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Cost savings associated with nutritional support in medical inpatients: an economic model based on data from a systematic review of randomised trials

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ABSTRACT

Background and aims Nutritional support improves clinical outcomes during hospitalisation as well as after discharge. Recently, a systematic review of 27 randomised, controlled trials showed that nutritional support was associated with lower rates of hospital readmissions and improved survival. In the present economic modelling study, we sought to determine whether in-hospital nutritional support would also return economic benefits.

Methods The current economic model applied cost estimates to the outcome results from our recent systematic review of hospitalised patients. In the underlying meta-analysis, a total of 27 trials (n=6803 patients) were included. To calculate the economic impact of nutritional support, a Markov model was developed using transitions between relevant health states. Costs were estimated accounting for length of stay in a general hospital ward, hospital-acquired infections, readmissions and nutritional support. Six-month mortality was also considered. The estimated daily per-patient cost for in-hospital nutrition was US$6.23.

Results Overall costs of care within the model timeframe of 6 months averaged US$63 227 per patient in the intervention group versus US$66 045 in the control group, which corresponds to per patient cost savings of US$2818. These cost savings were mainly due to reduced infection rate and shorter lengths of stay. We also calculated the costs to prevent a hospital-acquired infection and a non-elective readmission, that is, US$820 and US$733, respectively. The incremental cost per life-day gained was –US$1149 with 2.53 additional days. The sensitivity analyses for cost per quality-adjusted life day provided support for the original findings.

Conclusions For medical inpatients who are malnourished or at nutritional risk, our findings showed that in-hospital nutritional support is a cost-effective way to reduce risk for readmissions, lower the frequency of hospital-associated infections, and improve survival rates.

Strength and limitations of this study

- ⇒ Large data set of randomised nutritional trials based on a recent systematic reviewand meta-analysis.
- ⇒ Different patient-relevant outcomes considered in the cost analyses.
- ⇒ Calculation of costs and cost savings from the perspective of the 27 hospitals included in the underlying meta-analysis which limit generalisability.
- ⇒ Focusing on direct costs as the main drivers of economic decision, but not on costs associated with faster recovery, less disability and lower loss of work productivity.

INTRODUCTION

As a significant public health issue, malnutrition has detrimental effects on the care and recovery of hospitalised patients.[1] If unrecognised or undertreated, impaired nutritional status can worsen health outcomes and escalate healthcare use and costs.[2 3] Nutritional shortfalls occur when unintended loss of weight and muscle result from collusion of various predisposing factors—older age, limited physical activity, insufficient protein and energy intake relative to needs, altered hormone function, and anorexia.[4] Studies estimate that between 30% and 50% of adult inpatients are malnourished or at nutritional risk when admitted to hospital; nutritional risk is higher in patients who are older and have underlying chronic health conditions.[5–7]

The presence of malnutrition can impair a patient's response to medical treatment and can increase susceptibility to hospital-acquired comorbidities, which include urinary tract infections, falls and fractures, acute respiratory infections, skin tears, and hospital-acquired pressure injuries.[8–10] As a result, malnutrition in a hospitalised adult can hinder the patient's recovery, prolong length of hospital stay, and increase the need for postdischarge institutional care.[8–11]

Not surprisingly, the high prevalence and adverse effects of malnutrition in hospitalised

patients affect the overall cost of healthcare in the USA, as in the rest of the world. The estimated annual cost of disease-associated malnutrition in the USA is over US$15.5 billion.[7] In Canada, the added cost of in-hospital care for a malnourished patient is US$1500–2000 per hospital stay (compared with the cost for an adequately nourished patient); this translates to an excess US$1.56–2.1 billion per year, similar to the US when adjusted for population.[5] Studies from Latin America estimate an annual costs of US$10.2 billion for management of malnourished patients in public hospitals,[12 13] and studies from Europe and Asia likewise report markedly higher costs for care of malnourished hospital patients.[14–18]

