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Original article

Clinical and economic outcomes associated with malnutrition in hospitalized patients

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SUMMARY

Background & aims: Hospitalized patients show a high rate of malnutrition, which is associated with poor patient outcomes and high healthcare costs. However, relatively few studies have investigated the association between clinical and economic outcomes and malnutrition in hospitalized patients, particularly those with cardiac and pulmonary conditions.

Methods: This multicenter prospective observational cohort study included 800 patients hospitalized at four Colombian hospitals with a diagnosis of congestive heart failure, acute myocardial infarction, community-acquired pneumonia, or chronic obstructive pulmonary disease. All patients were screened for malnutrition using the Malnutrition Screening Tool (MST). A descriptive analysis of baseline variables was followed by multivariate analysis and inverse probability weighting (IPW) to compare the clinical outcomes, i.e., length of stay (LOS), mortality, and readmission, and hospital costs associated with a positive MST result.

Results: The prevalence of a positive MST result was 24.62% (n = 197) and was more common in patients with older age and greater comorbidities. Multivariate analysis controlling for age, gender, healthcare plan, university degree, hospitalization, entrance disease and Charlson co-morbidity index showed that a positive MST result was associated with increased LOS (1.43 ± 0.61 days) and both in-hospital mortality (odds ratio, 2.39) and global mortality (odds ratio, 2.52). IPW analysis confirmed the association between a positive MST result and increased hospital LOS and 30-day mortality, as well as a relative increase of 30.13% in the average cost associated with hospitalization.

Conclusions: This study of hospital inpatients demonstrated a high burden of malnutrition at the time of hospital admission, which negatively impacted LOS and mortality and increased the costs of hospitalization. These findings underscore the need for improved diagnosis and treatment of hospital malnutrition to improve patient outcomes and reduce healthcare costs.

1. Introduction

There is a high burden of malnutrition in hospitals across Latin America, including those in Colombia. The results of prevalence studies performed since 2000 indicate that nearly 50% of hospitalized patients in Latin America are malnourished at admission, and more patients may be malnourished upon hospital discharge [1,2]. From 67 studies conducted across Latin America (n = 20,881), the prevalence of malnutrition varies greatly in the general hospitalized population, and studies from Colombia report a prevalence of more than 60% [3,4]. However, there is significant variability in the reported incidence of hospital malnutrition due to differences in patient populations, hospital admission rates, and the method or nutritional marker used for diagnosis. Older patients [5] and those with critical illness [6] show particularly high rates of malnutrition, and the percentage of patients discharged with malnutrition

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continues to rise—both in emerging and industrialized countries—despite recent advances in medical care [7–12].

Malnutrition in the context of a pre-existing disease delays wound healing and inhibits the ability to mount an effective response to infection [12]. Moreover, malnourished patients are at increased risk of developing complications during hospitalization and are at risk of adverse health events after discharge [13]. As a result, malnutrition at hospital entry has repeatedly been shown to have a negative impact on clinical outcomes, including hospital length of stay (LOS) [7,14,15], readmission [16,17], and mortality [15,18,19].

Besides the clinical impact, studies worldwide have demonstrated the increased costs and overall economic burden associated with hospital malnutrition. However, limited up-to-date information exists regarding the costs associated with hospital malnutrition in Latin America. One study reporting data from 25 Brazilian hospitals showed that the mean daily cost of care was 61% higher in malnourished compared to well-nourished patients [20]. Studies from Europe have reported similar findings [21,22], showing an additional cost ranging from 1640 to 5829 Euros per hospitalized patient and an overall cost ranging from 2.1% to 10% of the national health expenditure [23].

Although the prevalence of malnutrition is high, few patients are diagnosed and treated [3,24,25]. Application of a standardized protocol to detect and treat malnutrition can identify patients at risk and can have a positive impact on hospital costs and patient outcomes. A number of tools have been developed to detect malnutrition, including the Malnutrition Screening Tool (MST) [26], which can easily be implemented in the clinical setting without the need for patient blood samples or anthropometric measurements. Using the MST to detect malnutrition, a recent study reported that oral nutrition supplementation (ONS) in malnourished patients could significantly reduce 30-day readmissions and LOS [27]. Furthermore, treatment of hospital malnutrition in the US was shown to decrease LOS by 2.3 days and decrease the hospital episode cost by >20% [28].

