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Original article

Decline in nutritional status is associated with prolonged length of stay in hospitalized patients admitted for 7 days or more: A prospective cohort study

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SUMMARY

Background & aims: Reducing length of stay (LOS) is a priority for hospitals but patients' decline in nutritional status may have a negative impact. The aims of the study were to assess the change in nutritional status during hospitalization and determine if its decline is associated with prolonged LOS.
Methods: This is a prospective cohort study conducted in 18 Canadian hospitals. Subjective global assessment (SGA) and weight measurements were performed at admission and discharge. Patient information was collected at admission and extracted from the chart during hospitalization. Association between LOS and changes in SGA or weight loss ≥5% was tested using multivariate Cox PH approach. Results are expressed as hazard ratios (HR) and their 95% CI.
Results: 409 patients (53% male) with a LOS >7 days were analyzed. Patients' median (q1,q3) age was 68 years (58,79) and LOS was 11 days (8,17). At admission, 49% of patients were well nourished (SGA A), 37% were moderately malnourished (SGA B) and 14% were severely malnourished (SGA C). From admission to discharge, 34% remained well-nourished, 29% remained malnourished (SGA B or C), 20% deteriorated and 17% improved. Of the 409 patients, 373 had weight measurements at admission and discharge: 92 (25%) had ≥5% weight loss. Multivariate models showed that after adjusting for covariates, decline in nutritional status from SGA A to B/C or SGA B to C (HR: 0.62, CI: (0.44, 0.87); HR: 0.35, CI: (0.20, 0.62) respectively) and weight loss ≥5% (HR: 0.52; CI: 0.40, 0.69) were significantly associated with longer LOS.
Conclusion: In-hospital decline in nutritional status as assessed by SGA or weight loss ≥5% is associated with prolonged LOS independently of factors reflecting demographics, living accommodations and disease severity. This suggests a role for nutrition care in reducing LOS.

1. Introduction

Reducing length of stay (LOS) is a priority for hospitals and health care systems, due to significant increases in costs. However,

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this marker of efficiency may be detrimentally affected by poor nutritional status or a decline in nutritional status during hospitalization.

Malnutrition is prevalent in hospitals, between 15% and 70% [1–8] depending on populations, types of institutions and methods of assessment. Several factors may contribute to malnutrition such as underlying illnesses, aging, socioeconomic situations as well as in-hospital medical procedures that impact food intake, lack of monitoring of the nutritional status and lack of standardized nutrition care protocols [8–11]. The presence of malnutrition has been shown to negatively impact outcomes such as LOS and increased health care costs [12–22], independently from other factors. However, there is very little literature on how decline in nutritional status during hospitalization can affect outcomes [14,23].

In the US, Braunschweig et al. [23] conducted a prospective observational single center study with a retrospective component, which assessed changes in nutritional status in 404 patients using subjective global assessment (SGA) at admission and discharge. Results showed that a decline in patients' nutritional status during hospitalization, regardless of their nutritional status at admission, was associated with significantly higher hospital charges and higher likelihood of complications and LOS in patients staying longer than 7 days. However, no covariate adjustment for demographics and comorbidities was done when testing the associations between nutritional status and LOS. In Italy, Caccialanza et al. [14] evaluated 1274 hospitalized patients in one hospital and evaluated the associations between malnutrition and prolonged LOS (>17 days) adjusting for several potential nutritional and clinical confounders recorded at admission and collected during and at the end of the hospital stay. They found that a nutritional risk index less than 97.5 at admission and an in-hospital weight loss of ≥5% were associated with prolonged LOS. In that study, one of the confounders, the physician-assessed severity score was performed only within 36 h of admission but was not repeated at discharge. Also, as the nutritional risk index is a weight-based measure, they excluded patients with edema from the study sample. To our knowledge, there are no other studies assessing the impact of a decline in nutritional status on LOS in general patient populations admitted to acute care hospitals and no multi-center studies. Furthermore, no studies have controlled for in-hospital changes in medical condition.

To assess nutritional status, SGA [24] is a well validated tool [2,5,21,25–29] associated with clinical outcomes [15,21,23,25,30–34]. Except for Braunschweig's study [23], there is no report on its use to assess nutritional decline in hospitalized patients and SGA is not regularly used by health care professionals. Body weight is more routinely measured on the wards but has limitations due to fluctuations in fluid status. Excluding patients with fluid issues, a weight loss ≥5% has been associated with extended LOS [14]. It would be of interest to determine if weight loss ≥5% in the "real world" of clinical practice, i.e. not specifically excluding patients with fluid retention, has the same impact.

The first aim of this study was to measure the nutritional status of patients at hospital admission and at discharge, using SGA as the primary measure, and body weight as a secondary measure, and to assess the changes during hospitalization. The second aim was to determine if decline in nutritional status, as assessed by these 2 measures, is associated with prolonged LOS.

