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NRS-2002 components, nutritional score and severity of disease score, and their association with hospital length of stay and mortality

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Summary

BACKGROUND: Malnutrition is a substantial issue in hospitals, leading to prolonged length of hospital stay, increased perioperative morbidity and increased mortality. There are several validated screening tools for malnutrition, one of which is the Nutritional Risk Screening 2002 (NRS). It screens patients based on recent weight loss, reduction of recent food intake, body mass index (BMI), severity of disease and age. Higher NRS scores have been shown to be negatively associated with patients' outcomes such as increased morbidity and mortality.

OBJECTIVES: The aim of the study was to evaluate how the two NRS components Nutritional Score (NS) and Severity of Disease Score (SDS) are associated with patients' length of hospital stay and mortality.

METHODS: All patients admitted to the medical department of a large community hospital in Switzerland were screened for malnutrition using the nutrition screening NRS during the years 2014 to 2017. Data on patients' NRS, primary diagnosis, number of secondary diagnoses, mortality, length of stay (LOS), discharge, sex and age were collected. The association between the NRS components and LOS/mortality was estimated using a linear mixed-effects regression model and a logistic regression model, respectively, with adjustment for confounders (age, sex, comorbidity, diagnosis group, mode of discharge and year of hospitalisation).

RESULTS: The evaluation of the outcomes of 21,855 hospitalisations demonstrated that the NS was associated with an increment in the LOS of 5.5–12.3% per score point, depending on the diagnosis group. An increase in the SDS by one point was associated with an increase in the LOS of 2.2–11.3%. The odds for all-cause in-hospital mortality were increased by 44.1% (95% confidence interval [CI] 33.7–55.2%) per point in the NS, and by 73% (95% CI 57.5–90.1%) per point in the SDS.

CONCLUSIONS: Increases in both components of the NRS are associated with longer LOS. The NS has a slightly stronger impact on LOS compared to the SDS and its effect is dependent on the patient's diagnosis group. Increases in the SDS are linked to a higher mortality than increases in the NS.

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Introduction

Background

Malnutrition and patients at risk for malnutrition are a considerable issue in hospitals with a prevalence ranging from 20% to 60% at the time of hospital admission, depending on the investigated population and diagnostic tools used [1–8]. Until 2019 there existed no international consensus on the exact definition and diagnosis of malnutrition. It is now agreed that the diagnosis requires either unintentional weight loss, low body mass index (BMI), or reduced muscle mass by either reduced food intake/assimilation or disease burden [9].

Malnutrition can be categorised into three major groups: disease-related malnutrition with inflammation by acute or chronic disease; disease-related malnutrition without inflammation; and malnutrition without disease, resulting from starvation or psychological factors [10].

Malnutrition negatively affects patients by decreasing quality of life, prolonging length of hospital stay (LOS), causing functional impairment [11] and increasing the incidence of comorbidities such as nosocomial infections [12] and mortality. In addition, malnutrition-related effects are an economic burden in the diagnosis-related group healthcare system [13], if malnutrition is not identified and subsequently treated [14]. This further highlights the need for early and consistent screening, diagnosis and treatment of patients at risk or already manifesting malnutrition, and an understanding of the tools used for identifying malnutrition.

In the hospital setting, one of the validated tools used to screen patients at risk for malnutrition is the Nutritional

Risk Screening 2002 (NRS) [15]. The NRS screens the nutritional status, the severity of disease and the age of the patient. The nutritional status is based on nutrition-related information acquired from patient interviews and/or the patient's weight or body mass index (BMI). The scoring system for severity of disease was created on the basis of how well patients' outcomes with certain diagnoses improved as a response to meeting daily caloric and protein requirements with nutritional support. It has been established that a higher NRS score is strongly associated with longer LOS [16], increased number of complications [6], higher morbidity, increased mortality and increased hospital costs [6, 16–19].

However, as the NRS encompasses a patient's severity of disease, it might be challenging to determine to what degree the disease itself, regardless of the patient's nutritional state, is responsible for the above-mentioned association between NRS scores and LOS. The NRS has been well validated, but only a few studies have analysed its two components, namely the Nutrition Score (NS) and the Severity of Disease Score (SDS), separately in relation to LOS and/or clinical outcome.

