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Association between early postoperative nutritional supplement utilisation and length of stay in malnourished hip fracture patients

David G. A. Williams[1,2], Tetsu Ohnuma[1], Krista L. Haines[3], Vijay Krishnamoorthy[1], Karthik Raghunathan[1], Suela Sulo[4], Bridget A. Cassady[4], Refaat Hegazi[4] and Paul E. Wischmeyer[1,2,*]

[1]CAPER Unit, Department of Anesthesiology, USA, [2]Duke Clinical Research Institute, Durham, NC, USA, [3]Division of Trauma and Critical Care and Acute Care Surgery, Department of Surgery, Duke University School of Medicine, Durham, NC, USA and [4]Abbott Nutrition, Columbus, OH, USA

*Corresponding author. E-mail: paul.Wischmeyer@duke.edu

Abstract

Background: Malnutrition in older hip fracture patients is associated with increased complication rates and mortality. As postoperative nutrition delivery is essential to surgical recovery, postoperative nutritional supplements including oral nutritional supplements or tube feeding formulas can improve postoperative outcomes in malnourished hip/femur fracture patients. The association between early postoperative nutritional supplements utilisation and hospital length of stay was assessed in malnourished hip/femur fracture patients.

Methods: This is a retrospective cohort study of malnourished hip/femur fracture patients undergoing surgery from 2008 to 2018. Patients were identified through International Classification of Diseases, Ninth Revision (ICD-9) and Tenth Revision (ICD-10) codes and nutritional supplement utilisation via hospital charge codes. The primary outcome was hospital length of stay. Secondary outcomes included infectious complications, hospital mortality, ICU admission, and costs. Propensity matching (1:1) and univariable analysis were performed.

Results: Overall, 160 151 hip/femur fracture surgeries were identified with a coded-malnutrition prevalence of 8.7%. Early postoperative nutritional supplementation (by hospital day 1) occurred in 1.9% of all patients and only 4.9% of malnourished patients. Propensity score matching demonstrated early nutritional supplements were associated with significantly shorter length of stay (5.8 [6.6] days *vs* 7.6 [5.8] days; $P<0.001$) without increasing hospital costs. No association was observed between early nutritional supplementation and secondary outcomes.

Conclusion: Malnutrition is underdiagnosed in hip/femur fracture patients, and nutritional supplementation is underutilised. Early nutritional supplementation was associated with a significantly shorter hospital stay without an increase in costs. Nutritional supplementation in malnourished hip/femur fracture patients could serve as a key target for perioperative quality improvement.

Keywords: complications; early postoperative nutritional supplement; hip/femur fracture; malnutrition; older adult; surgery

Editor's key points

- Malnutrition is more common in older individuals and is associated with many perioperative complications.
- This study found that few (<5%) malnourished post-surgical patients receive nutritional supplementation postoperatively.
- Nutritional supplementation was associated with a shorter hospital stay after surgery.

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It is estimated that between 250 000 and 300 000 hip fractures occur in the USA and 75 000 in the UK annually, resulting in a significantly negative impact on quality of life and functional status.[1,2] When compared with elective hip replacements, patients presenting with hip fracture have a 6–15-fold mortality risk.[3] In older patients after hip fracture, malnutrition is a key comorbidity associated with reduced functional status, loss of independence, impaired cognitive function, higher postoperative complication rates, prolonged rehabilitation time, and increased risk of mortality.[4–8] Depending on the defining criteria and when actively assessed for, malnutrition is common among older hip fracture patients occurring in between 18% and 45% of patients.[9] Several studies demonstrate that nutritional intake in older people with hip fractures frequently does not meet energy and protein requirements as compared with age-matched patients without hip fracture.[6,10,11] Reduced nutrient intake observed in hip fracture patients often leads to weight loss and a reduction in lean muscle mass, both predictors of postoperative surgical complications and poor clinical outcomes.[12,13] This poor preoperative nutritional status often deteriorates much further during hospitalisation because of the acute trauma and surgery-associated anorexia and immobility.[14] Oral nutritional supplementation (ONS) by means of the oral route or tube feeding offers the possibility to increase or to insure nutrient intake when oral food intake alone is insufficient. Current nutrition guidelines, therefore, recommend ONS in geriatric patients after hip fracture and orthopaedic surgery to reduce those complications.[15]