In Colombia, there is a lack of studies addressing the impact of malnutrition on the costs associated with hospitalization and clinical outcomes, especially in patients with cardiovascular or pulmonary disease. Thus, the current multicenter prospective observational cohort study was performed to determine the association between clinical and economic outcomes and malnutrition in hospitalized patients. Four diseases were selected for the present analysis, including congestive heart failure (CHF), acute myocardial infarction (AMI), community-acquired pneumonia (CAP) and chronic obstructive pulmonary disease (COPD), because these represent common diseases found in Colombian hospitals and have high rates of healthcare resource utilization.

2. Methods

2.1. Type of study

This prospective observational cohort study was conducted in four hospitals in Bogotá, Colombia and sought to determine the clinical and economic outcomes associated with a positive result from the MST in patients hospitalized due to CHF, AMI, CAP or COPD compared to hospitalized patients with a negative result.

2.2. Study population

The following four Colombian hospitals participated in this study: San Ignacio University Hospital (HUSI), Fundación Cardioinfantil (FCI), Hospital de San José (HSJ), and University Hospital Infantil de San José (HISJ). The aforementioned centers were selected due to the large number of highly complex patients receiving care for the four targeted diseases. The eligibility criteria included the following: 1) both sexes, age 18 years or older; 2) hospitalization due to a diagnosis of CHF, AMI, CAP or COPD; 3) nutritional status evaluated with the MST during the first 24 h after hospital admission; and 4) life expectancy ≥30 days upon admission. Exclusion criteria consisted of 1) pregnancy and 2) receiving nutritional support at the time of the study.

The patients were divided into two cohorts based on the presence or absence of malnutrition: MST+, with an MST score ≥2, and MST−, with an MST score <2 [26]. Patient inclusion into each cohort was performed in an attempt to guarantee proportionality in relation to the four diseases chosen and the MST result. Due to the high probability of comorbidity in the selected patients, those with one or more diseases (including the target diseases of this study) were included.

2.3. Sample size

Hospital LOS was used as the primary outcome to estimate sample size. Due to the absence of data from Colombian hospitals, the results of the Spanish study by Leon-Sanz et al. were used for estimation, in which the average LOS in the control group was 8.5 days compared to 11.5 days for the exposure group [29]. With a tolerated $\alpha = 0.05$, power of 0.8, and $\beta = 0.2$, the sample size required to detect differences between the MST+ and MST− groups was 150 patients per group (Supplementary Fig. 1). Taking into account the potential for withdrawal from the study or losses to follow-up, a sample of 800 individuals was estimated, with an equal number for each type of diagnosis (n = 200 per disease). Stata 14© statistical software was used to calculate sample size.

2.4. Measurement of malnutrition

The MST consists of two questions related to weight loss and appetite. The result is considered positive if the total score is ≥ 2. The MST has been validated in an adult hospital population [26], is easy to apply, and has received the endorsement of the Alliance to Advance Patient Nutrition, thereby justifying its use in the present study to assess the risk of malnutrition in Colombian adult hospitalized patients. Table 1 presents the questions used and the scoring system for the MST.

2.5. Variables examined

The main outcome variable was hospital LOS, defined as the time (measured in days) from hospital admission to discharge.

Table 1
Screening tool for malnutrition (MST).

Question	Score
1. Have you lost weight lately without having proposed it?	
No	0
I'm not sure	2
If yes, how much weight have you lost?	
1–5 kg	1
6–10 kg	2
11–15 kg	3
15 kg or more	4
I'm not sure	2
2. Have you eaten poorly lately due to lack of appetite?	
No	0
Yes	1
MST score	Sum

Secondary variables included costs, 30-day unplanned hospital readmission, and mortality. Costs associated with the utilization of health resources during hospitalization and within 30 days after discharge were recorded. The costs of hospitalization were calculated from the perspective of a third-party payer and identified through the hospital billing process. The cost category was identified according to the type of billed health service. The national codes of procedures and health services and the anatomical, therapeutic and chemical classification system (ATC) for medicines was used, according to those proposed by the national government through the Colombian Ministry of Health. The costs were divided as follows: total costs of hospitalization, costs of hospital stay, costs of diagnostic tests, costs of procedures, and other costs. Hospital readmission within 30 days of discharge was determined by telephone follow-up with the patient or caregiver. Finally, mortality was identified during hospitalization and within 30 days after discharge.