Identifying and treating malnutrition are critical to improving patient health outcomes and to reducing healthcare costs.[6] To identify and manage hospitalised patients at risk for malnutrition, nutrition-focused quality improvement programmes can be used to guide nutrition screening and assessment, to intervene with nutrition care when needed, and to provide ongoing monitoring and adjustment of nutrition, as needed.[19 20] Such programmes improved patient outcomes and decreased healthcare costs, as evidenced by reduced rates of hospital-acquired infections, shorter lengths of hospital stay, and lower rates of readmission.[19 21–24] A systematic review of studies using oral nutritional supplements to treat malnutrition revealed cost savings, which were attributed to fewer medical complications, shortened hospital stays, prevention of pressure ulcers, and improved quality-adjusted life years.[25] A large clinical trial on use of individualised nutritional support during hospitalisation showed improved nutritional intake, functional outcome, and quality of life, along with lowered risk of adverse effects and decreased 30-day mortality.[26] Results of the follow-on economic-evaluation study demonstrated cost savings related to reduced intensive care unit stays and fewer hospital-acquired complications.[27]

Gomes *et al* recently conducted a systematic review of 27 trials of patients who were malnourished or at risk of malnutrition on admission to the hospital.[4] Results showed that in-hospital nutritional support could significantly improve patient outcomes by increasing patients' energy and protein intake, which was associated with weight gain, lowered mortality rates, and reduced rates of non-elective hospital readmissions.[4] Based on these findings, the aim of our current analysis was to use economic modelling to predict whether benefits of in-hospital nutritional support are accompanied by returns in terms of economic benefits. In modelling, we also considered other Gomes *et al* endpoints that showed a clinically meaningful improvement, that is, lowered infection rates and shorter length of stay in hospital.[4]

METHODS

To clarify the current economic modelling analysis, we provide definitions of health economic terms used in our report (table 1).[28] Our model examined costs and potential cost benefits of using nutritional support for hospitalised patients. Nutritional support includes (1) screening admitted patients for malnutrition or its risk, (2) for those identified, systematic nutritional assessment by a dietitian, including recommendations for nutritional targets, (3) development of an individualised nutritional care plan, including implementation and follow-up.[26 29]

Economic modelling and analysis

For our Markov model, we assumed that all patients were in a stable health state—hospitalised and malnourished (figure 1). Thereafter, patients could develop major infections. This was modelled as a separate health state because the probability of death, as well as healthcare costs and utilisation, were assumed to be higher in comparison with patients not experiencing in-hospital complications. In another state, patients could be discharged from the hospital. Following discharge, patients may require unplanned readmission to the hospital. Finally, patients have different probabilities of death in each state, depending on their health status.

Table 1 Definition of terms for health economic analyses

Markov model	A model used for randomly changing systems. Applied to healthcare, Markov models assume that a patient is in one of a finite number of discrete health states, for example, inpatient with malnutrition, inpatient with infectious complication, patient discharged from hospital, or patient readmitted to hospital non-electively. In modelling, the patient transitions from one state to another, with death as an unalterable state.
Cost effectiveness	Value for the cost. In healthcare, the goal is to maximise the benefit of treatment for a patient population while using limited resources.
Incremental Cost-Effectiveness Ratio (ICER)	Used in health economics to compare two different interventions in terms of the cost of *gained* effectiveness. ICER is computed by dividing the difference in cost of 2 interventions by the difference of their effectiveness, for example, if treatment A costs US$50 per patient and provides 2 quality-adjusted life days (QALDs), and treatment B costs US$80 while providing 3 QALDS, the ICER of treatment B is US$80-50/3-2 = US$30. The ICER determination is also called a cost–utility analysis.
Sensitivity analysis	A "what-if" analysis. This value focuses on what happens to the dependent variable when various parameters change.

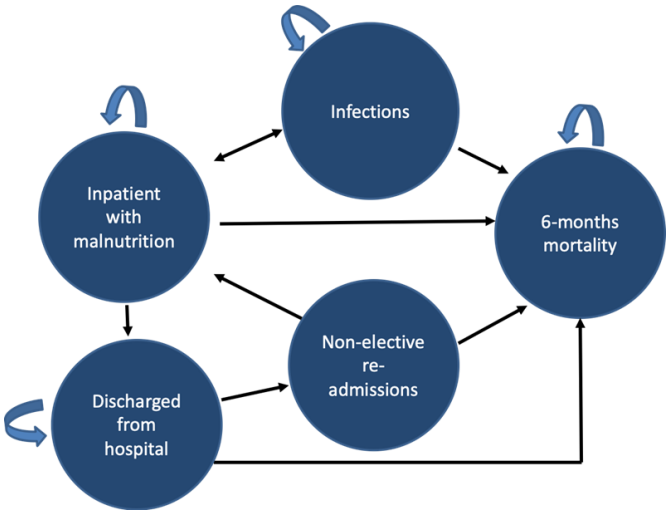

Figure 1 Health states within the Markov model. Designations of health states were based on findings in the meta-analysis report by Gomes *et al*.[4]

