



Contents lists available at ScienceDirect

Clinical Nutrition ESPEN

journal homepage: <http://www.clinicalnutritionespen.com>

Original article

Hospital nutrition care informs potential cost-savings for healthcare: A budget impact analysis



Suela Sulo^{a,*}, Juan Vargas^b, Gabriel Gomez^c, Juan Diego Misas^c,
Aurora E. Serralde-Zúñiga^d, M. Isabel T.D. Correia^e

^a Health Economics and Outcomes Research, Abbott Nutrition, Chicago, IL, USA

^b Health Economics, EconoPharma Consulting, Mexico City, Mexico

^c Scientific and Medical Affairs and Market Access, Abbott Laboratories, Bogota, Colombia

^d Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán, Mexico City, Mexico

^e Universidade Federal de Minas Gerais, Medical School, Belo Horizonte, Brazil

ARTICLE INFO

Article history:

Received 25 August 2020

Accepted 30 January 2021

Keywords:

Mexico

Healthcare costs

Malnutrition

Hospitalized patients

Oral nutritional supplements

SUMMARY

Background and aim: In Mexico, about half of hospitalized patients are malnourished or at risk of malnutrition upon hospital admission, while many others experience deterioration of their nutritional status while in the hospital. Such patients often experience poor health outcomes and have increased hospital costs. The aim of our budget-impact analysis was to estimate potential savings associated with the implementation of a Mexican hospital-based program of nutrition care for patients at malnutrition risk or malnourished.

Methods: The budget-impact model was based on data published previously. Our model compared patients assigned to receive individualized early nutrition therapy (initiated within 24–48 h of hospital admission) with those who received standard delayed nutrition therapy (not initiated early). Outcomes included length of stay, infectious complications, and 30-day readmissions. We modeled a 30-day time-horizon, estimated event probabilities on the basis of published data, and projected costs in 2020 US dollars.

Results: Average total healthcare costs over 30-days were \$3527 for patients with early nutrition therapy vs \$6032 for patients with standard nutrition therapy—a savings of \$2505 per early nutrition-treated patient (41.5% lower). Cost differences between the groups were \$2336 vs \$3065 for hospital-associated costs (23.8% lower), \$262 vs \$780 for 30-day readmissions (66.4% lower) and \$1348 for malnutrition-associated infections. Applying these potential savings from individualized early nutrition care to a one-year estimate of 3.22 million Mexican hospital patients with malnutrition or its risk, the total overall savings for public health expenditures was equivalent to \$8.1 billion per year or 32.1% of total healthcare expenditures.

Conclusions: The results demonstrated the potential for hospital-based nutrition care programs to reduce costs of patient hospitalizations. These notable findings provide a rationale for Mexican healthcare institutions to implement programs of comprehensive nutrition-focused care for inpatients with malnutrition or its risk. To this end, we advise implementation of professional programs for education and training in order to increase awareness of patients' nutritional needs and to better prepare clinical personnel to identify, treat, and monitor patients at-risk/malnourished.

© 2021 The Author(s). Published by Elsevier Ltd on behalf of European Society for Clinical Nutrition and Metabolism. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Among patients admitted to hospitals, disease-associated malnutrition is a common condition that levies substantial health and economic burdens in Mexico (where anywhere between 23 and 65% of hospitalized population is at-risk or malnourished) and

* Corresponding author. 100 Abbott Park Road, Abbott Park, Illinois, USA.
E-mail address: Suela.sulo@abbott.com (S. Sulo).

other countries of Latin America [1–4], as it does in countries worldwide [5–11].

Being nutritionally-at-risk during hospitalization significantly raises the chance of medical complications, which can in turn necessitate intensified care, delay recovery, extend hospital length of stay, and increase the likelihood of infectious complications and hospital readmission or death [12–15]. Accordingly, healthcare professionals have expressed concern that patients hospitalized in Mexico, too often fall short on nutritional intake (oral, enteral, or parenteral nutrition) during their stay because of fasting practices and unintentionally missed meals, and because of suboptimal use of nutrition therapy to counter illness-associated appetite loss [1,16].