Despite a large body of data supporting the use of ONS in medical patients and initial data for benefit in postoperative major abdominal surgical patients,[16–18] heterogeneous results exist regarding the impact of ONS on postoperative outcomes in patients with hip fractures. Several studies have demonstrated that ONS provisions after hip fracture reduced hospital length of stay (LOS), rehabilitation facility LOS, or both,[19,20] postoperative complication,[20–22] and mortality and improved functional status,[20] whereas other data do not show similar benefits.[22–24]

The primary objective of this study was to determine the association between early postoperative nutritional supplementation (NS) and hospital LOS in malnourished patients with hip fractures in US hospitals by conducting a large health outcomes database analysis. It was hypothesised that early NS by postoperative day 1 among malnourished patients with hip fractures is associated with a reduction in hospital LOS when compared with patients who received delayed postoperative NS.

Methods

Data source and population

Data for this investigation were obtained by performing a retrospective cohort study of adult patients from 2008 to 2018, utilising the Premier Healthcare Database, approved by the Duke University Hospital System Institutional Review Board (Pro 00102758). This database uses billing information to form a detailed date-specific billing record for each patient during a hospital admission. The Premier database is robust and represents approximately 20% of all discharges for annual inpatients (Premier Inc., Charlotte, NC, USA).[24] Malnourished patients who suffered a hip fracture and underwent either hip or femur fracture repair (procedures included internal fixation with open, closed, or without reduction) were identified using International Classification of Diseases, Ninth Revision (ICD-9) and Tenth Revision (ICD-10) diagnosis and Current Procedural Terminology (CPT) codes (Supplementary Tables S1 and S2).[25,26] Exclusion criteria included elective surgery, encounters with hospital LOS <2 days, and encounters with missing ONS charges, or patients who experienced in-hospital death or required mechanical ventilation within 24 h of surgery.

Exposure

The study exposure was early NS defined as receipt of ONS, tube feed formulas, or modular nutrition supplements by day 1 after surgery. As there are no specific ICD-9, ICD-10, or CPT codes identifying ONS use, the charge codes were used. Product information under this definition was manually checked for accuracy.

Outcomes

The primary outcome was hospital LOS. Secondary outcomes included a composite of infectious complications including pneumonia, sepsis, urinary tract infection, and surgical site infection, (which was identified using ICD-9 codes) hospital mortality, ICU admission, and total hospital cost.

Covariates

The following covariates were used in analysis: age, race, payor category, comorbidities using the 29 Elixhauser comorbidity index categories,[25] general anaesthesia, hospital size by number of beds, teaching hospital, hospital location (rural or urban), and fiscal year.

Statistical analysis

Descriptive statistics were calculated and presented as number (percentage) for categorical variables and median (interquartile range) or mean (standard deviation [SD]) for continuous variables. Owing to the large sample size, hypothesis tests do not provide a good assessment of covariate balance.[27] Thus, baseline comparisons between covariates are given as standardised mean differences (SMD). A SMD closer to zero indicates a more even balance between the two groups, and a SMD greater than 0.1 or less than −0.1 is generally taken to indicate significant imbalance.

We estimated propensity scores as the probability of receiving early NS *vs* delayed NS using the logistic regression model. A propensity score was built with the covariates above. Then, patients unexposed to early NS were matched to exposed patients using greedy propensity score techniques (in a 1:1 fashion) without replacement and a calliper within 0.10 SD of the propensity score distribution.[27] After matching, the SMD was used to test the balance of covariates. Univariable logistic and linear regression models with robust standard errors for binary and continuous outcomes were used to determine the association between early NS exposure and clinical outcomes in the fully matched cohort.

We performed sensitivity analysis with propensity scores and inverse-probability-of-treatment weighting. We calculated the standard mortality ratio (SMR), which weights 'exposed' participants with 1 and 'unexposed' participants with (propensity score/[1−propensity score]). The SMR

Table 1 Baseline characteristics of patients. LOS, length of stay; MCO, managed care organisation; NS, nutritional supplementation; SMD, standardised mean difference.