We modelled the economic impact of the nutritional support from a payer's perspective. To do so, we developed a Markov cohort model with daily cycles.[28 30] The timeframe for our model was 6 months, consistent with results reported in the meta-analysis by Gomes *et al*.[4] We applied utility values (cost of gained effectiveness of nutritional support) that were derived from a study by Schuetz *et al*, assuming the utility value for preventing an in-hospital adverse event was a reasonable proxy for developing an infection during hospitalisation.[27] Likewise, we applied a utility value from Harvey *et al* for preventing non-elective readmission.[31] Additionally, we assumed that the utility value for a released patient was 10% higher than for a patient in the stable health state. A more detailed description of the methods and assumptions is provided in online supplemental appendix A.1. We assumed costs for the various health states as follows: (1) no cost for patients released from hospital, (2) costs for nutritional support and readmission were sourced from the Nutrition effect On Unplanned Readmissions and Survival in Hospitalised patients (NOURISH) health economic analysis,[32] assuming SD as 10% of the input value, (3) costs for a heterogeneous distribution of infections were estimated on the basis of US hospital infection costs reported,[33] (4) no cost for death, and (5) the cost of nutritional support as reported previously.[34]

The primary outcomes in our model were cost-by-health-state and total cost. We calculated days in each health state, and we calculated utility value as the difference between the total costs of individualised nutritional support compared with no support. Individualised nutritional support refers to patient screening, assessment, definition of individual nutrition goals (including energy and protein, micronutrients) and a nutritional protocol to reach these goals (including oral nutritional supplements). The estimated daily per-patient cost for in-hospital nutrition was US$6.23. Because we modelled real-life findings, we did not apply discount rates to any costs and outcomes.[35–37] Sensitivity analyses were executed on key variables of the model, including probability of patient release from hospital, cost for infections, cost for general ward hospitalisation, and cost for individualised nutritional support. Because costs of nutritional supplements may vary in different care sites, we performed a sensitivity analysis to determine whether cost savings would be maintained when nutritional supplement costs) were US$3 per day (lower bound), US$4 per day (medium), and US$6 per day (upper bound).

To optimise our reporting of health economic evaluations, we used the Consolidated Health Economic Evaluation Reporting Standards checklist.[38]

Patient and public involvement

The data used for this study are based on a previous meta-analysis and as a result, patients were not involved in the design and conduct of the study, choice of outcome measures or recruitment to the study. However, we discussed the study concept and economic models beforehand in our multiprofessional team consisting of physicians, nurses, researchers from nutritional industries and economists.

RESULTS

Patient outcomes

The original systematic review included a total of 27 trials with 6803 patients.[4] Compared with patients in the control group, those who received nutritional support had a significantly lower mortality rate (230 of 2758 (8.3%) vs 307 of 2787 (11.0%) with an OR of 0.73 (95% CI 0.56 to 0.97)).

Costs and cost-benefits of nutritional intervention

A base-case analysis summarises our cost results (table 2). Here, 'Life' represents the number of patient lives in each health state. Utilities results are shown as quality-adjusted life days (QALD), which were calculated in the model. Finally, the calculated cost for each health state is shown. The per-patient cost for in-hospital nutritional support was estimated at US$36.44 per patient across the patient's hospital length of stay. In terms of costs over the 6-month timeframe of the study model, hospital care averaged US$63 227 per patient in the nutrition-intervention group versus US$66 045 in the control group. Sensitivity analysis within a range of US$3–6 per day cost for the nutritional supplement did not overcome the cost-benefit for nutritional support (total cost US$105,632 for US$4 US$105,681 for US$6 in the nutritional support, respectively).