2. Materials and methods

Patients with a hospital stay of at least 7 days, discharged alive, and with nutritional assessment performed at admission and discharge were selected from a larger prospective multicenter cohort study involving 1022 patients. A 7-day threshold was chosen to select the study subgroup to better detect any potential changes in nutritional status based on clinical experience and literature [23]. This large cohort study was conducted from July 2010 to February 2013 (Fig. 1) and included adult patients (≥18 y) admitted for ≥2 days directly to the surgical and medical wards of 18 participating acute care hospitals (11 academic, 7 community) from 8 provinces across Canada with the main goal of determining contributors to malnutrition at hospital admission and its impact on LOS [35]. Hospitals were made aware of the study by various modes of communication (national conferences, direct contact with hospital dietitians and administrators, through website visit at www.nutritioncareincanada.ca). Patients were excluded if admitted directly to intensive care unit (ICU), obstetric, psychiatry, palliative wards or admitted to a medical day unit. Patients were enrolled according to a strict protocol to avoid selection bias. Days of enrollment rotated from Monday to Friday, with Monday capturing the week-end admissions from Friday 5pm to Monday 5pm. Consecutive admissions were approached for consent and a maximum of 7 patients were followed at the same time. The study was approved by all institutions' administration and REBs and all participants or their alternative decision maker signed a consent form.

2.1. Data collection

The nutritional status of the patients was assessed at admission and at discharge using two different measures. SGA [24] was performed by 18 trained coordinators (one in each hospital) to avoid inter-rater variability (SGA A = well-nourished; SGA B = moderately malnourished; SGA C = severely malnourished). Body weight was measured in light clothes with shoes off using a chair scale (Seca 952 Chair Scale. Weigh and Measure, LLC). Both parameters were measured within 48 h from admission to the hospital ward and prior to discharge.

Data regarding demography, contact information, living arrangements, primary admission diagnosis, presence/absence of cancer, Charlson Comorbidity Index (CCI) [36] and number of medications were collected at admission. Due to the variety of diagnoses, these were classified under 11 broad standard categories (Table 1). If there was more than one category for the same patient, a 2nd and 3rd diagnostic category was coded. During hospitalization patient charts were reviewed approximately every two days: new diagnostic categories, new diagnosis of cancer, numbers of daily medications for the first 10 days of admission and surgical interventions were recorded. At discharge, CCI was again evaluated to assess potential changes in medical condition during hospitalization.

2.2. Measures of nutritional status, main outcomes and covariates

Change in nutritional status was assessed as a difference between nutritional parameters at admission and at discharge. For SGA, we considered that patients with SGA A at admission and SGA B or C at discharge, or SGA B on admission and SGA C at discharge had a decline in nutritional status during hospitalization. For SGA C further deterioration in nutritional status was defined as having ≥5% decrease in weight from admission to discharge: as there was only 1 such patient in our data set, the observation was included into "SGA C stable" group for the analysis. Seven patients with admission SGA C had a weight measurement missing; as the main outcome (LOS) was not statistically significant different for these as compared to other patients with SGA C (data not given), they were grouped with the "SGA C stable" group. Patients who had SGA B at admission and SGA A at discharge or SGA C at admission and