Such adverse health consequences are also associated with high costs to healthcare providers and payers. In fact, the annual economic burden of disease-associated malnutrition in Latin America was recently estimated as \$10 billion United States dollars (US, USD) [17]. A health economic study of malnourished patients in Colombian hospitals showed health and cost consequences—a 1.4-day longer length of stay, more than doubled risk of 30-day mortality, and approximately 30% increase in the incident cost of hospitalization [3]. In Mexico, malnutrition or its risk reportedly affects about half of all inpatients, so disease-associated malnutrition similarly imposes excess financial costs on the Mexican healthcare system [12,13,18].

Despite the known negative consequences of malnutrition, only limited research has been done to quantify benefits of interventional nutrition care in hospitals of Mexico. A key study by Cano-Torres and colleagues (n = 55 patients) recently showed that hospitalized patients who were diagnosed as malnourished and provided an individualized nutrition care plan had a 2-day shorter length of stay than did patients who had no plan; such findings suggest faster recovery from illness with associated potential for cost-savings [19].

In the present budget-impact analysis, our objective was to build a scaled-up estimate of the total annual cost savings from providing comprehensive nutrition care for at-risk/malnourished patients in hospitals across Mexico. Such an estimate can help shape the rationale for community- and hospital-based nutrition policies that will in turn guide care programs for individuals with malnutrition or its risk.

2. Methods

Literature review. A PubMed, HEED and Cochrane search was conducted using relevant keywords to identify primary and review articles on health and economic outcomes and costs associated with disease-associated malnutrition in hospitalized patient populations between January 2015 and March 2019. Keywords (either alone or in combination) included in the search were: disease-associated malnutrition, hospital malnutrition, malnutrition, undernutrition, length of stay, cost, hospital stay, readmission within 30-days, comorbidity, infections, complications, hospitalization, Latin America, and Mexico. We considered articles in English, Spanish, and Portuguese as eligible for review.

From identified articles (N = 29), four were selected based on the target population, analyzed outcomes (length of stay, readmission, infectious complications), and interventions (initial screening and nutritional therapy) to build the model: (1) Sriram et al. for the association between nutritional intervention and improved outcomes, especially 30-day readmissions [20]; (2) Correia et al. for estimates of ward hospitalizations in Latin American countries, including Mexico [17]; (3) Correia et al. for the prevalence of malnutrition-associated infections in Latin American countries;¹³ and (4) Canos-Torres et al. for outcomes of interest,

especially length of stay and cost analysis of early nutritional therapy for malnourished hospitalized patients in Monterrey, a city in northern Mexico [19].

Budget impact model. As described for a similar budget-impact analysis in at-risk/malnourished hospitalized patients in Colombia [4], we modeled an association between nutrition interventions and 30-day readmission using data from the US study by Sriram et al. [20] To fill-in the model for complications, we used data from a Latin America country analysis of infectious complications [13] and for length of stay, we used data from a Mexican study at a hospital in Monterrey [19]. In that study, researchers randomly allocated patients with a diagnosis of malnutrition to either an intervention or a control group. Participants in the intervention group received an individualized nutrition plan according to energy and protein intake requirements, as well as dietary advice based on face-to-face interviews with patients and their caregivers or family members. Individuals in the control group received standard delayed nutritional management according to usual hospital procedures.

The US [20] and Mexican [19] hospitals in the two studies were generally similar in terms of target population, patient diagnoses, nutritional intervention procedures, and patient sociodemographic characteristics (Table 1) [19,20].

Cost modeling. All costs were calculated from the perspective of a third-party payer, corresponding to costs generated for care in the Mexican health system and reported in year 2020 USD (\$). For the costs reported in the model, a variety of data sources were used for nutritional therapy evaluation, ONS, cost per inpatient day in the hospital, and readmission costs (Table 2).