Objectives
The aim of this study was to evaluate how the two NRS components, the NS and the SDS, are associated with a patient's LOS across different diagnosis groups. As a secondary endpoint, we assessed how the all-cause in-hospital mortality was associated with the NRS.

Patients and methods

Patients
Patient data were collected from the hospital records and made anonymous by the hospital patient data management. All patients aged ≥18 years admitted to the department of general internal medicine of the Kantonsspital Winterthur in Switzerland during the years 2014–2017 were eligible for inclusion in the study. Kantonsspital Winterthur is a large community hospital covering urban as well as rural regions. Patients who were admitted to day-care units, underwent elective procedures or did not stay in hospital for more than one day were excluded. Patients who were discharged against a doctor's recommendation or transferred to another institution were also excluded.

Study variables
At admission, patients were screened within 48 hours for malnutrition with the NRS per hospital protocol. The screening was conducted by the treating physician. Physicians received reminders for missed screenings via email at 2-week intervals. The NRS screening tool consists of an NS and an SDS; in addition, patients aged ≥70 years get an extra point. The maximum score amounts to 7 points (see table 1).

Patients with an NRS score ≥3 were considered to be at risk for malnutrition and referred to in-hospital dietitians for assessment and therapy, since it has been shown that patients who are at risk for malnutrition benefit from an evaluation and therapy by a dietary expert [20]. After the assessment by the dietitians, the NRS score was subject to change if previously unknown information concerning the patient's nutritional status was acquired. If the NRS was not conducted during the hospitalisation, it was coded as missing data.

Patient characteristics were recorded as follows: length of hospital stay in days, age at hospital admission, sex (male/female), intensive care unit treatment during hospital stay (yes/no), enteral feeding during hospital stay (yes/no), parenteral feeding during hospital stay (yes/no), the primary diagnosis, and the number of secondary diagnoses.

Patients were grouped into their respective diagnosis categories according to the Major Diagnostic Categories, which are based on a patient's main diagnoses being treated at the time of the hospital stay. Diseases and disorders of the digestive system and diseases of the hepatobiliary system and pancreas were merged into one group. Patients with a cancer diagnosis requiring treatment at the time of their hospital stay were in a separate group. Six groups of diagnoses were considered: cardiovascular, respiratory, gastrointestinal/hepatobiliary, neurological and oncological. All other diagnoses were summarised as a diagnosis group "other".

Table 1: Summary of the NRS-2002 Scoring System according to Kondrup et al. (2003) [15]. For the total screening score, add the score of "Nutritional Status" and "Severity of Disease", patients of age ≥70 receive an extra point.

Nutritional Status (NS)	Severity of Disease (SDS)
Score 0: Normal nutritional status	***Score 0:*** Normal nutritional requirements
Score 1: Weight loss >5% in 3 months *or* Food intake 50–75% of normal requirement in preceding week	***Score 1*** *(weakened, but not bedridden):* Chronically ill patients, in particular with acute complications, such as cirrhosis, COPD
Score 2: Weight loss >5% in 2 months *or* BMI 18.5–20.5 kg/m^2 + impaired general condition *or* Food intake 25–50% of normal requirement in preceding week	***Score 2*** *(confined to bed):* Major abdominal surgery, stroke, severe infection
Score 3: Weight loss >5% in 1 month (≈ 15% in 3 months) *or* BMI <18.5 kg/m^2 + impaired general condition *or* Food intake 0–25% of normal requirement in preceding week.	***Score 3*** *(ventilated, inotropic drugs):* Severe head injuries, bone marrow transplantation, intensive care patients with APACHE >10

APACHE = acute physiology and chronic health evaluation; BMI = body mass index; COPD = chronic obstructive pulmonary disease

Ethics

This study was designed and conducted according to the Declaration of Helsinki as well as the rules for Good Clinical Practice. All personal data of patients were made anonymous prior to data analysis. The research project was deemed ethically unproblematic by the ethics committee of the canton of Zurich under the BASEC-Nr. Req-2017-00216.

Statistical methods

The association between the NRS components and the LOS was assessed with a linear mixed-effects regression model [21, 22], since patients had repeated hospital visits over the observation period. LOS as a response variable was log transformed because of the skewness of its distribution. The components of the NRS were used as predictor variables. For adjustment, we included the following patient characteristics and potential confounders: age, biological sex, number of secondary diagnoses, diagnosis group, mode of discharge and year of hospitalisation. To evaluate the association of the NRS components with mortality, we used a generalised linear mixed model.