	All (N=14 016)	No NS (N=13 336)	Early NS (N=680)	SMD
Male, *n* (%)	4180 (29.8)	3993 (29.9)	187 (27.5)	−0.06
Age group (yrs), *n* (%)				0.14
<30	31 (0.2)	31 (0.2)	0 (0)	
30–39	49 (0.3)	47 (0.4)	2 (0.3)	
40–49	189 (1.3)	179 (1.3)	10 (1.5)	
50–59	762 (5.4)	735 (5.5)	27 (4)	
60–69	1715 (12.2)	1637 (12.3)	78 (11.5)	
70–79	3016 (21.5)	2888 (21.7)	128 (18.8)	
≥80	8254 (58.9)	7819 (58.6)	435 (64)	
Payor category, *n* (%)				0.18
MCO	507 (3.6)	491 (3.7)	16 (2.4)	
Medicaid	531 (3.8)	514 (3.9)	17 (2.5)	
Medicare	12 228 (87.2)	11 624 (87.2)	604 (88.8)	
Other	750 (5.4)	707 (5.3)	43 (6.3)	
Race, *n* (%)				0.22
African-American	880 (6.3)	814 (6.1)	66 (9.7)	
Caucasian	11 544 (82.4)	10 979 (82.3)	565 (83.1)	
Other	1592 (11.4)	1543 (11.6)	49 (7.2)	
General anaesthesia, *n* (%)	11 777 (84)	11 203 (84)	574 (84.4)	0.01
Comorbidity, *n* (%)				
Congestive heart failure	2727 (19.5)	2583 (19.4)	144 (21.2)	0.04
Valvular disease	1620 (11.6)	1553 (11.6)	67 (9.9)	−0.06
Pulmonary circulation disease	701 (5)	668 (5)	33 (4.9)	−0.01
Peripheral vascular disease	1449 (10.3)	1387 (10.4)	62 (9.1)	−0.04
Other neurological disorders	2980 (21.3)	2853 (21.4)	127 (18.7)	−0.07
Chronic pulmonary disease	4374 (31.2)	4177 (31.3)	197 (29)	−0.05
Diabetes mellitus, no chronic complications	1742 (12.4)	1662 (12.5)	80 (11.8)	−0.02
Diabetes mellitus with chronic complications	1023 (7.3)	978 (7.3)	45 (6.6)	−0.03
Hypothyroidism	2931 (20.9)	2776 (20.8)	155 (22.8)	0.05
Renal failure	2828 (20.2)	2688 (20.2)	140 (20.6)	0.01
Liver disease	514 (3.7)	498 (3.7)	16 (2.4)	−0.08
Cancer	922 (6.6)	885 (6.6)	37 (5.4)	−0.05
Rheumatoid arthritis/collagen	617 (4.4)	587 (4.4)	30 (4.4)	0.00
Coagulopathy	1162 (8.3)	1109 (8.3)	53 (7.8)	−0.02
Obesity	954 (6.8)	943 (7.1)	11 (1.6)	−0.27
Weight loss	9376 (66.9)	8822 (66.2)	554 (81.5)	0.35
Fluid and electrolyte disorders	4299 (30.7)	4080 (30.6)	219 (32.2)	0.03
Chronic blood loss anaemia	308 (2.2)	286 (2.1)	22 (3.2)	0.07
Deficiency anaemias	4042 (28.8)	3827 (28.7)	215 (31.6)	0.06
Alcohol abuse	955 (6.8)	925 (6.9)	30 (4.4)	−0.11
Psychoses	651 (4.6)	626 (4.7)	25 (3.7)	−0.05
Depression	2648 (18.9)	2495 (18.7)	153 (22.5)	0.09
Hypertension	9737 (69.5)	9286 (69.6)	451 (66.3)	−0.07
Hospital bed size, *n* (%)				0.31
<200	1611 (11.5)	1496 (11.2)	115 (16.9)	
200–499	7742 (55.2)	7462 (56)	280 (41.2)	
≥500	4663 (33.3)	4378 (32.8)	285 (41.9)	
Teaching hospital, *n* (%)	5773 (41.2)	5463 (41)	310 (45.6)	0.09
Rural hospital, *n* (%)	1846 (13.2)	1775 (13.3)	71 (10.4)	−0.09
Year, *n* (%)				0.27
2009	821 (5.9)	789 (5.9)	32 (4.7)	
2010	1048 (7.5)	1008 (7.6)	40 (5.9)	
2011	1255 (9)	1219 (9.1)	36 (5.3)	
2012	1411 (10.1)	1365 (10.2)	46 (6.8)	
2013	1428 (10.2)	1370 (10.3)	58 (8.5)	
2014	1496 (10.7)	1414 (10.6)	82 (12.1)	
2015	1643 (11.7)	1548 (11.6)	95 (14)	
2016	1664 (11.9)	1557 (11.7)	107 (15.7)	
2017	1881 (13.4)	1769 (13.3)	112 (16.5)	
2018	1369 (9.8)	1297 (9.7)	72 (10.6)	