Despite an increase in a wide range of complications reported for malnourished patient populations (e.g., sepsis, pneumonia, cardiac arrest, respiratory failure, pressure ulcers, postoperative pulmonary complications (atelectasis, trachea bronchitis, pneumonia), reoperation, and wound dehiscence) [13], the present cost modeling analysis only includes the most commonly malnutrition-associated infections reported in the literature and their costs (Table 3).

3. Results

Results of our budget-impact analysis provided an estimate of cost savings that could be derived from instituting nutrition care programs for patients with malnutrition or its risk in hospitals across Mexico. We found that average total healthcare cost estimates over 30-days were \$3527 for patients with individualized early nutrition therapy compared to \$6032 for patients with standard delayed nutrition therapy—a savings of \$2505 (41.5% lower) per individualized early nutrition therapy patient (Table 4).

For a full-scale estimate, we applied the potential per-patient savings to a one-year estimate of over 3.22 million hospitalized malnourished Mexican patients. We thus projected a total savings of \$8.1 billion per year on public health expenditures. Given a total Mexican healthcare cost equivalent of \$25.1 billion, a \$8.1 billion savings represents a 32.1% overall cost savings each year (Table 5).

4. Discussion

Summary of study findings. Our budget-impact analysis provided a scaled-up estimate of cost savings that could be derived from a comprehensive and individualized nutrition care program for patients with malnutrition or its risk in hospitals across Mexico. In our analytic model with a 30-day time horizon, average healthcare cost estimates were \$3527 for patients with individualized early nutrition therapy compared to \$6032 for patients with standard delayed nutrition therapy, which leads to a 41.5% savings

Table 1
Comparison of nutrition programs used for the budget-impact model.

Program components	US Nutrition Program Sriram et al., 2017	Mexican Nutrition Program Cano-Torres et al., 2017
Screening with validated tool on hospital admission	Yes, MST*	Yes, NRS-2002†
Registered dietitian or clinician consult	Yes	Yes
Oral diet + early intervention with oral nutritional supplement	Yes	Yes
Discharge education and planning	Yes	Yes
Patient characteristics		
Adult patients	≥18 years	≥20 years
Multiple diagnoses	Yes	Yes
Outcomes		
Length of stay for intervention, control	Yes	Yes
Readmissions	Yes	No
Infections	No	No

*MST, Malnutrition Screening Tool [21]; NRS, Nutritional Risk Screening 2002 [22].

Table 2
Sources for cost analysis.

Concept	Cost, in USD ^a	Reference
Nutritional therapy evaluation ^b	\$33.35	Mexican Social Security Institute (IMSS), 2020 ^c
Oral nutritional supplement (2 bottles/day) ^d	\$4.40	Abbott Laboratories, Chicago, IL
Cost per inpatient day	\$364.92	IMSS, 2020 ^c
Readmission cost	\$2700.43	Estimated ^e

^a Costs in USD were determined using a pesos/dollar exchange rate MXN/USD: 23.9283 consulted 5/04/2020 at <https://www.banxico.org.mx/tipcamb/main.do?page=tip&idioma=sp>.

^b Based on consultations at admission, at the time of malnutrition diagnosis for patients who received intervention, and in preparation for discharge.

^c DOF 30/12/2019 available at <http://www.imss.gob.mx/sites/all/statics/pdf/acuerdos/4165.pdf>.

^d Estimated as a weighted average of \$2.20 USD/bottle, considering a cost of \$2.30 for Ensure and \$2.00 for Glucerna at 70:30 use ratio.

^e IMSS 2020 cost/hospital day x length of stay from Cano-Torres et al., 2017 [19].

Table 3
Malnutrition-associated infection prevalence and treatment cost.

