the data collection and writing the manuscript. AH and JO participated significantly in the data collection. MAEvB, MV, PJMW, AME and HMK participated in writing the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors declare no conflict of interest.

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