assesses the average treatment effect in the treated, which is the difference in effect between patients who received early NS compared with those who did not.[28,29] Lastly, we modelled the outcomes using the weighted logistic and the linear regression analyses with robust variance estimators. The type I error rate was set at 0.05 as the threshold for statistical significance. Statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Table 2 Propensity score matched analysis of early NS *vs* no early NS. MCO, managed care organisation; NS, nutritional supplementation; SMD, standardised mean difference.

	No Early NS (N=680)	Early NS (N=680)	SMD
Male, *n* (%)	193 (28.4)	187 (27.5)	−0.02
Age group (yrs), *n* (%)			0.21
<30			
30–39	6 (0.9)	2 (0.3)	
40–49	19 (2.8)	10 (1.5)	
50–59	30 (4.4)	27 (4)	
60–69	71 (10.4)	78 (11.5)	
70–79	118 (17.4)	128 (18.8)	
≥80	436 (64.1)	435 (64)	
Payor category, *n* (%)			0.00
MCO	12 (1.8)	16 (2.4)	
Medicaid	19 (2.8)	17 (2.5)	
Medicare	602 (88.5)	604 (88.8)	
Other	47 (6.9)	43 (6.3)	
Race, *n* (%)			0.04
African-American	65 (9.6)	66 (9.7)	
Caucasian	573 (84.3)	565 (83.1)	
Other	42 (6.2)	49 (7.2)	
General anaesthesia, *n* (%)	576 (84.7)	574 (84.4)	−0.01
Comorbidity, *n* (%)			
Congestive heart failure	142 (20.9)	144 (21.2)	0.01
Valvular disease	64 (9.4)	67 (9.9)	0.01
Pulmonary circulation disease	38 (5.6)	33 (4.9)	−0.03
Peripheral vascular disease	63 (9.3)	62 (9.1)	−0.01
Other neurological disorders	116 (17.1)	127 (18.7)	0.04
Chronic pulmonary disease	188 (27.6)	197 (29)	0.03
Diabetes mellitus, no chronic complications	65 (9.6)	80 (11.8)	0.07
Diabetes mellitus with chronic complications	51 (7.5)	45 (6.6)	−0.03
Hypothyroidism	158 (23.2)	155 (22.8)	−0.01
Renal failure	138 (20.3)	140 (20.6)	0.01
Liver disease	19 (2.8)	16 (2.4)	−0.03
Cancer	41 (6)	37 (5.4)	−0.03
Rheumatoid arthritis/collagen	33 (4.9)	30 (4.4)	−0.02
Coagulopathy	56 (8.2)	53 (7.8)	−0.02
Obesity	13 (1.9)	11 (1.6)	−0.02
Weight loss	556 (81.8)	554 (81.5)	−0.01
Fluid and electrolyte disorders	237 (34.9)	219 (32.2)	−0.06
Chronic blood loss anaemia	22 (3.2)	22 (3.2)	0.00
Deficiency anaemias	212 (31.2)	215 (31.6)	0.01
Alcohol abuse	34 (5)	30 (4.4)	−0.03
Psychoses	28 (4.1)	25 (3.7)	−0.02
Depression	165 (24.3)	153 (22.5)	−0.04
Hypertension	440 (64.7)	451 (66.3)	0.03
Hospital bed size, *n* (%)			0.07
<200	113 (16.6)	115 (16.9)	
200–499	299 (44)	280 (41.2)	
≥500	268 (39.4)	285 (41.9)	
Teaching hospital, *n* (%)	312 (45.9)	310 (45.6)	−0.01
Rural hospital, *n* (%)	63 (9.3)	71 (10.4)	0.04
Year, *n* (%)			0.13
2009	33 (4.9)	32 (4.7)	
2010	39 (5.7)	40 (5.9)	
2011	37 (5.4)	36 (5.3)	
2012	53 (7.8)	46 (6.8)	
2013	49 (7.2)	58 (8.5)	
2014	68 (10)	82 (12.1)	
2015	97 (14.3)	95 (14)	
2016	123 (18.1)	107 (15.7)	
2017	104 (15.3)	112 (16.5)	
2018	77 (11.3)	72 (10.6)	