The following variables were used to control for possible confounding factors: 1) sociodemographic variables (age, gender, type of health plan and educational level); 2) variables related to the reason for hospitalization (diagnosis and type of service related to diagnosis [i.e., medical or surgical]); 3) the presence of comorbidities using the Charlson Co-morbidity Index [CCI] (the CCI is a severity index based on comorbidities covering serious disease areas, with the value calculated as a weighted sum of these comorbidities. More severe conditions are given a higher weight [30,31]); and 4) variables associated with interventions (diagnostic tests, medications, procedures, prescription/administration of nutritional supplements, and admission to the intensive care unit [ICU]).

2.6. Study procedure

All hospitalized patients who met the eligibility criteria of the study were provided with the informed consent document on the first day of hospitalization. After receiving consent, an institutional employee, who was appointed and trained, completed the MST within 24 h of hospital admission.

An electronic case report form (CRF), which contained the questions associated with the MST score and clinical and patient cost information was maintained for each study subject. The CRF consisted of three forms that were completed at three different times. The first form contained the information on admission to the hospital and the results of the MST; the second form contained the clinical and cost information associated with hospitalization and discharge; and the third form contained the patient information for the 30-day post-hospital discharge follow-up. To collect data on readmissions within 30 days of discharge, the study coordinator called each patient or caregiver and requested the required information using a standardized survey. All study data were included in an electronic database that was stored at the Department of Clinical Epidemiology and Biostatistics, Pontificia Universidad Javeriana. Patient data were anonymized to guarantee the privacy rights of human subjects.

2.7. Analysis

A descriptive analysis of the baseline variables was carried out for each cohort. Subsequently, a univariate analysis was performed between the variables of interest and other variables that could serve as cofounders or modifiers of the observed effect. Differences in the distribution of the cohorts for each variable were compared, according to the type of distribution found and using standardized differences.

Both the significant variables identified in the univariate analysis and those previously reported in the literature were included in the multivariate models. The association between a positive MST result with each of the outcomes was determined, after adjusting for the confounding variables by means of multivariate regression models, logistic models for the dichotomous variables (death and readmission), and linear models for the continuous variables (LOS and costs).

The potential modifying variables of the effect (interactions) were also evaluated. Finally, the best model was selected based on the goodness of fit and compliance with the assumptions. From each model, the coefficient associated with the risk of malnutrition was extracted according to the result of the MST.

As a secondary analysis, inverse probability weighting (IPW) was performed according to the baseline variables that might indicate selection bias. For this analysis, per previous recommendations [32], the propensity score was estimated using a multivariate logistic model in which the baseline variables were predictors of the MST result. After estimating the propensity index, the IPW for each individual subject was calculated, the balance of the baseline variables with standardized differences less than 0.1 was evaluated, and the effect of the exposure on each of the aforementioned outcomes was estimated.

The data were analyzed using the Stata 14© program, and a p value < 0.05 was defined as statistically significant.

2.8. Ethics

Colombian regulations for human research were followed. The current study was classified as expedited. The study protocol and all its amendments, the informed consent form, the recruitment materials, and any written information provided to the individuals were reviewed and approved by all the research and ethics committees of each of the institutions invited to participate.

This study was carried out in accordance with the approved research protocol, good clinical practice guidelines and Colombia National Drug and Food Surveillance Institute (INVIMA) regulations, which regulate the execution of clinical studies, and with the ethical principles that have their origin in the Declaration of Helsinki.

The confidentiality of the information obtained was guaranteed. The databases are safeguarded in the Department of Clinical Epidemiology and Biostatistics at Pontificia Universidad Javeriana. No identifiable patient information was shared in preparation of this manuscript.

3. Results

3.1. Descriptive results

A total of 800 patients were included, and all patients were followed until hospital discharge. Only 745 patients could be contacted within 30 days after discharge. This difference was due to the fact that 29 patients died during hospitalization and 26 patients could not be contacted. These 26 patients (3.25%) were analyzed as non-informative censors.

The basic characteristics of the included patients, for the total and for each of the cohorts (MST + or MST−), are presented in Table 2. The most frequent disease was COPD (42.63%), followed by CHF (33.00%), AMI (28.88%) and CAP (25.75%).