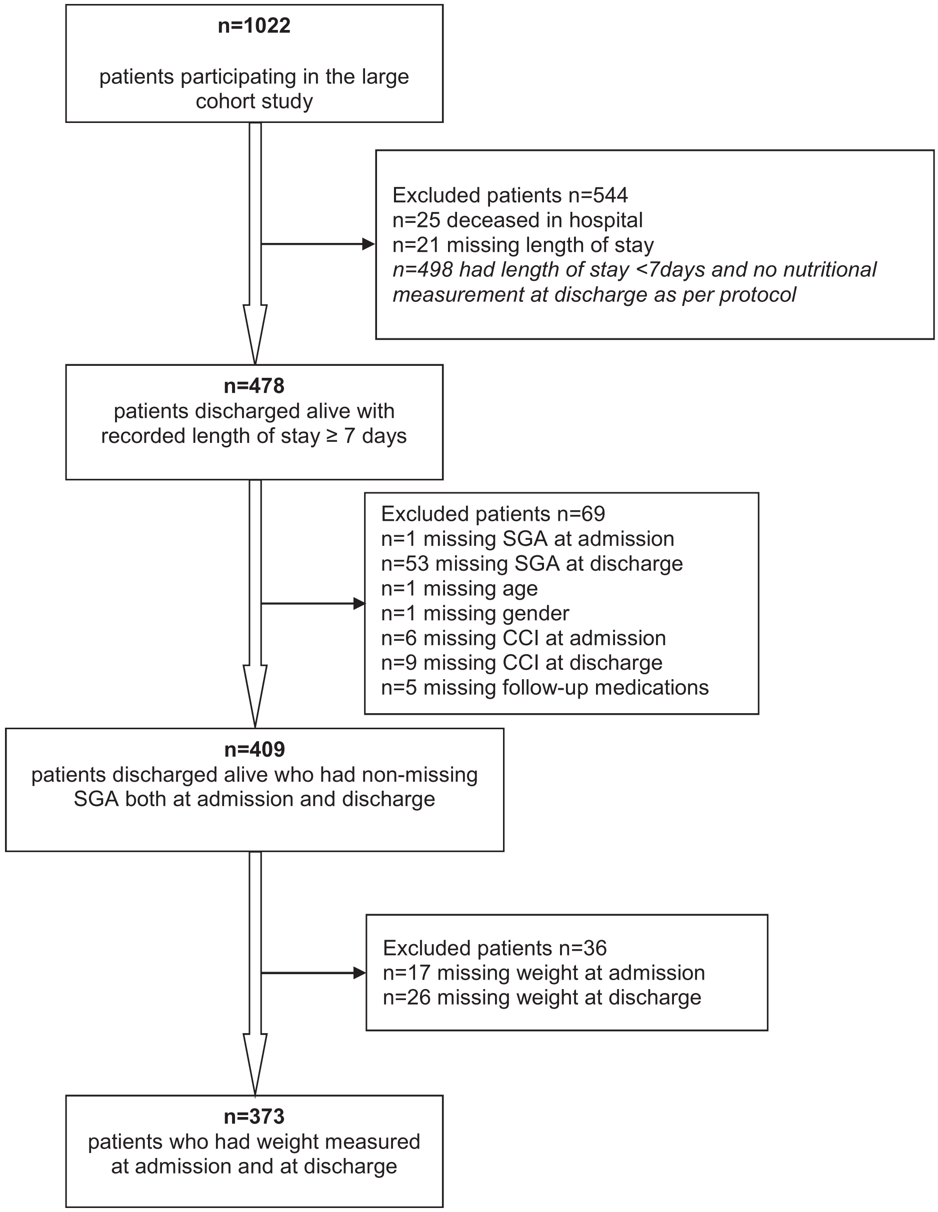

Fig. 1. Data used in the analysis. [a]Some patients had more than one reason for exclusion. [b]Some patients had weight measurement missing both at admission and at discharge.

SGA B or A at discharge were considered as having improvement in nutritional status. Thus, all patients were grouped into the "deteriorated", "stable" or "improved" groups and those were included into the analysis nested within admission SGA categories.

Change in weight was calculated as a percentage based on the difference in weight between discharge and admission (negative values indicate weight loss) divided by admission weight; patients who lost ≥5% weight were considered as having nutritional deterioration. Admission weight was used as a covariate in the multivariate analysis to control for initial nutritional status.

The main outcome, LOS, was defined as the difference (days) between the date of discharge or transfer to another hospital and the date of admission to the hospital.

The potential covariates for analysis of association between LOS and nutritional changes (SGA in model 1, weight in model 2) were identified based on literature, clinical experience and previous analysis for the larger cohort [35]. These included demographics (age, gender, living independently, either alone or with others, or in care facilities), medical condition-related parameters and covariates indicating initial nutritional status at admission. For medical condition, due to the high number of different diagnostic categories, the overall number of those (1, 2 or 3) was used as candidate predictor, in addition to the presence/absence of cancer, CCI (dichotomized at 2), having surgery during hospitalization, and number of medications to account for type and severity of illnesses. Change in CCI from admission to discharge was also used as a measure of change in severity of medical condition and comorbidities.

2.3. Statistical analysis

Categorical variables were characterized by frequency tables, continuous and count variables by median and 1st and 3rd quartiles (q1, q3); distribution of the latter was assessed using graphical methods and Kolmogorov–Smirnov normality test. Differences between groups defined according to SGA or weight changes during hospitalization were tested by Chi-square and Fisher exact tests for categorical variables and by Kruskal–Wallis tests for continuous and countable predictors; as those were mainly for descriptive purposes, pairwise post hoc comparisons were not done.

Exploratory analysis on LOS was done using Kaplan–Meier plots and log-rank tests. Modeling was done by the frailty Cox PH method that accounts for correlations of observations within hospitals. If a patient was transferred to another hospital, the observation was considered censored (n = 29). The LOS distribution was truncated at the 98th percentile of distribution (60 days) to prevent the most extreme observations from influencing parameter estimates. Associations between potential predictors were explored to assess multicollinearity. As weight change and change in SGA are highly associated variables they were not included into the same model, but added into 2 separate multivariate models as indicators of nutritional status change. The final model was built in a two-step process. First, a multivariate model for LOS was built which included only the variables chosen from a list of candidate confounders based on clinical experience, literature, and results of exploratory analyses. The model included age, gender, living arrangements, number of diagnostic categories, CCI at admission and change in CCI. After that, nutrition-related measures were added: SGA at admission and change in SGA (model 1) and weight at admission and % weight loss dichotomized at ≥5% (model 2). Proportionality assumption was assessed using Kaplan–Meier plots and weighted Schoenfeld residual plots, the functional form of continuous predictors was assessed using the simulated score process plots, and overall model fit using Cox-Snell residuals plots. The model was examined for the presence of influential observations and outliers using dfbetas and deviance residuals.

Due to the presence of missing data on weight, the sample used for model 2 (n = 373) was smaller than for model 1 (n = 409). Therefore, a sensitivity analysis for Model 1 with SGA as the predictor was done using the same sample as in the weight loss model (n = 373). Sensitivity analyses excluding ICU patients from the sample were performed for both multivariate models. All analyses were performed using SAS 9.4 software, p-value <0.05 was considered as significant.

3. Results

3.1. Study sample and patient characteristics

From the initial cohort study of 1022 patients, 478 patients had a LOS ≥7days and were discharged alive. Of those, 409 had SGA measured at admission and at discharge and non-missing candidate confounder variables, and in this group, 373 patients also had weights measured at admission and at discharge (Fig. 1). Compared to the included patients, those with missing values had lower LOS (median 9 days compared to 11 days for those included in this analysis, Wilcoxon test p-value 0.036), but did not differ in terms of age, weight, number of diagnoses, and frequency of cancer.

For the 409 patients, SGA at admission was A for n = 200 (48.9%), B for n = 153 (37.4%) and C for n = 56 (13.7%). For the 373 patients, the median (q1, q3) admission weight was 73.3 (61.7, 73.3) kg.