Results

A total of 160 051 hip/femur fracture patients were identified between 2008 and 2018. As 14 016 of these patients were also diagnosed with malnutrition, the prevalence of malnutrition among patients with hip/femur fractures was 8.7% during the study period. The mean age of malnourished patients was 78.8 (11.1) yr, 29.8% were male, 82.4% were Caucasian, and 87.2%

Table 3 Outcomes before and after matching. CI, confidence interval; LOS, length of stay; NS, nutritional supplementation; OR, odds ratio; SD, standard deviation; SMD, standardised mean difference; UTI, urinary tract infection.

Outcomes	Before matching			After matching			
	No early NS (N=13 336)	Early NS (N=680)	SMD	No early NS (N=680)	Early NS (N=680)	OR (95% CI)	P-value
Hospital mortality, n (%)	402 (3.0)	14 (2.1)	−0.06	22 (3.2)	14 (2.1)	0.63 (0.32, 1.23)	0.18
ICU admission, n (%)	420 (3.1)	9 (1.3)	−0.12	18 (2.6)	9 (1.3)	0.49 (0.22, 1.11)	0.09
Sepsis, n (%)	1221 (9.2)	64 (9.4)	0.01	64 (9.4)	64 (9.4)	1.00 (0.69, 1.45)	1
Pneumonia, n (%)	1366 (10.2)	60 (8.8)	−0.05	77 (11.3)	60 (8.8)	0.76 (0.53, 1.08)	0.13
UTI, n (%)	3099 (23.2)	163 (24.0)	0.01	146 (21.5)	163 (24.0)	1.15 (0.89, 1.49)	0.27
Surgical site infection, n (%)	72 (0.5)	1 (0.1)	−0.07	2 (0.3)	1 (0.1)	0.50 (0.05, 5.53)	0.57
Any infection, n (%)	4759 (35.7)	242 (35.6)	0.00	237 (34.9)	242 (35.6)	1.03 (0.83, 1.29)	0.78
						Estimates (95% CI)	
LOS, mean (SD)	8.3 (7.8)	5.8 (6.6)	−0.18	7.6 (5.8)	5.8 (6.6)	−1.1 (−1.7, −0.4)	<0.001
Total cost, mean (SD)	$16 817 (19 982)	$13 424 (19 203)	−0.05	$19 844 (13 424)	$13 424 (19 203)	−641 (−2188, 906)	0.43

were covered by Medicare (Table 1). Among malnourished patients, 680 patients (4.9%) received early NS. Analysis by fiscal year demonstrated the malnutrition rate increased from 6.4% in 2009 to 11.8% in 2018 (P<0.0001), and the rate of ONS exposure increased from 4.0% in 2009 to 5.3% in 2018 (P<0.0001). Malnourished patients were more likely to have been diagnosed with weight loss (66%) codes.

Propensity score matching

Propensity score matching produced two groups of 680 patients who were matched with regard to baseline patient characteristics (Table 2; Supplementary Figs. S1 and S2). After matching, the two groups were generally comparable for preoperative confounders (−0.1<SMD<0.1).

Association between early NS exposure and reduced hospital LOS

Early NS was associated with a significantly shorter LOS of 5.8 (6.6) days compared with 7.6 (5.8) days for patients who did not receive early NS (−1.1 day; 95% confidence interval [CI], −1.7 day to −0.4 day; P<0.001; Table 3). In patients receiving early NS, this benefit on LOS occurred without an increase in hospital costs (−$640.6; 95% CI, −$2187.5 to $906.3; P=0.43). Early NS was not associated with reduced infection, hospital mortality, or ICU admission (Table 3).