The prevalence of a positive MST (MST+) result was 24.62%. Compared to those with a negative MST result, the patients in the MST + cohort were older (73.61 vs. 68.93 years), more likely to have a subsidized healthcare plan (15.74% vs. 8.96%), less educated (9.64% vs. 16.58%) and had more comorbidities (35.03% vs. 31.84%

Table 2
Baseline characteristics of the study population according to the MST results.

Variable	Total (n = 800)	MST+ (n = 197)	MST− (n = 603)
Age, years[a]	70.08 (0.51)	73.61 (0.96)	68.93 (0.59)
Female, %	50.25 (1.77)	55.84 (3.55)	48.42 (2.04)
Subsidized healthcare, %	10.63 (1.09)	15.74 (2.60)	8.96 (1.16)
University education, %	14.88 (1.26)	9.64 (2.11)	16.58 (1.52)
High comorbidity,[b] %	32.63 (1.66)	35.03 (3.41)	31.84 (1.90)
Entry disease, %			
COPD	42.63 (1.75)	52.28 (3.57)	39.47 (1.99)
CHF	33.00 (1.66)	34.01 (3.38)	32.67 (1.91)
CAP	25.75 (1.55)	27.92 (3.20)	25.04 (1.77)
AMI	28.88 (1.60)	17.26 (2.70)	32.67 (1.91)
Hospital, %			
FCI	25.38 (1.54)	19.80 (2.85)	27.20 (1.81)
HISJ	18.75 (1.38)	13.71 (2.46)	20.40 (1.64)
HSJ	25.38 (1.54)	41.12 (3.51)	20.23 (1.64)
HUSI	30.50 (1.63)	25.38 (3.11)	32.17 (1.90)
ONS administration, %	2.38 (0.54)	5.08 (1.57)	1.49 (0.49)

Standard errors are shown in parentheses.
CCI = Charlson Co-morbidity Index.
MST = Malnutrition Screening Tool.
HUSI = San Ignacio University Hospital.
FCI = Fundación Cardioinfantil.
HSJ = Hospital de San José.
HISJ = University Hospital Infantil de San José.
[a] Average.
[b] High comorbidity implies CCI ≥3.

with a CCI ≥3). Thus, a positive MST result was associated with older age, lower level of education, female gender and greater comorbidity, indicating that the baseline characteristics at the time of hospitalization of MST + patients were, for the most part, more predictive of adverse outcomes compared to those of MST− patients. Of note, ONS administration was rarely performed for patients in either group (5.08% of MST + patients vs. 1.49% of MST− patients) (Table 2).

In relation to outcomes, Table 3 presents descriptive information for the total patient group and the MST+ and MST− cohorts. For the outcomes that could be evaluated during hospitalization, the MST + cohort showed worse outcomes than the MST− cohort, including a longer average LOS, higher average cost of total hospitalization, and higher hospital mortality rate.

For the analysis of overall mortality rate, which included mortality during hospitalization and mortality up to 30 days after discharge, the number of patients included was 774, due to 26 losses to follow-up. The results show a global mortality rate of 4.78%, with marked differences between the MST+ and MST− cohorts (10.00% vs. 3.08%, respectively).

Table 3
Descriptive comparison of outcomes for the total population according to the MST results.

Variable	Total (n = 800)	MST+ (n = 197)	MST− (n = 603)
Hospital LOS,[a] days	7.16 (0.26)	8.52 (0.59)	6.72 (0.28)
Total cost of hospitalization,[a] million COP	7.91 (0.45)	8.27 (0.90)	7.79 (0.52)
In-hospital mortality, %	3.63 (0.66)	7.61 (1.89)	2.32 (0.61)
	Total (n = 774)	**MST+ (n = 190)**	**MST− (n = 584)**
Global mortality, %	4.78 (0.77)	10.00 (2.18)	3.08 (0.72)
	Total (n = 745)	**MST+ (n = 175)**	**MST− (n = 570)**
Readmission, %	10.47 (1.12)	13.71 (2.61)	9.47 (1.23)

Standard errors are shown in parentheses.
MST = Malnutrition Screening Tool.
LOS = Length of stay.
COP = Colombian Pesos.
[a] Average.