Type of Infection	DRG ^a -IMSS	Treatment Cost ^b	Infection Prevalence	
			With Malnutrition	Without Malnutrition
Pulmonary infection	DRG 193	\$4104	5.9%	4.1%
Urinary infection	DRG 689	\$3239	3.7%	1.9%
Wound infection	DRG 857	\$6292	1.7%	2.1%
Intra-abdominal abscess	DRG 371	\$3615	2.1%	0.4%
Pneumonia ^c	DRG 193	\$4104	20.3%	6.3%
Sepsis ^d	DRG 871	\$10,077	7.7%	1.7%

^a DRG, Diagnosis Related Group; IMSS, Mexican Social Security Institute.

^b All DRG costs were updated to 2020 cost by applying a 82.56% accumulated Inflation from January 2004 to January 2020 as reported in <https://www.inegi.org.mx/app/indicesdeprecios/calculadorainflacion.aspx>; using an exchange rate MXN/USD: 23.9283 consulted 5/04/2020 at <https://www.banxico.org.mx/tipcamb/main.do?page=tip&idioma=sp>.

^c Used the total prevalence of pneumonia [mild 34/171 (19.9%) and severe 12/56 (21.4%) malnutrition] as reported by Perman et al., 2001.

^d Sepsis rate was estimated as the weighted average of the two values reported by Correia et al., 2017 [13]. Thus, Correia et al., 20,032 [well-nourished = 5/467 (1.07%); malnourished = 9/242 (7.68%)] and Perman et al., 2001 [for pneumonia, we use the total prevalence of sepsis] [well-nourished = 7/221 (3.17%); malnourished = 27/227 (11.9%) resulting from mild 17/171 (9.9%) and severe 10/56 (17.9%) malnutrition categories].

per individualized early nutrition-treated patient, or \$2505 each. When applying a one-year estimate of over 3.22 million hospitalized malnourished patients, we projected a potential total savings of \$8.1 billion (or 32.1%) per year for public health expenditures in Mexico — a savings that is clinically and economically important.

Malnutrition and excess healthcare costs worldwide. As in Mexico, excess healthcare costs for people with malnutrition have likewise been projected from studies around the world. European Union governments together spend at least €120 billion annually for care of 20 million patients affected by disease-associated malnutrition [25], while costs in the Netherlands totaled 2.1% of the country's national health expenditure [26]. In one US study, results showed that hospitalized patients with malnutrition had more than a 50% higher rate of 30-day readmission compared to adequately nourished patients, and the cost of a readmission

episode was about 30% more for a malnourished patient than for a non-malnourished patient (\$17,000 vs \$13,000) [27]. Similarly, costs for hospitalization in Canada were on average more than 30% higher for malnourished patients than for well-nourished patients with similar characteristics [7]. And in Singapore hospitals, malnourished patients (29% of all patients) had higher costs for hospitalization due to significantly longer hospital stays and twice the likelihood of hospital readmission within 15 days [10].

Nutrition care benefits shown by other Latin American and world countries. Other recent studies have demonstrated that nutritional interventions for patients with disease-associated malnutrition are associated with better outcomes at lower healthcare costs. For example, a Colombian hospital study showed that individualized early implementation of nutrition therapy for malnourished patients led to shortened length of stay, fewer

Table 4
Per-patient budget impact of using an individualized nutrition therapy.

Item	IMSS-2020 Unitary Cost	Individualized Nutrition Therapy		Standard Nutrition Therapy	
		Quantity	Total	Quantity	Total
Nutritional therapy evaluation ^a	\$33.35	2	\$67	1	\$33
Oral nutritional supplement (2 bottles/day) ^b	\$4.40	12.8	\$56	–	–
Cost per inpatient day ^c	\$364.92	6.4	\$2336	8.4	\$3065.36
30-day readmission rate; mean length of hospital stay of 7.4 days ^d	\$2700	9.7%	\$262	28.9%	\$780
Pulmonary infection DRG 193 ^e	\$4104	4.1%	\$168.26	5.9%	\$242.14
Urinary infection DRG 689 ^e	\$3239	1.9%	\$61.54	3.7%	\$119.84
Wound infection DRG 857 ^e	\$6292	2.1%	\$132.13	1.7%	\$106.96
Intra-abdominal abscess DRG 371 ^e	\$3615	0.4%	\$14.46	2.1%	\$75.92
Pneumonia DRG 193 ^e	\$4104	6.3%	\$258.55	20.3%	\$833.11
Sepsis DRG 871 ^e	\$10,077	1.7%	\$171.31	7.7%	\$775.93
		Total	\$3527	Total	\$6032
Per-patient saving			\$2505		

