Nutrition Therapy Cost-Effectiveness Model Indicating How Nutrition May Contribute to the Efficiency and Financial Sustainability of the Health Systems

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Abstract

Background: Malnutrition is highly prevalent in hospitalized patients but seldom recognized and treated. Malnutrition poses several adverse events, such as increased infection rates, length of hospital stay, and mortality, as well as costs. Early nutrition interventions have been shown to decrease the associated malnutrition burdens, leading to relevant savings. Thus, this study aims to evaluate the cost-effectiveness of nutrition therapy, including oral supplements to at-risk or malnourished adult inpatients admitted to the Brazilian Public System (SUS) hospitals.

Method: A cost-effectiveness model, encompassing a 1-year period and regarding total costs, length of hospital stay, readmissions, and mortality related to malnutrition, was developed, having the provision of early nutrition therapy as the intervention variable. The number of avoided hospitalization days, prevented hospital readmissions, and prevented deaths defined the effectiveness of the model. All the costs were estimated based on the SUS database. Results: Early nutrition therapy provided to all at-risk or malnourished patients would represent cost-effectiveness of US $92.24, US $544.59, US $1848.12, and US $3698.92, for each day of hospitalization avoided, for additional patients having access to hospitalization, for preventing readmission, and for prevented death, respectively. The highest impact on savings was represented by the mean reduction in the length of hospital stay. Conclusion: Early oral nutrition intervention for patients malnourished or at risk of malnutrition resulted in overall reduced hospital costs. These findings provide a rationale to tackle the implementation of educational programs focusing on the care of inpatients with malnutrition or its risk. (JPEN J Parenter Enteral Nutr. 2020;0:1–9)

Keywords
cost-effectiveness; enteral nutrition; malnutrition; medical inpatients; nutrition therapy; oral supplements; parenteral nutrition

Clinical Relevant Statement

Early nutrition therapy to at-risk or malnourished patients is cost-effective, and this was the goal of the current study.

Introduction

Malnutrition is highly prevalent in hospitals worldwide.1–13 In Brazil, the prevalence of malnutrition has been reported to be about 50%, and when specific groups of patients are assessed, such as those with cancer or on the waiting list for a liver transplant, the rates reach 70%.14,15 There are several risk factors related to malnutrition, such as socioeconomic problems, particularly poverty. Depressive and emotional variations, poor oral health, and polypharmacy, especially in elderly patients, also contribute to malnutrition. However, the most relevant risk factor is the disease per se, which may lead to anorexia, changes in nutrient metabolism (absorption, distribution, storage, utilization, and excretion), drug-nutrient interactions, increased requirements, and losses, as well as metabolic derangements.2

Patients with malnutrition present increased chances of medical complications, mostly infectious, which can,
in turn, require intensified care and lead to delay in recovery, thus causing extended hospitalization time.\textsuperscript{16–19} Furthermore, malnourished patients are at higher risk of hospital readmissions and mortality.\textsuperscript{8,20–23} On the other hand, nutrition interventions—oral nutritional supplements (ONSs), enteral nutrition (EN), and parenteral nutrition (PN)—have been shown to lead to clinical improvement and may reduce the economic burden related to malnutrition.\textsuperscript{24–39} However, nutrition therapy is underrecognized and underprescribed, as demonstrated by the Inquérito Brasileiro de Avaliação Nutricional (IBRANUTRI) study\textsuperscript{13} and by other authors worldwide.\textsuperscript{40} Despite the malnutrition prevalence of 48.7%, there were few registries suggesting awareness about the nutrition status, and only a few patients were receiving nutrition therapy (6.1% EN, 4.0% oral supplements, and 1.2% PN).\textsuperscript{13}

The economic impact of malnutrition has been addressed by a few authors who have highlighted the increased related costs, and interventions have demonstrated positive cost-effectiveness and clinical outcomes.\textsuperscript{41–47} In Brazil, a model study derived from the IBRANUTRI indicated that for every dollar invested in the treatment of malnutrition, there would be a savings of US $4.\textsuperscript{48} Therefore, the goal of the current study is to provide a pharmacoeconomic model to estimate the efficiency (costs apropo of effects) related to the provision of early nutrition therapy, including oral supplements, to patients malnourished or at risk of malnutrition, considering the Brazilian Public System (SUS) reimbursement system.

Methods

To set up the economic model, at-risk or malnourished adult nonsurgical, non-oncologic hospitalized patients were considered. Critically ill patients were excluded. All the analyses were carried out based on a 1-year perspective and considering the dollar value for the year 2017. The assessed variables relied on the nutrition therapy offered by SUS. In this regard, 6.9% of the SUS hospitals are qualified to receive reimbursement and only EN and PN are covered, leaving ONSs without coverage.