For the analysis of readmission rate, 745 patients were included, due to differences in hospital mortality and losses to follow-up. As with the other outcomes, a higher rate of readmission was observed for patients with a positive MST result (13.71%) compared to those with a negative result (9.47%). Thus, for each of the clinical outcomes listed in Table 3, patients with a positive MST result showed a worse outcome compared to those with a negative result.

3.2. Multivariate and pairing analysis

The multivariate analyses included controls for age, gender, subsidized healthcare plan, university degree, hospitalization, entrance disease and CCI. The association of a positive MST result with each of the outcomes was evaluated.

In addition to conventional regression analysis, IPW was performed to balance the basic characteristics between cohorts. Table 4 presents the balance assessment of the total sample (raw) and weighted sample based on IPW analysis; standardized differences according to the Austin et al. recommendations [32] are shown. An absolute value of standardized difference greater than 0.1 indicates unbalance. The results show that the raw sample was unbalanced for age, gender, subsidized healthcare plan, university education and comorbidities. However, after weighting with IPW, the balance reached between cohorts for basic patient characteristics was adequate (the absolute values of all the standardized differences were less than 0.1). Additionally, an over-identification test of the baseline variables was performed [33], which resulted in a Chi-square value equal to 13.44 (p = 0.49), indicating that there was no imbalance of the baseline variables in the weighted sample.

Table 5 presents the results for hospital outcomes. By multivariate analysis, a positive MST result was associated with an average increase of 1.43 days in LOS (relative increase 29.54%). Additionally, MST positivity was associated with increases in both in-hospital mortality (odds ratio (OR) 2.39) and global mortality (OR 2.52). Thus, the association between a positive MST result and longer hospitalization and increased mortality remained after multivariate analysis. On the contrary, there was no statistically significant association between the MST result and readmission. The complete results of the multivariate analysis are presented in Supplementary Table 1.

Using the sample weighted with IPW, the qualitative results were maintained in comparison to the multivariate regression results. However, quantitatively, the association showed modifications. A positive MST result was associated with an increase of 1.56 days in average LOS, corresponding to a relative increase of 22.84% above the average value, as well as an increased risk of global mortality (OR 2.24).

Table 6 presents the results for economic outcomes, disaggregated by the following types: hospital stay, diagnostic tests, procedures and others. The results of multivariate linear regression models for hospital costs showed that a positive MST result was associated with a relative increase of 38.46% in the costs associated with hospital stay (absolute increase of COP $400,000), while no association was found for the other cost types. By IPW, a positive MST result was associated with an increase in the average cost of hospital stay of COP $440,000, equivalent to a relative increase of 30.13%. Additionally, a positive MST result seemed to be associated (at a significance of 90%) with the total cost of hospitalization and the cost associated with diagnostic tests.

4. Discussion

Disease-related malnutrition is highly prevalent across the globe and Latin American in particular, and places significant burdens on the healthcare system and economy [3]. This multicenter

Table 4
Balance assessment of the total sample (raw) and weighted sample based on IPW analysis.

	Standardized difference	
	Raw	Weighted
Age	0.34	0.03
Female	0.15	0.06
Subsidized healthcare plan	0.21	−0.01
University education	−0.21	0.01
CCI	0.04	0.00
Hospital		
HISJ	−0.18	−0.06
HSJ	0.46	0.03
HUSI	−0.15	0.04
Disease		
COPD	0.26	0.04
CHF	0.03	−0.03
CAP	0.07	0.04
AMI	−0.36	0.00

CCI = Charlson Co-morbidity Index.
HSJ = Hospital de San José.
HUSI = San Ignacio University Hospital.
HISJ = University Hospital Infantil de San José.

study was the first to examine the burden of malnutrition among patients hospitalized with cardiovascular or pulmonary disease in Colombia. The specific objectives were to investigate the association between the MST result and hospital LOS, mortality, readmission and hospital costs. Using multivariate regression and IPW analysis, the results show that a positive MST result was associated with an increase of 1.6 days in average LOS, a relative increase of 30.13% in the average cost associated with hospitalization, and an increase in the risk of mortality up to 30 days after hospital discharge.