Details regarding LOS, demographic, disease-related and nutritional characteristics for patients overall and then classified according to nutritional categories (stable well-nourished or malnourished, deteriorated or improved, weight loss ≥5% and <5%) are presented in Table 2. For all patients, the median age was 68 y, 53% were male and 57%, 29% and 14% had 1, 2 or 3 diagnostic categories respectively; 22% of patients had cancer and 39% had surgery during their hospitalization. The group that showed deterioration as defined by SGA had the highest percentage of males and proportions of patients with surgical procedures and cancer among all groups. The improved group had the lowest proportion of patients undergoing surgical procedures among all groups and the 2nd highest proportion of cancer patients among the groups (after those who deteriorated). When defining deterioration according to weight, patients with weight loss ≥5% compared to patients with <5% had higher proportions of surgical patients and patients with 3 diagnostic categories but there were no differences in proportions of males and cancer patients. The distribution of diagnostic categories of the study sample is presented in Table 1. The most frequent category was gastrointestinal, closely followed by respiratory and infection.

Table 1
Frequencies of diagnostic categories and cancer in the study sample.

Diagnostic category	n (%)[a] n = 409	Proportion of patients with cancer within the diagnostic category[b] n (%)
GI	107 (26.2)	27 (25)
Infection	95 (23.2)	19 (20)
Respiratory	90 (22)	25 (28)
Other	70 (17.1)	23 (33)
CVD	66 (16.1)	5 (8)
Genitourinary	49 (12.0)	10 (20)
Musculoskeletal	43 (10.5)	8 (19)
Metabolic	43 (10.5)	9 (21)
Hematopoietic disorder	42 (10.3)	21 (50)
Neurologic	26 (6.4)	3 (12)
Trauma	8 (2.0)	0
Sensory organ impairment	5 (1.2)	1 (20)
Autoimmune	2 (0.5)	1 (50)

CVD – cardiovascular disease, GI – gastrointestinal.
[a] % of those having this diagnostic category out of total number of patients in the cohort; some patients may have more than 1 diagnostic category.
[b] Some patients with cancer may have more than 1 diagnosis category.

3.2. Changes in nutritional parameters from admission to discharge

Descriptive statistics on changes in SGA status of hospitalized patients from admission to discharge are presented in Table 3. Overall, 81 (19.8%) patients had a decline in nutritional status: 20 (25%) of them were malnourished (SGA B) at admission and 61 (75%) were well nourished (SGA A). In addition, one patient with SGA C at admission and at discharge showed further deterioration with a weight loss ≥5%. Another 71 patients (17.3%) showed an improvement in nutritional status but 18 (25%) of those still remained malnourished (SGA B) at discharge. Of the 217 (53.1%) patients discharged with malnutrition, 118 (54.3%) were admitted with malnutrition and their nutritional status did not change during hospitalization.

Median (q1, q3) of absolute weight loss were −1.1 (−3.8, 0.4) kg and median (q1, q3) of percentage weight loss were −1.5% (−4.8, 0.5) (n = 373). For both indicators, the median was statistically significantly lower than 0 (sign tests p-values <0.001) showing that the majority of patients lost weight during hospitalization.

The relationship between SGA changes and percentage weight change were assessed for 373 patients who had both measurements performed and are presented in Fig. 2 and Table 4. The two measures are closely related, as SGA assessment includes percent weight loss as an indicator: 51% (n = 47) of patients with weight loss ≥5% belonged to groups with SGA deterioration; 43% (n = 39) belonged to groups with stable SGA (among those the highest proportion (32%) of patients with weight loss ≥5% was in SGA B group) and; 6% (n = 6) belonged to groups where SGA improved.

Table 2
Characteristics of patients according to change in nutritional status, median (q1, q3) or n (%).