To analyse potential differences between diagnosis groups, interactions between the NRS components and diagnosis groups were planned for both models. Whether a model profited from an interaction term was assessed with likelihood ratio tests. In the logistic regression model, the interaction was not required and, hence, removed in favour of a more parsimonious model. Goodness-of-fit was visually assessed using Tukey-Anscombe plots, quantile-quantile and scale-location plots of the residuals, and quantile-quantile plots of the random effects. To address potential selection bias, multivariate imputation by chained equations (MICE) was used to complete the missing NRS score values [23]. All available variables able to provide clinical information were used for imputing NRS scores. The statistical analyses were performed with the programming language R (version 3.6.2) [24].

Results

Patient characteristics

The study lasted from 1 January 2014 until 31 December 2017. From 29,298 patients admitted to the department of medicine, 17,328 were included (49.2% women). Overall, 2720 patients (48.1% women) were admitted more than once during the study period. In total, we analysed 21,855 hospitalisation outcomes, 10,585 in women (48.4%) and 11,270 in men. The median age of the patients was 73 years (interquartile range [IQR] 61–82). The median number of secondary diagnoses was 6 (IQR 4–9). For detailed patient characteristics, refer to table 2.

Outcomes

NRS-2002

In 5673 (26%) of the 21,855 observations, the NRS score was ≥3 and the patient was considered to be at risk for malnutrition.

A total 356 (1.6%) patients had an SDS score of 3, whereas 1143 (5.2%) patients had the maximum score of 3 in the NS. In the comparison of diagnosis groups, oncological patients had the highest percentage of patients with a score of 3 in both the NS (448, 13.3%) and SDS (106, 3.2%). For detailed information regarding the distribution of both NRS components as well as the total NRS score for each diagnosis group, refer to the supplementary table S1 in the appendix.

Association between NRS components and LOS

The median LOS was 7 days (IQR 4–11). Table 3 shows the results of the multivariable mixed-effects model. Depicted are the estimated effects (on a multiplicative scale) on LOS for the defined diagnosis groups per unit increase of NS or SDS. All covariates were associated with an increase of LOS. There were varying effects on LOS both in NS and in SDS across diagnosis groups. An increase in NS by one unit was associated with a LOS increase ranging from 5.5% to 12.3% per score point, depending on the

Table 2: Summary of categorical variables.

Variable		n	%
Gender	Female	10,585	48.4
	All	21,855	100.0
Discharge	Normal	20,388	93.3
	Deceased	1467	6.7
	All	21,855	100.0
ICU	Yes	2263	10.3
	All	21,855	100.0
Artificial nutrition	Enteral	573	2.6
	Parenteral	84	0.4
	All	21,855	100.0
Diagnosis group	Cardiovascular	4620	21.1
	GIT/Hepatobiliary	2492	11.4
	Respiratory	2838	13.0
	Neurological	2702	12.4
	Oncological	3365	15.4
	Other	5838	26.7
	All	21,855	100.0

GIT = gastrointestinal tract; ICU = intensive care unit Depicted are the total number of observations (n) and percent (%). ICU indicates whether patients required intensive care at one time during their hospital stay.

diagnosis group. An increase in SDS was associated with a LOS increase from 2.2% to 11.3% per score point, depending on the diagnosis group.

Neurological patients were associated with the highest increase of LOS with 12.3% (95% confidence interval [CI] 7.6–17.2%) per point increase in the NS. Likewise, cardiological patients had the highest increase in LOS with 11.3% (95% CI 7.7–15.0%) per point in the SDS.

Association between NRS components and all-cause in-hospital mortality

Overall, 1467 out of 17,328 (8.4%) patients died. Table 3 shows the odds ratio for death during hospital stay per increase of one point in either the NS or SDS. The results indicate that the odds for all-cause in-hospital mortality are increased by 44.1% (95% CI 33.7–55.2%) per point in the NS and by 73% (95% CI 57.5–90.1%) per point in the SDS.