The prevalence of malnutrition, based on a positive MST result, was 24.62% in this study. This result is lower than others reported in the literature due to the conservative inclusion and exclusion criteria used, but still notable, as nearly 1 in 4 patients with cardiovascular or pulmonary disease presented with malnutrition at the time of hospital admission. Previous studies performed in Colombia reported malnutrition rates of 63% [34] and 69.3% [35] in the general hospitalized population, which were higher than the values reported for the hospitals included in the current study. However, the prevalence obtained in the current study should not be interpreted to reflect the true prevalence of adult malnutrition at hospital admission in Colombia. The population of patients in the current study excluded those with more severe disease (i.e., life expectancy <30 days upon admission), and the four study hospitals share similar patient pathologies, which differ from other hospitals in the country.

The average LOS in patients with a positive MST result was 8.52 ± 0.59 days, as compared to 6.72 ± 0.28 days in the MST− group, and a statistically significant association between LOS and a positive MST result was demonstrated in the multivariate analysis and IPW analysis. Similar LOS findings have been reported in the US [7] and Singapore [15], and a prospective cohort study conducted in 18 Canadian hospitals found that malnutrition at admission was independently associated with prolonged LOS (hazard ratio, 0.73; 95% CI, 0.62–0.86) after controlling for demographic, socioeconomic, and disease-related factors and treatment [14]. The patients in the current study showed a global mortality rate of 4.78%, with marked differences between the MST+ and MST− cohorts (10.00% and 3.08%, respectively), and analysis of the weighted sample with IPW confirmed the increased risk of global mortality (OR 2.24) in patients with a positive MST result. This finding is in accordance with results in the literature showing higher mortality rates during

Table 5
Multivariate regression and IPW analysis of the association between a positive MST result and clinical outcomes.

Variable	(1)	(2)	(3)	(4)
	LOS (n = 800)	In-hospital mortality (n = 800)	Global mortality (n = 774)	Readmission (n = 745)
Multivariate regression				
MST	1.43** (0.61)	2.39** (1.02)	2.52** (0.94)	1.43 (0.40)
Constant	4.84*** (1.61)	0.00*** (0.00)	0.00*** (0.00)	0.20** (0.15)
R-squared	0.06	NA	NA	NA
IPW				
MST	1.56** (0.60)	2.13* (0.86)	2.24** (0.94)	1.30 (0.11)

Standard errors are shown in parentheses.
LOS = Length of stay.
MST = Malnutrition Screening Tool.
NA = Not applied.
***p < 0.01, **p < 0.05, *p < 0.1.
Column (1) presents coefficients.
Columns (2), (3), and (4) present odds ratios.

Table 6
Multivariate linear regression and IPW analysis of the association between a positive MST result and cost categories.

Variable	Total (n = 800)	Hospital stay (n = 800)	Test Dx (n = 800)	Procedures (n = 800)	Others (n = 800)
Multivariate regression					
MST	1.63 (1.03)	0.40** (0.20)	0.20* (0.11)	−0.18 (0.23)	0.94 (0.63)
Constant	12.99*** (2.71)	1.04* (0.53)	1.24*** (0.28)	1.72*** (0.61)	7.06*** (1.65)
R-squared	0.11	0.08	0.10	0.06	0.14
IPW					
MST	1.96* (1.15)	0.44** (0.20)	0.22* (0.11)	−0.17 (0.17)	1.19 (0.88)

Standard errors are shown in parentheses.
All columns present coefficients.
***p < 0.01, **p < 0.05, *p < 0.1.

hospitalization [7], at 90 days [19] and at 1, 2 and 3 years post-discharge [15] among malnourished patients.

The hospital readmission rate was not significantly associated with a positive MST result (OR 1.30). In contrast, numerous previous studies have demonstrated that hospital malnutrition increases the risk of subsequent hospitalizations [16,17,36,37]. Moreover, the overall 30-day readmission rate in this study was 10.47%, which is lower than the rates of 14.9% [17] and 17% [36] reported previously for general medicine patients. Thus, the cardiac and pulmonary patients in the current study showed a relatively low rate of hospital readmission, with no significant difference between the MST+ and MST− cohorts. Several factors may explain this finding. First, this lower rate of readmission may be explained by the organization of the healthcare system in Colombia, making comparisons to other studies performed in different countries difficult. Also, the sample size of MST+ patients may have been too small (n = 197) to produce statistically meaningful conclusions. Because different risk factors may influence early vs. late readmissions [38], the timepoint for readmission analysis could be lengthened, particularly when dealing with chronic diseases such as CHF and COPD. In support of this, one recent analysis demonstrated that malnutrition remained a significant risk factor for late readmission (up to 180 days) [16].