Characteristic	All patients n = 409	Malnourished stable n = 118 (28.9%)	Well nourished stable n = 139 (34.0%)	Deteriorated n = 81 (19.8%)	Improved n = 71 (17.3%)	p-value[a]	No wt loss or wt loss <5% n = 281 (75.3%)	Wt loss≥5% n = 92 (24.7%)	p-value[a]
Length of stay, days	11 (8, 17)	12 (9, 16)	9 (8, 13)	15 (9, 24)	11 (8, 18)	<0.001	10 (8, 15)	15 (11, 24.5)	<.001
Age, yrs	68 (58, 79)	71 (58, 80)	68 (58, 78)	66 (57, 78)	66 (58, 79)	0.37	68 (58, 79)	68 (59, 79)	0.81
Gender						0.015			0.41
Female	194 (47.4)	68 (57.6)	66 (47.5)	28 (34.6)	32 (45.1)		136 (48.4)	40 (43.5)	
Male	215 (52.6)	50 (42.4)	73 (52.5)	53 (65.4)	39 (54.9)		145 (51.6)	52 (56.5)	
Living arrangements						0.56[b]			0.35[b]
Lives alone	109 (26.7)	35 (29.7)	37 (26.6)	19 (23.5)	18 (25.3)		74 (26.3)	28 (30.4)	
Lives with others	250 (61.1)	65 (55.1)	86 (61.9)	56 (69.1)	43 (60.6)		178 (63.4)	50 (54.4)	
Lives in care facilities	45 (11.0)	16 (13.6)	13 (9.4)	6 (7.4)	10 (14.1)		27 (9.6)	12 (13.0)	
Other[c]	5 (1.2)	2 (1.7)	3 (2.2)	0	0		2 (0.7)	2 (2.2)	
Had surgical procedure during hospitalization						0.012			0.012
No	249 (60.9)	68 (57.6)	86 (61.9)	41 (50.6)	54 (76.1)		182 (64.8)	46 (50.0)	
Yes	160 (39.1)	50 (42.4)	53 (38.1)	40 (49.4)	17 (23.9)		99 (35.2)	46 (50.0)	
Number of diagnostic categories						0.079			0.009
1 category	231 (56.5)	66 (55.9)	90 (64.7)	36 (44.4)	39 (54.9)		160 (56.9)	44 (47.8)	
2 categories	119 (29.1)	32 (27.1)	35 (25.2)	28 (34.6)	24 (33.8)		90 (32.0)	26 (28.3)	
3 categories	59 (14.4)	20 (17.0)	14 (10.1)	17 (21.0)	8 (11.3)		31 (11.0)	22 (23.9)	
Cancer present						0.003			0.25
No	318 (77.8)	97 (82.2)	116 (83.4)	51 (63.0)	54 (76.1)		221 (78.7)	67 (72.8)	
Yes	91 (22.3)	21 (17.8)	23 (16.6)	30 (37.0)	17 (23.9)		60 (21.3)	25 (27.2)	
CCI at admission						0.25			0.42
CCI ≤ 2	219 (53.6)	63 (53.4)	83 (59.7)	40 (49.4)	33 (46.5)		151 (53.7)	45 (48.9)	
CCI > 2	190 (46.4)	55 (46.6)	56 (40.3)	41 (50.6)	38 (53.5)		130 (46.3)	47 (51.1)	
Change in CCI						0.13			0.53
Increased	47 (11.5)	13 (11.0)	8 (5.8)	13 (16.0)	13 (18.3)		28 (10.0)	13 (14.1)	
No change	311 (76.0)	90 (76.3)	112 (80.5)	60 (74.1)	49 (69.0)		217 (77.2)	67 (72.8)	
Decreased	51 (12.5)	15 (12.7)	19 (13.7)	8 (9.9)	9 (12.7)		36 (12.8)	12 (13.0)	
Median number of medications (first 10 days)	13 (10, 17)	14 (10, 17)	13 (9, 17)	14 (10, 18)	12 (8, 15)	0.065	13 (10, 17)	14 (9, 17)	0.72

Groups based on SGA: n = 409; Groups definitions: malnourished stable: SGA B to B and C to C; well-nourished stable: SGA A to A; deteriorated SGA A to B/C or SGA B to C; improved SGA C to B/A and SGA B to A.
Weight loss >5%/no substantial weight loss groups: n = 373.
CCI – Charlson Comorbidity Index; SGA – Subjective Global Assessment.
[a] Chi-square or Fisher exact test for categorical variables, Kruskal–Wallis test for continuous variables.
[b] Chi-square test done with "Other" group excluded.
[c] The group includes patients with no permanent home.

3.3. *Associations between changes in nutritional status and LOS*

The overall median (q1, q3) for LOS was 11 (8,17) days (Table 2). It was 11 (8,18) days for patients with improved nutritional status; 9 (8,13) days for well-nourished stable, 12 (9,16) days for malnourished stable patients; and; 15 (9,24) days for those with nutritional decline ($p < 0.001$). The median LOS was statistically significantly lower for patients with <5% weight loss compared to those with weight loss ≥5%: 10 (8,15) vs 15 (11,25) days, respectively. In all the SGA sub-groups defined in Table 4, with either declined, improved or stable nutritional status, patients with weight loss ≥5% had higher median LOS compared to patients with <5% weight loss, but statistical hypotheses were not tested due to the low number of patients in some sub-groups.

The LOS was modeled using Cox PH approach (Table 5); HR less than 1 indicates reduced chances for discharge at any particular day, and, consequently, association with prolonged LOS. After controlling for nutritional status at admission, deterioration of nutritional status in both model 1 (where SGA was used as predictor) and model 2 (weight change as predictor) was statistically significantly associated with prolonged LOS. In model 1, patients whose nutritional status deteriorated stayed in hospital longer as compared to those who had the same initial SGA, but were stable or improved; HR and 95% CI for deteriorated compared to stable was 0.62 (0.44, 0.87) for patients with SGA A at admission and 0.35 (0.20, 0.62) for patients with SGA B at admission; deteriorated compared to improved was 0.36 (0.19, 0.66) for patients with SGA B at admission. Patients who deteriorated from SGA B stayed in hospital longer than patients who deteriorated from SGA A: HR and 95% CI were 0.50 (0.28, 0.90). There were no statistically significant differences in LOS between patients with different SGA (A, B or C) at admission but stable nutritional status from admission to discharge (estimated HR and 95% CIs were 0.89 (0.65, 1.20) for SGA B compared to SGA A; 0.71 (0.45, 1.13) for SGA C compared to A, and 1.17 (0.74, 1.83) for SGA B compared to C). Additionally, there were no statistically significant differences in LOS between patients who improved or were stable within the same SGA admission group (Table 4). In model 2, HR and 95% CI for patients with weight loss ≥5% compared to those who experienced <5% weight loss was 0.52 (0.40, 0.69) after controlling for admission weight.