DRG, Diagnosis Related Group

^a Individualized Nutrition Therapy required an additional initial screening for malnutrition risk, as reported by Sriram et al., [20].^b Recommended daily oral nutritional supplement.^c The length of stay for Mexican patients with/without an early nutritional therapy are taken from Canos-Torres et al. [19].^d The readmission rates are taken from the readmission data informed by a quality improvement program of hospitalized malnourished patients as reported by Sriram et al., [20]; The length of stay at readmission was estimated as the average hospital stay of bout groups (patients with/without an early nutritional therapy) as reported by Canos-Torres et al. [19].^e All malnourished-associated infection prevalence and costs are described in Table 3.**Table 5**
Estimated cost savings with use of nutrition care programs in Mexican hospitals.

Parameter	Value
Total number of hospitalizations in Mexico 2020 ^a	6,562,235
Hospitalized patients with malnutrition ^b	49.1%
Estimated number of hospitalized patients with malnutrition	3,222,058
Calculated savings/patient, based on use of individualized nutrition care plan	\$2505
Potential cost savings in Mexico with hospital nutrition care programs	\$8.1 billion
National public health expenditure in Mexico 2019^b	\$25.1 billion
Potential savings to Mexican healthcare system, % total health expenditure	32.1%

^a Estimated total ward patient admissions/year [17] updated to reflect 2020 projections according to growth projected by the Mexican Population Council [23].^b Global Initiative for Fiscal Transparency [24].

complications, and lower mortality rates [15]. A subsequent budget-impact analysis, which was based on malnourished inpatients in Colombian hospitals, projected a 36% cost savings over 60 days for patients who received individualized early nutrition interventions compared to those whose nutrition interventions were delayed [4]. When applied broadly, these savings were extrapolated to \$862.6 million USD per year in Colombia [4].

For patients in US hospitals, researchers similarly reported that a quality improvement program focused on nutrition interventions (oral nutritional supplement + patient education + post-discharge nutrition care) had the potential to reduce per-patient 30-day healthcare costs by over \$3800 as a result of lowering hospital readmission rates and reducing lengths of hospital stays [28]. As well, results of a systematic review and meta-analysis showed that nutrition intervention with ONS reduced mortality risk by 35%, reduced complications by 35%, and reduced length of hospital stay by approximately 2 days or approximately 13% reduction [29]. Findings in a recent review and cost analysis indicated that the US Medicare system could save as much as \$580 million annually by providing nutrition-focused care in 5 key therapeutic areas (sepsis, gastrointestinal cancer, hospital-acquired infections, surgical complications, and pancreatitis) [30]. Finally, a large multi-center randomized controlled study of 2088 patients in Switzerland (EFFORT trial) demonstrated that early nutrition therapy (ONS provision within 48 h of hospital admission) among malnourished hospitalized patients reduced adverse clinical outcomes including

30-day mortality, while improving functional outcomes and quality of life [31]. The authors also showed that nutrition therapy in medical hospitalized patients is a highly cost-effective intervention due to reducing risks for intensive care unit admissions and hospital-associated complications, while improving patient survival [32].