Discussion

In this single-centre analysis of 21,855 NRS results, we showed that independent increases in both score components of the NRS, namely the NS and the SDS, were associated with a longer LOS and increased odds for all-cause in-hospital mortality. Furthermore, we included interactions between diagnosis groups and the NRS score components to show how different diagnoses have varying associations between the NRS components and the LOS. Common confounders such as patient's demographics (age, sex), clinical characteristics (comorbidity, diagnosis group) and administrative variables, such as mode of discharge and year of hospitalisation, were taken into account. The study population had a malnutrition prevalence similar to other studies [6, 17, 18] using the NRS, which is comparable to the prevalence in hospitals of countries with well-established medical care. Thus, our findings can be generalised for patients hospitalised in medical wards in western countries.

Because of the study's retrospective nature, some information was unavailable. LOS is dependent not only on medical, but also on social and organisational factors. A patient might have a prolonged LOS due to delay in organisation of post-hospital care even though discharge would have been possible from a medical point of view. In a prospective study this could have been addressed by noting the date on which the patient no longer required hospital medical care, in a similar fashion to Johansen et al. (2004) [2].

Despite instructions to physicians, we were confronted with missing NRS scores in this study. These missing screenings could have had many reasons, such as an inability to interview a patient, or the physician forgetting to perform the interview. Missing NRS scores potentially introduce a selection bias towards an unhealthier study population for a variety of reasons. Physicians might be more likely to neglect screening if the patient appears to be well nourished. Furthermore, healthier patients tend to have a shorter length of hospital stay and, thus, make it more likely for a physician to omit screening during the hospitalisation. We were not able to discern what the exact reasons for missing screenings were, but our data support the link between missing screenings and younger patients with a shorter LOS.

The results of our study show that the strength of both associations between LOS and the two NRS components is highly dependent on a patient's diagnosis. The NS has a stronger impact on LOS, but the SDS has a stronger association with higher mortality. These results differ from earlier studies that analysed the relations between the NRS-2002 components and the clinical outcome or LOS [6, 15].

Sorensen et al. (2008) showed significantly stronger associations between the SDS and LOS or complication rate compared with the associations with the NS using a similar model. However, they did not include interactions between the NRS components and a patient's diagnosis. Without the interactions, our approach would have produced similar results, as almost all interactions, particularly those between the diagnosis groups and the SDS, reduced the effect on the LOS.

Kondrup et al. (2003) reviewed a total of 128 studies with various patient groups (medical as well as surgical) and their main study question was whether outcomes were improved by nutritional interventions if patients had a certain NRS score. They used a model with less adjustment for confounders to establish the NRS, but added oral, enteral and parenteral feeding as independent covariates. They found an almost equal association with clinical outcome for both the NS and the SDS, only slightly in favour of the SDS. They also used diagnostic groups, which resulted in no significant changes to the association between the NS

Table 3: Associations between Nutritional Score, Severity of Disease Score, and length of stay, as well as in-hospital mortality.

Diagnosis group	Nutritional Score		Severity of Disease Score	
	LOS increment (factor)	**95% CI**	**LOS increment (factor)**	**95% CI**
Cardiovascular	1.089	1.039–1.141	1.113	1.077–1.150
GIT/Hepatobiliary	1.077	1.042–1.113	1.067	1.024–1.112
Respiratory	1.077	1.040–1.116	1.027	0.989–1.068
Neurological	1.123	1.076–1.172	1.036	0.998–1.075
Oncological	1.076	1.050–1.102	1.050	1.014–1.087
Other	1.055	1.025–1.085	1.022	0.989–1.055
	Mortality (odds ratio)	**95% CI**	**Mortality (odds ratio)**	**95% CI**
All	1.441	1.337–1.552	1.730	1.575–1.901

CI = confidence interval; LOS = Length of hospital stay, in days An increase of either the Nutritional Score or the Severity of Disease Score by one point is associated with the change in LOS, grouped by diagnosis. LOS change values are reported on a multiplicative scale. For a cardiovascular patient, an increase of the Nutritional Score by one point is associated with an increase of 8.9% (95% CI 3.9–14.1%) in LOS. The associations between all-cause mortality during hospital stay and the NRS components are reported as odds ratios and their 95% confidence intervals. An increase of the Nutritional Score by one point is associated with having 1.44 times increased odds for death during hospital stay (95% CI 1.34–1.55). For the statistical methods, the specific models, and adjusting variables please refer to the methods section.

and SDS and clinical outcome, in striking contrast to our results.