In the sensitivity analysis using the SMR weighting method (Supplementary Tables 1 and 2, and Supplementary Fig. S3), compared with those unexposed to early NS, early NS was associated with a shorter LOS (−1.0 day, 95% CI: −1.4 day to −0.5 day; Supplementary Table S3).

Discussion

Although the reported prevalence of malnutrition in hip fracture patients ranges between 18% and 45%,[9] the current study of US hospital real-world data revealed limited malnutrition coding of only 4.9%. This value is significantly lower than the reported prevalence of malnutrition in this surgical population when measured in studies focused on accurate malnutrition diagnosis and reporting.[9] This highlights the long-standing and persistent under-diagnosis of malnutrition in surgical patients and the need for improved screening and diagnosis protocols in the perioperative setting.

In addition, these data show limited postoperative NS coding in malnourished hip/femur fracture patients. Early NS was provided in 1.6% of all hip fracture surgeries, most often as ONS. Strikingly, only 4.9% of hip/femur fracture patients who were diagnosed and coded for malnutrition were also prescribed early NS. These findings suggest that a large percentage of patients with hip and femur fractures are not receiving guideline-recommended NS interventions for malnutrition while hospitalised after surgery.[30,31] The limited utilisation of NS among malnourished patients was similarly observed in a recent retrospective cohort study of 8713 malnourished adult inpatient encounters that showed only 3.1% of malnourished patients received ONS during their hospital stay.[32] We previously determined that only 15% of malnourished post-surgical patients receive ONS during their postoperative course.[33] The limited use of ONS among malnourished hip/femur fracture patients can be partly explained by the lack of structured nutrition care pathways in hospitals that include evidence-based interventions such as ONS. Although surgeons recognise the importance of adequate perioperative surgical nutritional support to improve postoperative outcomes, our previous work showed that only 21% of patients at risk for malnutrition received perioperative ONS.[34] This serves to perpetuate the ‘silent epidemic’ of perioperative malnutrition.[35]

In our study, analysis of malnutrition rates by fiscal year demonstrates a slowly increasing rate of malnutrition diagnosis from 6.4% in 2009 to 11.8% in 2018. Similarly, the rate of ONS use also increased from 3.98% in 2009 to 5.26% in 2018. We hypothesise the increasing rate in observed malnutrition diagnosis and NS may be explained by an increased emphasis on timely screening for malnutrition risk and expeditiously intervening when risk is identified. Quality improvement (QI) studies and initiatives are urgently needed to improve the efficiency and rate of providing nutritional support to hospitalised and surgical patients and to determine if such advances would improve patient health and economic outcomes. One such study by Meehan and colleagues[36] demonstrated that screening for malnutrition risk at patient admission and then promptly beginning ONS for those at risk resulted in a higher proportion of hospitalised patients receiving ONS. With an increased rate from 6.1% of pre-QI to 8.1% post-QI patients, the revised nutrition practice potentially captured patients who were neglected in pre-QI practice. Moreover, the time from nutrition screening to initiation of nutrition intervention for patients at risk of malnutrition was reduced to less than 24 h, resulting in an average LOS reduction from 5.74 to 4.97 days.[36] Similarly, Sriram and colleagues[37] showed that initiation of ONS within 24 h of identification of nutrition risk resulted in a 1.8 day reduction in LOS ($P<0.001$). Finally, a large multicentre RCT of 2088 patients recently examined the effects of early nutritional support in malnourished hospitalised patients (Effects of early nutritional support on Frailty, Functional Outcomes, and Recovery of malnourished hospitalised patients Trial [EFFORT]).[38] This trial showed early protocolised nutrition delivery, including early ONS (within 48 h of admission) *vs* standard nutrition care in malnourished patients reduced adverse clinical outcomes at 30 days (adjusted odds ratio [OR]=0.79; 95% CI, 0.64–0.97; $P=0.023$) and reduced 30-day mortality (adjusted OR=0.65; 95% CI, 0.47–0.91; $P=0.011$). Patients receiving early nutrition support also had significant improvements in functional outcomes and quality of life.

A secondary economic evaluation of EFFORT showed that in-hospital nutrition support in medical inpatients is a highly cost-effective intervention to reduce risks for ICU admissions and hospital-associated complications, while improving patient survival.[39] These findings are supported by the results of previous studies demonstrating that ONS are not only cost-effective, but they can also result in cost savings as a result of reduced LOS and overall healthcare utilisation.[40,41] In our analysis, early ONS exposure was associated with significantly shorter LOS without an increase in hospital costs. Statistical significance for costs comparison analysis may not have been observed because of the small sample size in the final analysis after matching.