4.1. Limitations

This study has several limitations. Readmission data were informed by a comprehensive nutrition-focused quality improvement program of hospitalized malnourished US patients rather than Mexican patients. Similarly, due to lack of infectious complications information for Mexico patients, numbers reported by Correia et al. for a collection of countries in Latin America [3] were used to estimate the impact of malnourished-associated infections health expenditure, showing that the nutrition care therapy represents an opportunity for the Public Health System to generate an incremental cost savings per patient up to \$1348. Also, the costs and savings were calculated from a third-party payer perspective in Mexico; hence the model does not consider the societal perspective since it does not account for the full range of direct and indirect costs and savings (e.g., productivity gain arising from patients' ability to work as a result of being discharged earlier from the hospital, not being readmitted, or not experiencing complications), associated with the early nutrition therapy. Also, the model results

are not generalizable to non-Mexican hospitals or hospital systems. Finally, the model uses a short-term period of 30-days and does not consider the variability success of implementing an individualized nutrition care program, which could affect both outcomes and costs. Future models are needed to validate our findings with data coming out of nutrition-focused programs with Mexico patients that in addition to length of stay, infectious complications, and 30-day readmissions can also assess the impact of early nutrition therapy on other outcomes of interest not accounted for in this analysis.

5. Summary and conclusions

About half of all patients admitted to hospitals in Mexico are malnourished upon hospital admission and many more patients experience nutritional decline while in the hospital [13]. Disease-associated malnutrition has also been reported in nearly 50% of adult patients in Argentina, Brazil, Chile, Costa Rica, Cuba, Dominican Republic, Ecuador, Panama, Paraguay, Peru, Puerto Rico, Venezuela, and Uruguay [1]. We note that malnutrition among hospital inpatients worsens health outcomes and elevates burdens for care and cost to medical providers and payors. For malnourished patients, at the time of admission to hospitals, nutrition-focused care during hospitalization—by systematic screening for and identification of malnutrition and by use of oral nutritional supplements when appropriate—is a clear pathway to lessen in-hospital complications, speed recovery and shorten length of stay, and lower risk for hospital readmission.

We underscore the compelling results of our current nutrition-focused budget-impact analysis—a potential for cost-savings about \$8.1 billion per year by implementation of nutrition care programs in Mexican hospitals. This savings represents a remarkable 32.1% of Mexico's total annual healthcare expenditures. Based on these findings, we call for concerted efforts to enhance hospital procedures for identifying and treating malnourished patients in hospitals of Mexico and worldwide [33–35].

Trial registration

Not applicable.

Funding

Abbott provided a grant to cover expenses associated with the economic analysis.

Author contributions

S Sulo: Conceptualization, Investigation, Funding acquisition, Original draft; G Gomez, JD Misas, AE Serralde-Zúñiga, MITD Correia: Conceptualization, Writing - review & editing; J Vargas: Formal analysis and Writing - review & editing.

Declaration of competing interest

S Sulo, G Gomez, and JD Misas are employees and stockholders of Abbott. J Vargas received funding for the model development by Abbott. MITD Correia has received honoraria and funding from Abbott, Nestle, Baxter, Fresenius Kabi, Danone, and Takeda. AE Serralde-Zúñiga reports no conflicts of interest.

Acknowledgments

We would like to thank Cecilia Hoffman for support with manuscript editing and bibliography.