Our findings show that it is not only the severity of disease that is responsible for the associations between higher NRS scores and longer LOS, but that the nutritional state of a patient at hospital admission, measured by the NS, has prognostic value concerning a patient's LOS and mortality. The association between the NS and LOS/mortality might be more sensitive to treatment by nutritional support than the association between the SDS and LOS/mortality. The EFFORT trial [20] has shown that individualised nutritional support reduces mortality and adverse clinical outcomes in medical inpatients within 30 days who are, according to the NRS, at risk for malnutrition. It further established evidence that systematically screening medical inpatients on admission to hospital by NRS and subsequent nutritional support is relevant for improving a patient's outcome in a hospital setting. However, they did not find a difference in LOS between patients who did or did not receive individualised nutritional care and they did not distinguish between the NS and the SDS. To answer the question on whether one of the NRS components is associated with a better response to individualised nutritional support, a prospective, controlled study similar to the EFFORT trial is needed, as our study with its retrospective design was unable to answer this question.

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Appendix

Supplementary table

Table S1: Distribution of NRS-2002 scores and their components by diagnosis group.

Variable		Cardiovascular		GIT/heptological		Respiratory		Neurological		Oncological		Other		All	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%
Nutritional Score	0	3102	67.1	1091	43.8	1447	51.0	1773	65.6	1178	35.0	3289	56.3	11880	54.4
	1	501	10.8	558	22.4	580	20.4	367	13.6	677	20.1	1002	17.2	3685	16.9
	2	157	3.4	320	12.8	257	9.1	128	4.7	654	19.4	440	7.5	1956	8.9
	3	54	1.2	169	6.8	134	4.7	69	2.5	448	13.3	269	4.6	1143	5.2
	Missing	806	17.4	354	14.2	420	14.8	365	13.5	408	12.1	838	14.3	3191	14.6
	All	4620	100.0	2492	100.0	2838	100.0	2702	100.0	3365	100.0	5838	100.0	21,855	100.0
Severity of Disease Score	0	2162	46.8	906	36.4	859	30.3	1178	43.6	636	18.9	2560	43.9	8301	38.0
	1	1280	27.7	929	37.3	1093	38.5	842	31.2	1497	44.5	1922	32.9	7563	34.6
	2	313	6.8	273	11.0	412	14.5	268	9.9	718	21.3	460	7.9	2444	11.2
	3	59	1.3	30	1.2	54	1.9	49	1.8	106	3.1	58	1.0	356	1.6
	Missing	806	17.4	354	14.2	420	14.8	365	13.5	408	12.1	838	14.3	3191	14.6
	All	4620	100.0	2492	100.0	2838	100.0	2702	100.0	3365	100.0	5838	100.0	21,855	100.0
Age Score	0	1624	35.1	1035	41.5	1195	42.1	892	33.0	1520	45.2	2470	42.3	8736	40.0
	1	2996	64.8	1457	58.5	1643	57.9	1810	67.0	1845	54.8	3368	57.7	13,119	60.0
	All	4620	100.0	2492	100.0	2838	100.0	2702	100.0	3365	100.0	5838	100.0	21,855	100.0
Total NRS	0	801	17.3	279	11.2	340	12.0	402	14.9	227	6.8	1063	18.2	3112	14.2
	1	1545	33.4	616	24.7	627	22.1	862	31.9	571	17.0	1566	26.8	5787	26.5
	2	810	17.5	463	18.6	627	22.1	526	19.5	588	17.5	1078	18.5	4092	18.7
	3	396	8.6	378	15.2	440	15.5	319	11.8	552	16.4	687	11.8	2772	12.7
	4	174	3.8	239	9.6	222	7.8	143	5.3	498	14.8	347	5.9	1623	7.4
	5	67	1.4	119	4.8	108	3.8	62	2.3	368	10.9	196	3.4	920	4.2
	6	18	0.4	41	1.6	43	1.5	18	0.7	133	4.0	56	1.0	309	1.4
	7	3	0.1	3	0.1	11	0.4	5	0.2	20	0.6	7	0.1	49	0.2
	Missing	806	17.4	354	14.2	420	14.8	365	13.5	408	12.1	838	14.3	3191	14.6
	All	4620	100.0	2492	100.0	2838	100.0	2702	100.0	3365	100.0	5838	100.0	21,855	100.0

GIT = gastrointestinal tract; LOS = length of hospital stay, in days Depicted is the total number of observations (n), percent (%). Age in years,