Our findings of reduced hospital LOS with early postoperative NS in hip/femur fracture patients supports our hypothesis and are also supported by several earlier randomised trials that showed a reduction in hospital LOS in patients receiving postoperative ONS after hip surgery.[20,42] These findings encourage the use of ONS early during the postoperative period to reduce hospital LOS in patients with either hip or femur fractures.

Current nutrition guidelines recommend postoperative ONS use in order to reduce postoperative complications after major surgery,[30] and specifically in older patients after hip fracture and orthopaedic surgery.[15] Although some studies have found a beneficial effect of postoperative ONS on nutrition status, hospital stay, and postoperative complications, other studies have failed to demonstrate similar benefits.[22–24] In fact, a Cochrane review concluded that the evidence for the effectiveness of ONS after hip fracture remains weak owing to the small sample size and inconsistent methodologies used in the studies.[43] Although this retrospective cohort study uses propensity score matching to establish two cohorts generally comparable for preoperative confounders, this study highlights the need for a prospective randomised trial to vigorously examine the impact of postoperative ONS use on surgical outcomes, including LOS, in patients with hip or femur fractures.

Our study has several limitations that hold true for healthcare coding database publications. First, because we relied on ICD-9/ICD-10 codes to identify the patients diagnosed with malnutrition, we were unable to confirm the diagnosis by manual chart review or identify patients who met criteria but were undiagnosed. Our data support that malnutrition continues to be underdiagnosed in this surgical population as it is likely that many patients who met criteria for malnutrition were not diagnosed and coded. Next, this analysis did not include data on ONS compliance, dosing, and frequency; thus, it is not possible to discern how much ONS was consumed by the patients for whom it was prescribed. Next, it is also not possible to address whether certain ONS formulations were more advantageous than others because nutrition supplements were considered as a composite of products. Furthermore, we also only included hospitals known to have actively coded for ONS use across all the years studied, thus limiting the generalisability of our findings to all hospitals. Moreover, a large amount of data was discarded through the process of propensity score matching, which limits the quantity of data for broader interpretation. Despite these limitations, our study uses a large real-world patient sample representing the broad surgical patient population and provides important information about malnutrition.

Early postoperative NS exposure was most common in older, female, Caucasian patients insured by Medicare. In a well-matched sample, early NS was associated with significantly shorter LOS without an increase in hospital costs. Given the poor perioperative malnutrition diagnosis rate and very limited NS in malnourished hip fracture patients, improving perioperative malnutrition identification and treatment with simple and inexpensive ONS interventions should be considered a key target for perioperative QI.

Authors' contributions

Data interpretation: DGAW, SS, BAC, RH, PEW
Data analysis: TO, KH, VK, KR
Drafting and editing of manuscript drafting: DGAW, SS, BAC, RH, PEW
All authors were involved in study design and final approval of manuscript.

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Ethics approval and consent to participate

Data for this investigation was obtained by performing a retrospective cohort study of adult patients from 2009 to 2018, using the Premier Healthcare Database (Premier, Inc.), approved by the Duke University Hospital System Institutional Review Board (Pro 00102758).

The data that support the findings of this study are available from the Premier Healthcare Database (Premier, Inc.), but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Premier, Inc.

Declarations of interest

PEW has received grant funding related to this work from National Institutes of Health, Canadian Institutes of Health Research, Abbott, Baxter, Fresenius, Nutricia, and Takeda. PEW serves as a consultant to Abbott, Fresenius, Baxter, Nutricia, and Takeda for research related to nutrition in surgery and ICU care; has received unrestricted gift donation for surgical and critical care nutrition research from Musclesound and Cosmed; and has received honoraria or travel expenses for CME lectures on improving nutrition care in surgery and critical care from Abbott, Baxter, and Nutricia. DGAW receives support from NIH T32 Anesthesiology Department Research Training Grant and ASPEN Rhoads Research Foundation. SS, BAC and RH are employees and stockholders of Abbott. The other authors have no conflicts of interest to report.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2020.12.026.

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