Two sensitivity analyses were done. In the first one we applied model 1 to the subset of patients who had weight measurements (n = 373) to check the stability of the model (Supplementary Table 1). In the second one we excluded the group of patients who were transferred into the ICU (n = 26, 6.4% of 409) from model 1 and model 2, as these patients can be more severely ill, and consequently have more prolonged LOS compared to the rest of the sample (Supplementary Table 2). For all sensitivity analyses, the hazard ratios for the groups who showed nutritional changes were similar to those in the original models.

4. Discussion

This study shows that in patients hospitalized for ≥7 days in acute care centers, about half (51.4%) stayed either well-nourished (34.0%) or had an improvement in nutritional status (17.4%) while

Table 3
Change in SGA from admission to discharge n (%) of 409.

Admission	Discharge			Admission n (%)
	SGA A	SGA B	SGA C	
SGA A	139 (34.0)	57 (13.9)	4 (1.0)	200 (48.9)
SGA B	45 (11.0)	88 (21.5)	20 (4.9)	153 (37.4)
SGA C	8 (2.0)	18 (4.4)	30 (7.3)	56 (13.7)
Discharge n (%)	192 (46.9)	163 (39.9)	54 (13.2)	409

SGA – Subjective Global Assessment.

Table 4
Relationship between length of hospital stay, change in SGA and weight loss (n = 373).

SGA at admission	Change in SGA	Weight loss >=5%	n (%) within SGA subgroup	Length of stay, days Median (q1, q3)
SGA A	Deteriorated	No	25 (44)	10 (8, 17)
		Yes	32 (56)	16.0 (12, 28)
	No change	No	115 (91)	9.0 (8, 12)
		Yes	12 (9)	10.5 (9, 15)
SGA B	Deteriorated	No	3 (17)	21.0 (8, 30)
		Yes	15 (83)	23.0 (12, 64)
	No change	No	56 (68)	9.5 (8, 15)
		Yes	26 (32)	13.5 (10, 21)
	Improved	No	38 (90)	10.5 (8, 14)
		Yes	4 (10)	27.5 (11, 49)
SGA C	No change	No	22 (96)	12.5 (9, 20)
		Yes	1 (4)	16
	Improved	No	22 (92)	12.0 (8, 18)
		Yes	2 (8)	28, 29

SGA – Subjective Global Assessment.

the others (48.6%) remained either malnourished (28.8%) or deteriorated (19.8%). Overall, at discharge, 53.1% of patients were malnourished by SGA and about a quarter of patients (24.7%) experienced ≥5% weight loss during hospitalization. Furthermore, after controlling for covariates, nutritional decline based on SGA or weight loss ≥5% was significantly associated with longer LOS in adjusted models.

Our results are along the same line as the two previous single-center studies we found, assessing similar parameters in comparable patient populations [15,23]. Our study had additional strengths: it was a fully prospective multicenter cohort study (18 centers) involving different types of facilities (11 academic, 7 community) from across a country (8 provinces) where each province has its own health care policies, making the results more generalizable. Considering the potential heterogeneity among these different hospitals, we also used a different statistical approach (frailty Cox PH modeling) and addressed the question of association between decline and LOS as our primary outcome, controlling for disease-related and socio-demographic factors as well as changes in medical condition (CCI). Brauncshweig et al. primarily looked at hospital charges and, as secondary measures, complications, infections and LOS whereas Caccialanza et al. [14] assessed principally the association between nutrition risk index at admission and LOS, and, in secondary analysis, ≥5% weight loss during hospitalization. Change in medical condition was not accounted for in both studies and patients with fluid retention were excluded in Caccialanza study [14]. In our study, we elected to assess weight changes in the "real-world" and did not exclude or attempt to account for the presence of edema or urine in the bladder. It is possible that in a proportion of patients, the weight loss ≥5% reflected fluid loss. This could explain the small proportion of patients with weight loss ≥5% found in the SGA sub-groups that were unchanged or improved, as in SGA, other factors than weight loss are assessed before determining the SGA level. Similarly to Braunschweig et al. [23], we used SGA and selected patients with longer LOS to better detect changes in nutritional status. In their study, Braunschweig et al. did not find statistical differences in a decline in nutritional status associated with age, gender, race, admission department, history of surgery or other co-morbidities except for the presence of cancer (palliative patients were included). For our study, where palliative patients were excluded,