The model was developed as if patients who were malnourished or at risk of malnutrition were started on nutrition therapy on the first day of hospitalization. The assessed health outcomes were avoided days of hospitalization, potential new hospitalizations, prevented readmissions, and prevented deaths. These outcomes were also used to calculate the cost-effectiveness per day of avoided hospitalization, cost-effectiveness for potential new hospitalization, cost-effectiveness due to avoided readmission, and the cost-effectiveness due to avoided deaths. Second and third alternative scenarios were also modeled. The former considered the same variables, but with nutrition therapy starting after the sixth day of hospitalization, and the latter with nutrition therapy initiated after 2 weeks of hospitalization.

A decision tree (Figure 1), according to the DATASUS admission data in the year 2017, was set up. Therefore, the data represent hospitalized patients in 2017 regarding the number of patients, number of days of hospitalization, hospitalization costs, and deaths. Since these data do not describe whether patients were nutritionally at risk or malnourished and because there was no information regarding any type of nutrition therapy, the comparator group of the decision tree was the prevalence of nutritionally at-risk or malnourished patients reported by a previous study.\textsuperscript{49} It is important to highlight that the overall prevalence of malnutrition of the latter study was lower than in data from 2 previous studies carried out in the country, in which the majority of the patients were admitted to public

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Figure1.png}
\caption{Structure of the model.}
\end{figure}
Table 1. Assumed Proportion of Nutrition Therapy, According to the Type.

| Type of nutrition therapy | Proportion of use | Reference          |
|---------------------------|-------------------|--------------------|
| Percent enteral           | 69.10%            | Clinical experts’ input |
| Percent parenteral        | 10.63%            | Clinical experts’ input |
| Percent enteral + parenteral | 20.27%       | Clinical experts’ input |

Table 2. Costs of Nutrition Therapy According to Government Reimbursement for Enteral and Parenteral Nutrition and Market Price for Oral Nutritional Supplements.

| Procedure | Unit cost | Reference |
|-----------|-----------|-----------|
| 03.09.01.004-7–Adult enteral nutrition (artificial enteral diet) | US $9.40 | SIGTAP |
| 03.09.01.007-1–Adult parenteral nutrition | US $18.80 | SIGTAP |
| Adult oral nutrition (oral nutritional supplements) | US $9.40 | Market value |

After that, we plotted what would happen if all these patients received nutrition therapy (Figure 1). For this purpose, we established a mean length of hospital stay (LOS) reduction of 0.35 days if the patients received early nutrition therapy, including oral supplements, based on a previous study with a similar population. As for nutrition therapy, we assumed that 50% of the patients, who were receiving EN, could be receiving ONSs, whereas the other 50% could be receiving tube feeding (currently, SUS does not cover oral supplements). Also, for those patients receiving both EN and PN, we assumed, based on clinical expertise, that on 80% of the days, they are receiving EN and, on 20% of the days, receiving PN. The length of time receiving nutrition therapy was estimated to be 80% of the total LOS (Table 1).

To estimate readmissions, once the SUS data do not contemplate this variable, data from a literature meta-analysis (submitted) were assessed. The latter indicated that, on average, at-risk or malnourished patients have a 31.3% risk of hospital readmission in 30 days compared with 19.7% for well-nourished individuals. Furthermore, it was hypothesized that if nutrition therapy were offered early, there would be a 6.0% reduction in hospital readmission risk over the course of 30 days. Mortality, having the same meta-analysis as support, was assumed to be decreased by 12% of patients if early nutrition were provided.

The costs of LOS are based on SUS reimbursement (supplementary material S1), and in Table 2, there are data regarding the costs of nutrition therapy.

Sensitivity analysis, using a second-order Monte Carlo simulation of 10,000 iterations, was used to investigate the effects of uncertainty in the model. The Palisade’s @risk software was used for this analysis. The results are shown as a cost-effectiveness plane. One-way deterministic sensitivity analyses were carried out, whereby input values were individually adjusted to plausible upper and lower bounds, as shown in Table 3, with 95% confidence intervals (CIs). The remaining values retained their baseline value. Because, in Brazil, there is neither an official cost-effectiveness threshold nor a consistent assessment of quality-adjusted life-years (QALYs) for malnutrition, thresholds of US $9821.41 and US $29,464.23, corresponding to 1 and 3 per-capita gross domestic product, were used.

Costs and health outcomes were not discounted, as the time horizon was only 1 year.