Despite the existence of multiple clinical guidelines specifying the care process for malnourished patients [39–41], this condition is often overlooked or undertreated. Furthermore, approximately 70% of malnourished inpatients show worsening of nutritional status during the course of a hospital stay [42]. Even among the MST + cohort in the current study, ONS was administered to only 5% of patients. Similarly, in a Brazilian study of 4000 hospitalized adults, malnutrition was present in 48%, although less than 20% of these patients' records showed documentation of nutritional issues, and only 7% of patients received enteral or parenteral nutrition support [43]. Thus, there is significant room for improvement in diagnosing and treating hospital malnutrition, the effects of which can benefit both patients and healthcare providers. Among patients admitted for cardiac and pulmonary conditions, a recent randomized clinical trial showed that targeted administration of nutrient-dense ONS led to a consistent reduction in mortality at 30, 60 and 90 days post-discharge [44]. Numerous other studies have demonstrated the benefits of nutrition interventions on reducing hospital readmissions and LOS, suggesting that ONS can be a simple, cost-effective solution to improving the health of hospitalized malnourished patients [28,45–48]. Therefore, future studies are needed to evaluate the impact of nutrition-focused interventions that include ONS provision in treating Colombian patients with cardiac and pulmonary diseases.

Adverse clinical outcomes contribute to the excessive financial burden of malnutrition on the healthcare system in the form of costly treatments, extended hospital stays and more frequent readmissions. The present study reported an increase in the average cost of hospitalization for malnourished patients, confirming the findings from many other countries [20–23]. As a result of these findings, a growing body of research aims to evaluate the cost implications of ONS treatment [49]. Recent findings demonstrate cost savings of more than $4.8 million from reduced 30-day readmissions and hospital stays associated with nutrition intervention, with a net savings of more than $3800 per patient treated for malnutrition [27]. Other reports show a reduced episode cost of $4734 (21.6% decline) among total adult inpatients [28] and a hospitalization cost reduction of $1570 (12.5% decline) among older patients with a primary diagnosis of COPD [47] following ONS provision.

This study may have limited generalizability due to the inclusion of a select hospitalized population with cardiac and pulmonary diseases, although the diseases in this patient group have been shown to be associated with a significant risk of post-discharge readmission and other adverse events [50,51]. There was also significant heterogeneity among the study population in terms of baseline clinical characteristics, the effects of which were controlled for by weighting in the IPW analysis. Because this study was the first of its kind performed in adult patients hospitalized in Colombia, few comparisons could be made to other studies. Thus, further studies are required to confirm the findings presented herein and further assess the clinical and economic impact of nutritional interventions (including screening, assessment, and treatment) in preventing malnutrition across the different Colombian health settings. Regardless of these limitations, this one of a kind study of Colombian inpatients demonstrated a high burden of malnutrition at the time of hospital admission on the health and economic outcomes for patients with cardiac and pulmonary diseases. This study also provided important information to better understand the distribution of costs associated with different health care services provided to the targeted patient population.

5. Conclusion

This multicenter prospective observational cohort study showed that nearly 25% of Colombian patients with cardiac and pulmonary diseases were malnutritioned at the time of hospital entry. However, among those presenting with malnutrition, ONS was administered to only 5% of patients. Furthermore, malnutrition, defined as a positive result on the MST, was associated with a longer LOS, higher rate of mortality, and increased cost of hospitalization. Thus, because nutritional care can improve clinical outcomes and reduce healthcare costs, greater attention to nutrition during the hospital stay is vital to providing quality care.

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Author contributions

Drs. Ruiz, Buitrago, Rodriguez, Gómez-Restrepo, Gomez, Sulo and Partridge contributed to the conception and design of the research. Drs. Ruiz, Buitrago and Rodriguez performed the statistical analyses. Drs. Ruiz, Buitrago, Rodriguez, Gómez-Restrepo, Dennis, Alba, Chaves and Araque contributed to the patient selection and to data collection. All authors read and critically revised the manuscript and gave final approval.

Conflict of interest

Drs. Gomez, Sulo and Partridge and Mr. Misas are Abbott Nutrition employees and were involved with the research design and manuscript development. No other authors report any potential conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.clnu.2018.05.016.

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