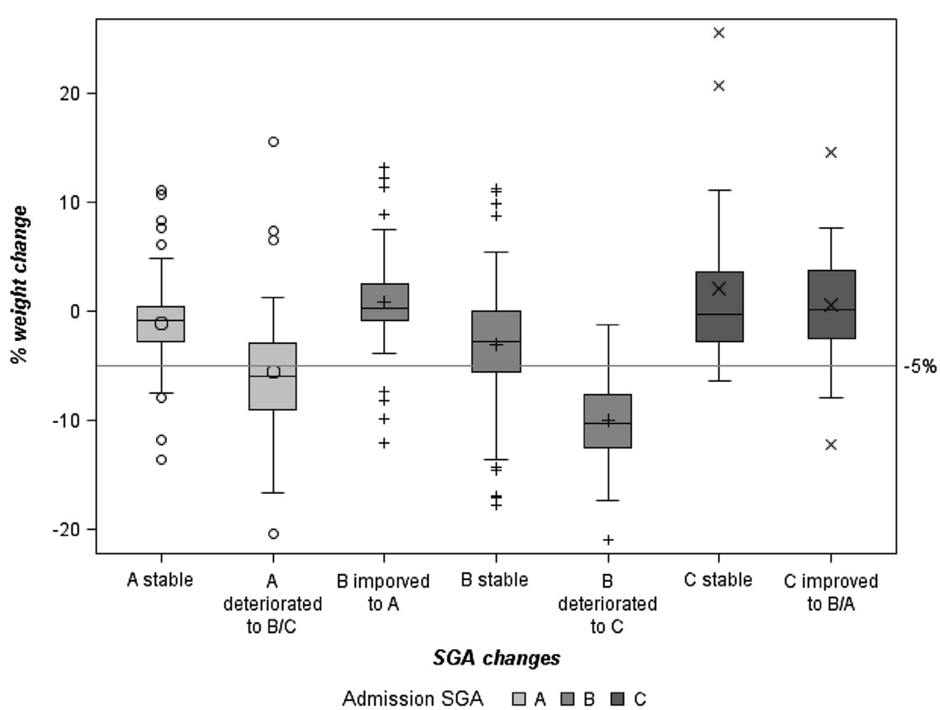

Fig. 2. Relationship between % weight change and SGA change groups (n = 373).

Table 5
Cox proportional hazard models for chances of earlier discharge. HR < 1 denotes lower chances for discharge, and, consequently, association with longer LOS; 95% CI that bound 1.0 are not significant. Descriptive statistics, univariate models and multivariate model 1 (includes change in SGA): n = 409, Multivariate model 2 (includes change in weight): n = 373.

Predictor	Length of stay, days Median (q1, q3)	Univariate models		Model 1[a]		Model 2[a]	
		HR (95% CI)	p-value[b]	HR (95% CI)	p-value[b]	HR (95% CI)	p-value[b]
Age (per 10 y difference)		0.90 (0.84, 0.96)	0.002	0.94 (0.88, 1.02)	0.11	0.95 (0.88, 1.03)	0.20
Gender			0.79		0.92		0.73
Female	11.0 (8, 17)	Ref		Ref		Ref	
Male	11.0 (8, 17)	0.97 (0.79, 1.20)	0.80	0.99 (0.80, 1.23)	0.92	1.04 (0.83, 1.30)	0.73
Living arrangements			<0.001		0.001		0.013
Lives independently	10.0 (8, 16)	Ref		Ref		Ref	
Lives in care facilities	14.0 (11, 36)	0.52 (0.37, 0.74)	<0.001	0.54 (0.37, 0.78)	0.001	0.62 (0.43, 0.91)	0.013
Number of diagnostic categories			0.008		0.088		0.004
1 diagnosis	10.0 (8, 15)	Ref		Ref		Ref	
2 diagnoses	11.0 (9, 18)	0.78 (0.61, 1.00)	0.047	0.80 (0.63, 1.02)	0.073	0.71 (0.56, 0.90)	0.005
3 diagnoses	13.0 (9, 25)	0.63 (0.46, 0.86)	0.004	0.75 (0.54, 1.04)	0.080	0.65 (0.47, 0.91)	0.012
CCI at admission			0.013		0.47		0.117
CCI ≤ 2	10.0 (8, 16)	Ref		Ref		Ref	
CCI > 2	12.0 (9, 19)	0.77 (0.62, 0.95)	0.014	0.92 (0.74, 1.16)	0.49	0.84 (0.67, 1.05)	0.118
Change in CCI			0.015		0.131		0.137
Increased comorbidities	14.0 (8, 27)	0.63 (0.45, 0.89)	0.009	0.81 (0.57, 1.16)	0.25	0.72 (0.50, 1.03)	0.069
No change	10.0 (8, 16)	Ref		Ref		Ref	
Decreased comorbidities	12.0 (9, 18)	0.78 (0.57, 1.08)	0.128	0.75 (0.53, 1.04)	0.088	0.85 (0.61, 1.18)	0.32
SGA at admission and SGA change			0.065[c] <0.001[d]		0.38[c] <0.001[d]		
SGA A, deteriorated	14.0 (9, 23)	0.63 (0.46, 0.88)	0.007	0.62 (0.44, 0.87)	0.005		
SGA A, no change	9.0 (8, 13)	Ref[e]		Ref[e]			
SGA B, deteriorated	21.0 (12, 39)	0.33 (0.18, 0.58)	<0.001	0.35 (0.20, 0.62)	<0.001		
SGA B, no change	10.5 (8, 16)	Ref[e]		Ref[e]			
SGA B, improved	11.0 (9, 16)	0.95 (0.64, 1.39)	0.78	0.98 (0.66, 1.44)	0.91		
SGA C, no change	13.0 (9, 20)	Ref[e]		Ref[e]			
SGA C, improved	13.0 (8, 20)	1.00 (0.57, 1.74)	0.99	0.93 (0.53, 1.66)	0.81		
Weight at admission (3rd vs 1st quartile) n = 373		1.00 (0.88, 1.13)	>0.99			0.99 (0.87, 1.13)	0.88
Weight loss >5% during admission (n = 373)							
Yes	15 (11, 25)	0.49 (0.38, 0.64)	<0.001			0.52 (0.40, 0.69)	<0.001
No	10 (8, 15)	Ref				Ref	

CCI – Charlson Comorbidity Index; SGA – Subjective Global Assessment, LOS – length of stay, Ref – reference level.
[a] Adjusted p-value for Hospital random effect 0.05 for model 1, and 0.17 in model 2.
[b] Adjusted p-value is given for F test of overall effect of covariate; Wald p-values for comparisons between factor levels.
[c] Adjusted F-test p-value for overall F test for effect of SGA at admission.
[d] Adjusted F-test p-value for overall F test for effect of SGA change nested within SGA at admission.
[e] Reference level for comparisons within corresponding SGA at admission category.

those who had SGA deterioration had higher proportions of males, surgical procedures and cancer among all groups. Based on weight change, patients with weight loss ≥5% compared to patients with <5% also had higher proportion of surgical patients and patients with 3 diagnostic categories but there were no differences in proportions of males and cancer patients.