Results

The use of early ONSs, EN, or PN would result in 420,658 avoided days of hospitalization, 71,252 new potential admissions, 20,996 avoided readmissions, and 10,491 deaths, with an increased cost of US $38,803,768.73 compared with the current SUS configuration (Table 4). Table 4 also depicts the comparison of cost-effectiveness in case the supplementation started on the 6th and 14th day of hospitalization. The cost-effectiveness results become progressively worse as there is a delay in the initiation of supplementation.

The results of the 1-way deterministic sensitivity analysis are shown in the tornado diagrams in Figure 2, in which the most influential driver of the cost-effectiveness is at the top and the least important driver is at the bottom. The mean reduction in the LOS has the highest influence on the incremental cost-effectiveness ratio (ICER) for all 4 cost-effectiveness outcomes. The model responds less to changes in any other values, including the percentage of days receiving nutrition therapy, readmission risk reduction, and mortality risk decrease for at-risk or malnourished patients who receive interventions.

The cost-effectiveness acceptability planes (Figure 3) display the distribution of results regarding the probabilistic sensitivity analysis for all 4 cost-effectiveness outcomes. They demonstrate the high probability for all outcomes (avoidable hospitalization [85.7%], decreased potential new admissions [83.7%], avoidable readmissions [73.3%], and preventable deaths [70.7%]) if nutrition therapy were prescribed to all malnourished or at-risk patients admitted to SUS hospitals, implying a cost-per-outcome threshold of less than US $9821.41.

Discussion

Malnutrition is a highly prevalent syndrome in the hospital setting, and it impacts worse outcomes, mortality, and costs. Despite this well-known scenario,
Table 3. One-Way Deterministic Sensitivity Analyses and Probabilistic Sensitivity Analysis.

| Parameters                                                                 | Base case  | Min value | Max value | Distribution |
|---------------------------------------------------------------------------|------------|-----------|-----------|--------------|
| Percent of patients at nutrition risk                                   | 37.25%     | 26.25%    | 48.24%    | β            |
| Reduction in the number of hospital days                                 | −0.35      | −1.04     | 0.34      | Normal       |
| Percent of days with nutrition therapy                                   | 80.00%     | 70.00%    | 90.00%    | β            |
| Percent of days without nutrition therapy                                | 20.00%     | 10.00%    | 30.00%    | β            |
| Percent enteral use                                                      | 69.10%     | 57.00%    | 80.00%    | β            |
| Percent parenteral use                                                   | 10.63%     | 10.00%    | 10.00%    | β            |
| Percent enteral + parenteral use                                         | 20.27%     | 10.00%    | 33.00%    | β            |
| Percent of enteral use among those who used enteral + parenteral         | 80%        | 70.00%    | 90.00%    | β            |
| Percent parenteral use among those who used enteral + parenteral         | 20%        | 10.00%    | 30.00%    | β            |
| Enteral nutrition cost                                                   | R$30       | R$30.00   | R$45.00   | Log-normal   |
| Oral supplement cost                                                     | R$30       | R$30.00   | R$45.00   | Log-normal   |
| Parenteral nutrition cost                                                | R$60       | R$60.00   | R$90.00   | Log-normal   |
| Risk of readmission in patients with nutrition risk or malnourished      | 31.28%     | 23.16%    | 39.41%    | β            |
| Risk of readmission in patients without nutrition risk                   | 19.73%     | 14.76%    | 24.71%    | β            |
| Readmission risk reduction in patients receiving nutrition therapy       | 0.94       | 0.79      | 1.12      | Log-normal   |
| Reduction of the risk of mortality in patients that were at nutrition risk or malnourished and received nutrition therapy | 0.88       | 0.64      | 1.21      | Log-normal   |

max, maximum; min, minimum.

b Clinical expertise.

b Reimbursement and market value (in real, Brazilian money).

c Literature meta-analysis (submitted).

Table 4. Cost-Effectiveness According to the Different Modeled Scenarios.