References

- [1] Correia MI, Hegazi RA, Diaz-Pizarro Graf JI, Gomez-Morales G, Gutierrez CF, Goldin MF, et al. Addressing disease-related malnutrition in healthcare: a Latin American perspective. *JPEN J Parenter Enteral Nutr* 2016;40(3): 319–25.
- [2] Castillo Pineda JC, Gomez Garcia A, Velasco N, Diaz-Pizarro Graf JI, Matos Adames A, Mijan de la Torre A. Nutritional assessment of hospitalized patients in Latin America: association with prognostic variables. The ENHOLA study. *Nutr Hosp Jun 30 2016*;33(3): 665–662.
- [3] Ruiz AJ, Buitrago G, Rodriguez N, Gomez G, Sulo S, Gomez C, et al. Clinical and economic outcomes associated with malnutrition in hospitalized patients. *Clin Nutr Jun 1 2019*;38(3):1310–6.
- [4] Buitrago G, Vargas J, Sulo S, Partridge J, Guevara-Nieto M, Gomez G, et al. Targeting malnutrition: nutrition programs yield cost savings for hospitalized patients. *Clin Nutr Dec 26 2019*;39(9):2896–901 [Epub ahead of print].
- [5] Corkins MR, Guenter P, DiMaria-Ghalili RA, Jensen GL, Malone A, Miller S, et al. Malnutrition diagnoses in hospitalized patients: United States, 2010. *JPEN J Parenter Enteral Nutr Feb 2014*;38(2):186–95.
- [6] Correia MI, Campos AC, Study EC. Prevalence of hospital malnutrition in Latin America: the multicenter ELAN study. *Nutrition Oct 2003*;19(10):823–5.
- [7] Curtis LJ, Bernier P, Jeejeebhoy K, Allard J, Duerksen D, Gramlich L, et al. Costs of hospital malnutrition. *Clin Nutr Oct 2017*;36(5):1391–6.
- [8] Goates S, Du K, Braunschweig CA, Arensberg MB. Economic burden of disease-associated malnutrition at the state level. *PLoS One 2016*;11(9):e0161833.
- [9] Khalatbari-Soltani S, Marques-Vidal P. The economic cost of hospital malnutrition in Europe; a narrative review. *Clin Nutr ESPEN Jun 2015*;10(3):e89–94.
- [10] Lim SL, Ong KC, Chan YH, Loke WC, Ferguson M, Daniels L. Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality. *Clin Nutr Jun 2012*;31(3):345–50.
- [11] Barrett M, Baily M, Owens P. Non-maternal and non-neonatal inpatient stays in the United States involving malnutrition. US Agency for Healthcare Research and Quality 2018; 2016. 2018, www.hup-us.ahrq.gov/reports.jsp.
- [12] Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. *Clin Nutr Jun 2003*;22(3):235–9.
- [13] Correia MITD, Perman MI, Waitzberg DL. Hospital malnutrition in Latin America: a systematic review. *Clin Nutr. Aug 2017*;36(4):958–67.
- [14] Cangelosi MJ, Rodday AM, Saunders T, Cohen JT. Evaluation of the economic burden of diseases associated with poor nutrition status. *JPEN J Parenter Enteral Nutr Nov 2014*;38(2 Suppl):355–41S.
- [15] Giraldo NA, Vásquez Velásquez J, Roldán Cano PA, Ospina Astudillo C, Sosa Cardona YP. Cost-effectiveness of early nutritional therapy in malnourished adult patients in a high complexity hospital. *Nutr Hosp 2015*;32: 2938–47.
- [16] Arenas Moya D, Plascencia Gaitan A, Ornelas Camacho D, Arenas Marquez H. Hospital malnutrition related to fasting and underfeeding: is it an ethical issue? *Nutr Clin Pract Jun 2016*;31(3):316–24.
- [17] Correia MITD, Perman MI, Pradelli L, Omaralsaleh AJ, Waitzberg DL. Economic burden of hospital malnutrition and the cost-benefit of supplemental parenteral nutrition in critically ill patients in Latin America. *J Med Econ. Nov 2018*;21(11):1047–56.
- [18] Áncer-Rodríguez PR, Porrata-Mauria C, Hernández-Triana M, Salinas-Zamora M, Bernal-García K, Trejo-Guzman V, et al. Nutritional screening and prevalence of hospital malnutrition risk. University Hospital of the UANL, Monterrey. *Medicina Univerditaria 2014*;16(65):165–70.
- [19] Cano-Torres EA, Simental-Mendia LE, Morales-Garza LA, Ramos-Delgado JM, Reyes-Gonzalez MM, Sanchez-Nava VM, et al. Impact of nutritional intervention on length of hospital stay and mortality among hospitalized patients with malnutrition: a clinical randomized controlled trial. *J Am Coll Nutr May–Jun 2017*;36(4):235–9.
- [20] Sriram K, Sulo S, VanDerBosch G, Partridge J, Feldstein J, Hegazi RA, et al. A comprehensive nutrition-focused quality improvement program reduces 30-day readmissions and length of stay in hospitalized patients. *JPEN J Parenter Enteral Nutr Mar 2017*;41(3):384–91.
- [21] Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutrition Jun 1999*;15(6):458–64.
- [22] Kondrup J, Allison SP, Elia M, Vellas B, Plauth M, et al. ESPEN guidelines for nutrition screening 2002. *Clin Nutr Aug 2003*;22(4):415–21.
- [23] <https://www.gob.mx/conapo/articulos/proyecciones-de-la-poblacion-de-los-municipios-de-mexico-2015-2030-215756>.%20Proyecciones%20de%20la%20Población%20de%20los%20municipios%20de%20México. [Accessed 12 March 2020].
- [24] Accessed, https://www.transparenciapresupuestaria.gob.mx/es/PTP/infografia_ppef2019.%20Proyecto%20de%20presupuesto%20de%20egresos%20de%20la%20federacion. [Accessed 12 March 2020].
- [25] Ljungqvist O, van Gossum A, Sanz ML, de Man F. The European fight against malnutrition. *Clin Nutr Apr 2010*;29(2):149–50.
- [26] Freijer K, Tan SS, Koopmanschap MA, Meijers JM, Halfens RJ, Nuijten MJ. The economic costs of disease related malnutrition. *Clin Nutr Feb 2013*;32(1): 136–41.
- [27] Fingar KR, Weiss AJ, Barrett ML, Elixhauser A, Steiner CA, Guenter P, et al. All-cause readmissions following hospital stays for patients with malnutrition,