The proportion of patients with a decline in nutritional status was larger in the Braunschweig's study (31%) [23], versus ours (19.6%), but the rate of improvement for those who were admitted with a compromised nutritional status was greater (30%) compared to our study (17.5%). This may have been due to specialized nutrition care procedures in this single site. Another single center study [37] assessed 298 surgical patients using various nutrition screening and assessment tools at admission and discharge to determine association of nutritional status with LOS. They did not use a multivariate approach but compared groups with different nutritional status. They also found that patients with weight loss ≥5% had a longer median LOS versus those with weight loss <5% (14 (11–23.5) vs 9 (7–12) days) and those who were male, age ≥65y or had non-elective surgery, cancer or gastrointestinal surgery also had longer LOS compared to the other surgical patients.

We did not look at complications or cost associated with changes in nutritional status. Braunschweig [23] reported increased charges in patients with nutritional deterioration, regardless of nutritional status at admission compared to those who did not decline, and the risk of complications was also increased, particularly for infections. They also found that decline in nutritional status was an independent factor associated with hospital charges along with LOS, history of surgery and complications while in hospital.

Screening patients at admission to detect those at nutrition risk or malnourished is important and promoted as best practice [38,39] because malnutrition at admission is associated with detrimental outcomes [12–22]. Screening at admission should lead to a nutrition care algorithm, which includes confirmation of the nutrition risk or malnutrition and specific nutrition intervention and monitoring for those who were detected and required treatment. But our findings and those of others [14,23,37] also suggest that since there is also a potential risk of nutritional decline in those who were admitted well-nourished (29.8%–38%), in-hospital regular nutrition screening is important, regardless of the nutritional status of the patients.

Food intake should also be monitored more closely as poor intake has been associated with negative outcomes [34,40]. Nutrition intervention, whether it is in the form of modified diets, oral nutrition supplementation or other types of nutrition support should be considered early in the management of these patients to prevent or reduce the decline in nutritional status. For example, in surgery, the implementation of adequate perioperative nutritional care such as the Enhanced Recovery After Surgery (ERAS) program has been reported to minimize catabolism and support anabolism, reducing morbidity and LOS [41]. In addition, available evidence shows that, although data vary across studies, early nutrition intervention can reduce complication rates, LOS, readmission rates, mortality and cost of care [42]. We did not specifically look at the impact of nutrition support on LOS as the use of these treatments was minimal in our study.

The strength of this study was the patient sample from several hospital centers across the country and the assessment of nutritional status using the 'gold standard' of SGA and significant weight loss. For internal validity, SGA was performed by trained coordinators. We considered several potential social and disease-related confounders to determine the independent effect of change in nutritional status on LOS. We also used the multivariate Cox PH analysis to account for heterogeneity among hospitals while controlling for these potential confounders. These unique strengths not only establish more firmly the association between the decline in nutritional status and prolonged LOS, but also provide direction for further research and practice.

Study limitations include the lack of an experimental design to confirm causality; specifically, we cannot exclude the potential that being in hospital longer contributed to nutritional decline. The true relationship between LOS and deterioration in nutritional status would need to be clarified in future studies. Also, nutritional assessment was performed at two time points (admission and discharge) similar to other studies [14,23,37] based on the assumption that the change in nutritional status was a gradual process, but this may not necessarily be the case. Other limitations include presence of missing data, which reflect the reality of observational studies in a complex and busy health system environment and hospital voluntary enrollment that may have introduced a selection bias. We also cannot fully exclude the possibility that there is heterogeneity in clinical practice and policies between institutions and provinces that may have affected LOS.

5. Conclusion

In this multicenter cohort study, in-hospital decline in nutritional status, as assessed by SGA and weight loss $\geq$5%, was associated with prolonged LOS independently of factors reflecting demographics, living accommodations and disease severity. This suggests that monitoring nutritional status and providing appropriate nutrition care in hospitalized patients may be important. Future interventional studies are required to determine if this can prevent or minimize deterioration in nutritional status and reduce LOS.

Author contributions

JPA, HK with the participation of KNJ, ML, DRD, LG and HP were involved in conception and design of study; AT, JPA, WL with participation of HK, KNJ, ML, DR, LG, LP and PB did statistical analysis and interpreted the data; JPA and AT drafted the manuscript; JPA, HK, ML, KN, DR, LG, AT and WL did critical revision of the article for important intellectual content; BD and AT did data collection and assembly.

Conflicts of interest

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare financial support from the Canadian Nutrition Society which funded the study with unrestricted grants from (Abbott Nutrition., Baxter, Fresenius-Kabi Canada., Nestle Healthcare Nutrition., Pfizer.). JA, HK, KJ, ML, DD, LG, HP and PB are also members of Abbott Nutrition speaker bureau. There are no other relationships or activities that could appear to have influenced the submitted work.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.clnu.2015.01.009.

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