| Parameter                                           | Incremental cost | Effectiveness | Cost-effectiveness |
|-----------------------------------------------------|------------------|---------------|--------------------|
| Early nutrition intervention                        |                  |               |                    |
| Prevented hospitalizations                          | US $38,803,768.73| 420,658       | US $92.24          |
| Potential new admissions                            | US $38,803,768.73| 71,252        | US $544.59         |
| Avoidable readmissions                              | US $38,803,768.73| 20,996        | US $1848.12        |
| Preventable deaths                                  | US $38,803,768.73| 10,491        | US $3698.92        |
| Nutrition therapy after the sixth day of hospitalization |                  |               |                    |
| Prevented hospitalizations                          | US $35,311,541.65| 111,452       | US $316.83         |
| Potential new admissions                            | US $35,311,541.65| 18,878        | US $1870.51        |
| Avoidable readmissions                              | US $35,311,541.65| 5314          | US $6645.43        |
| Preventable deaths                                  | US $35,311,541.65| 4237          | US $8333.46        |
| Nutrition therapy after the 14th day of hospitalization |                  |               |                    |
| Prevented hospitalizations                          | US $19,881,290.66| 33,671        | US $590.47         |
| Potential new admissions                            | US $19,881,290.66| 5703          | US $3485.99        |
| Avoidable readmissions                              | US $19,881,290.66| 1568          | US $12,683.16      |
| Preventable deaths                                  | US $19,881,290.66| 1522          | US $13,066.17      |

Malnutrition awareness is low,, and nutrition therapy is still underprescribed,, and its value for money is less commonly studied in the era of pharmacoeconomics.

Mitchell and Porter, in 2016, assessed the literature to establish the cost-effectiveness of identifying and treating hospital malnutrition. They reviewed data on adult patients with or at risk of malnutrition. They assessed 1174 published manuscripts, and 19 were potentially eligible, but they only included 3 in the systematic review, which highlighted the absence of high-quality data regarding the topic and limited their conclusions.. More recently, a few other authors have addressed the topic, and a study from Colombia showed that if patients received early nutrition therapy, there would be a 35.8% savings per nutrition-treated patient, and taken broadly, the potential cost savings from a nutrition care program for patients at malnutrition risk would be US $862.6 million per year.

The impact of hospital malnutrition on healthcare costs is multifactorial; however, the longer LOS was the variable that influenced the ICER for all areas of cost-effectiveness in our model. It is well known that malnourished patients remain in the hospital for longer periods. The IBRANUTRI study showed that malnourished patients had a mean LOS of 16.7 ± 24.5 days vs 10.1 ± 11.7 days.
of the well-nourished individuals. Longer LOS not only impacts costs but is also directly related to the availability of more beds, which are essential in countries with fewer resources and where it is common for hospitals to be short on availability.

Malnutrition is multifactorial, and if there are risk factors that cannot be immediately resolved by the system, such as socioeconomic imbalances, there are others that can be minimized by adequate interventions. In this regard, providing early treatment to at-risk populations, like elderly and sick patients, will decrease the burden imposed by these risk factors. Pan et al conducted a multicenter study with cancer patients to assess the influence of nutrition therapy (EN and PN) on the outcomes of those who were malnourished, and they were able to identify that patients who received EN or PN had a decreased relative risk of adverse events (EN, 0.08 [95% CI, 0.01–0.62] and PN, 0.56 [95% CI, 0.33–0.96]). Sun et al, in a randomized clinical trial with patients who were undergoing major abdominal operations and received either early postoperative oral nutrition or conventional care, showed that the intervention group had a better overall recovery. Mainly, these patients presented with better nutrient intake in the first week after the operation, and time of bowel sounds, flatus, and defecation was shortened in the individuals receiving early ONS. Moreover, these patients remained in the hospital 2 days less, and the total costs were significantly decreased. Sriram et al tested the effects of a nutrition-focused quality-improvement program (QIP) on readmissions and LOS in 4 North American hospitals. The QIP consisted of malnutrition risk screening by nurses at admission; early initiation (within 24 hours) of ONSs for at-risk patients, which were maintained post discharge; nutrition therapy; and postdischarge nutrition instructions and follow-up by telephone calls. Thirty-day readmissions and LOS were significantly decreased for at-risk or malnourished patients.

Health decision makers must be aware of the negative impact of malnutrition and the benefits of treating it early with either oral supplements, EN, or PN. Improving patient nutrition status may contribute to the efficiency and financial sustainability of the health systems. Unfortunately, few studies have addressed the value for money, the willingness-to-pay threshold, and the cost per QALY, commonly used in healthcare, regarding nutrition therapy.

Our cost-effectiveness model used the data from hospitalized patients in the public health sector in Brazil in 2017. Although there was no information regarding the nutrition status, interventions, and readmissions and although only a few hospitals were, in fact, allowed to be reimbursed for nutrition therapy, our model was able to provide a projection of what would have happened in terms of LOS, readmissions, and mortality if all nutritionally at-risk or malnourished patients were treated (including oral supplements, EN, and PN), and for this, a decision tree was used. To run the model, we assumed that 37.25% of the individuals were at risk or malnourished, a value below the
prevalence rates reported by previous studies in the country and the world\textsuperscript{8,12,15,40,50,61–66}. Therefore, this limitation, in fact, represents a potential benefit considering that many more individuals would be treated. For the other included missing SUS variables, we assumed values that have been published either in Brazil or in the world\textsuperscript{13,44,46,47} or relied on clinical expertise.