- 2013; statistical brief #218. Healthcare Cost and utilization project (HCUP) statistical briefs. Rockville (MD); 2016.
- [28] Sulo S, Feldstein J, Partridge J, Schwander B, Sriram K, Summerfelt WT. Budget impact of a comprehensive nutrition-focused quality improvement program for malnourished hospitalized patients. *Am Health Drug Benefits* Jul 2017;10(5):262–70.
- [29] Elia M, Normand C, Norman K, Laviano A. A systematic review of the cost and cost effectiveness of using standard oral nutritional supplements in the hospital setting. *Clin Nutr* Apr 2016;35(2):370–80.
- [30] Tyler R, Barrocas A, Guenter P, Araujo-Torres K, Bechtold ML, Chan L, et al. Value of nutrition support therapy: impact on clinical and economic outcomes in the United States. *JPEN J Parenter Enteral Nutr* Mar 2020;44(3):395–406.
- [31] Schuetz P, Fehr R, Baechli V, Geiser M, Deiss M, Gomes F, et al. Individualised nutritional support in medical inpatients at nutritional risk: a randomised clinical trial. *Lancet* 2019;393(10188):2312–21.
- [32] Schuetz P, Sulo S, Walzer S, Vollmer L, Stanga Z, Gomes F, et al. Economic evaluation of individualized nutritional support in medical inpatients: secondary analysis of the EFFORT trial. *Clin Nutr* 2020;39(11):3361–8.
- [33] Sherry CL, Sauer AC, Thrush KE. Assessment of the nutrition care process in US hospitals using a web-based tool demonstrates the need for quality improvement in malnutrition diagnosis and discharge care. *Curr Dev Nutr*. Nov 2017;1(11):e001297.
- [34] Tobert CM, Mott SL, Nepple KG. Malnutrition diagnosis during adult inpatient hospitalizations: analysis of a multi-institutional collaborative database of academic medical centers. *J Acad Nutr Diet* Jan 2018;118(1):125–31.
- [35] Tappenden KA, Quatrara B, Parkhurst ML, Malone AM, Fanjiang G, Ziegler TR. Critical role of nutrition in improving quality of care: an interdisciplinary call to action to address adult hospital malnutrition. *JPEN - J Parenter Enter Nutr* Jul–Aug 2013;37(4):482–97.