The model showed that an increase in nutrition therapy reimbursement with the addition of oral supplements (which currently is not reimbursed in the country) generates 2.2\% fewer days of hospitalization, which is in line with several other published data.\textsuperscript{42,67–69} Moreover, analysis of the 2 other scenarios (the patients would start nutrition therapy after the 6th and 14th days of hospitalization), which represent the routine practice in most hospitals, showed that the early initiation of nutrition therapy is more cost-effective. Our model also revealed that the number of readmissions may be reduced by 3\%, similar to what has been shown by other authors.\textsuperscript{67,68,70} Sharma et al, in Australia, assessed 11,750 readmissions within 6 months, with 2897 (11\%) early and 8853 (33.8\%) late readmissions. Malnourished patients had a higher risk of both early (odds ratio [OR], 1.39; 95\% CI, 1.12–1.73) and late readmissions (OR, 1.23; 95\% CI, 1.06–1.28).\textsuperscript{70}

Our study presents some further limitations. First, individual-level cost data were not collected because we used a population-based approach often used in public health, which is contrary to the high-risk approach that focuses on individuals. Whereas the former targets “vulnerable” population segments, as the hospitalized malnourished patients, the latter identifies the individual as having elevated risk of a particular outcome assessed in terms of the intervention. In this regard, to run randomized nutrition interventions to malnourished individuals to assess cost-effectiveness would be absolutely unethical. Therefore, the intersection of these 2 concepts seems appropriate and helpful in public health.\textsuperscript{71}

Second, although Brazil is a continental country with various cultural and educational nuances, this model did not account for variability and inequality in the practice of nutrition therapy, which could affect clinical and cost outcomes.

In conclusion, according to our model, the prescription of early nutrition therapy (ONS, EN, or PN) to adult patients nutritionally at risk or malnourished can decrease the LOS and hospital readmissions. Thus, there will be more available hospital beds, which would benefit more patients in need of hospitalization. Also, early nutrition therapy has shown to be cost-effective. In other words, the effects are large enough to justify the cost. This study highlights how proper medical inpatient nutrition care is of utmost importance in the quality of healthcare delivery, bringing clinically and economically significant outcomes. Furthermore, our study highlights that nutrition therapy is a valuable intervention for the healthcare system, especially for the Brazilian public health system.
Acknowledgments
We thank Grupo Estratégico de Nutrição Especializada (GENE) for funding this publication.

Funding Information
This work has been funded by Grupo Estratégico de Nutrição Especializada (GENE). The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the manuscript.

Conflicts of Interest
M. I. Toulson Davisson Correia is a speaker for Abbott Nutrition, Baxter International, Danone Nutrition, Fresenius Kabi, and Nestlé Nutrition. She is in the educational/scientific board for Baxter Nutrition, Fresenius Kabi, and Abbott. She is the receiver of a grant by CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico). D. de Oliveira Toledo is a speaker for Danone Nutrition, Fresenius Kabi, and Nestlé Nutrition. M. Castro is a speaker for Abbott Nutrition, Fresenius Kabi, and Nestlé Nutrition. M. C. M. Fonseca received a grant from Grupo Estratégico de Nutrição Especializada (GENE) to develop the hospital malnutrition model; he is the scientific director for Axia.Bio Life Sciences International, a consultancy company that provides assistance to distinct healthcare stakeholders.

Statement of Authorship
M. I. Toulson Davisson Correia, D. de Oliveira Toledo, G. Tannus Branco de Araújo, and M. C. M. Fonseca contributed to the study design; D. Sansone, D. Farah, and T. R. de Moraes Andrade contributed to the data collection and data figures; G. Tannus Branco de Araújo, M. C. M. Fonseca, D. Sansone, D. Farah, and T. R. de Moraes Andrade contributed to the data analysis; M. I. Toulson Davisson Correia, D. de Oliveira Toledo, M. Castro, G. Tannus Branco de Araújo, and M. C. M. Fonseca contributed to the data interpretation; M. I. Toulson Davisson Correia contributed to the writing and final editing of the manuscript; D. de Oliveira Toledo, M. Castro, D. Sansone, D. Farah, T. R. de Moraes Andrade, and M. C. M. Fonseca contributed to the drafting of the manuscript. All authors contributed to the final approval of the manuscript.

Supplementary Information
Additional supporting information may be found online in the Supporting Information section at the end of the article.

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