Incremental differences in cost savings, life days, QALDs, and Incremental Cost-Effectiveness Ratio (ICER) per life days were determined (table 3). When using nutritional support, the total cost savings over the 6-month modelling interval was US$2912, which was mainly driven by cost savings in the general ward hospitalisation (US$2818). Patients receiving nutritional support

Table 2 Base-case results

Patient state	Life days		Utilities, QALD		Cost, US$	
	Nutritional support	No nutritional support	Nutritional support	No nutritional support	Nutritional support	No nutritional support
Hospitalised, malnourished	11.49	12.00	0.022	0.023	63 227	66 045
Non-elective readmission	0.14	0.17	0.000	0.000	193	237
In-hospital with Infection	0.52	0.60	0.001	0.001	4554	5374
Discharged from hospital	162	159	0.342	0.333	37 597	36 863
Death	7.74	10.27				
Total (sum of health states above)	174.26	171.73	0.365	0.358	105 608	108 520

QALDs, Quality-Adjusted Life Days.

also had 2.5 more life days without complications during the modelled time. Finally, given the cost savings and the added life days, cost-effectiveness results show dominance for the nutritional support group.

We also calculated costs to prevent hospital-acquired infections and hospital readmission, which were US$820 for one prevented infection and US$733 for one prevented non-elective readmission. The incremental cost per life day gained was -US$1149 with 2.53 additional days. When varying the input values, the results of the sensitivity analyses provided support for the original findings.

DISCUSSION

When hospitalised patients with malnutrition or at nutritional risk receive nutritional support, risk for hospital infections is reduced, length of stay is shortened, and the likelihood of hospital readmission is decreased. Importantly, results of our current modelling study showed that the added cost of providing nutritional support is low, especially when considering the associated reductions in costs of hospitalisation and medical treatments. Taken together, results from our present Markov health cost modelling showed that in-hospital nutritional support is a highly cost-effective intervention.

Comparison with findings in other nutrition care studies

The underlying systematic review by Gomes *et al* found that nutritional support led to statistically significant reductions in mortality and non-elective hospital readmissions,[4] findings that have also been reported for other hospital populations.[4 21 23 24 26 39] As well, the results of our health economic modelling analysis confirmed and extended data and messages on the 'value of nutrition' in care for hospitalised patients in North America,[40 41] Latin America,[13 42 43] Europe and the UK,[25 44–46] and Asia.[17 34]

Hospital nutritional care has proven particularly efficacious and cost effective in older populations with multiple health conditions, including those living in different care settings—in the community[44 47–49] and in nursing care facilities.[47 50] Furthermore, it was recently shown that malnutrition is underdiagnosed in emergency departments, also leading to a higher burden in terms of healthcare costs.[51]

Table 3 Results for incremental differences from base-case analysis

Cost item	Incremental changes for nutritional support versus no nutritional support			
	Cost savings, US$	Life days	QALDs	ICER LD, US$
General ward hospitalisation	2818.17	0.51	−0.0009	−5569.72
Readmission	43.50	−0.03	−0.0001	1372.62
Infections	820.89	0.09	0.0001	−8891.82
Released	733.65	3.16	0.0081	231.92
Death		−2.53		
Total	2912.47	2.53	0.0070	−1149.63

ICER LD, Incremental Cost-Effectiveness Ratio Life Days; QALDs, quality-adjusted life days.

Limitations of this modelling analysis

As for all modelling analyses, our model had some limitations. Costs and cost savings were calculated from the perspective of the 27 hospitals included in the Gomes et al review and meta-analysis[4]; results may thus not be fully generalisable to hospitals where patient demographics, disease severity, and care costs differ markedly from those in the reviewed studies. As well, our modelled cost-savings calculations reflect reductions in infectious complications, hospital length of stay, and non-elective readmissions, as measures for the effectiveness of in-hospital nutritional support. Other clinical outcomes, such as non-infective complications, are not included in the evaluation but could be included in future studies on hospital-related costs. Additionally, our model used direct costs as the main drivers of economic decision-making from the perspective of US hospital administrators and payers; future models could tackle savings in cost terms important to the patients, such as faster recovery with less disability and lower loss of work productivity.

The way forward

Guidelines and recommendations on the importance of nutrition care for medical nutritionally vulnerable inpatients are increasingly available in the US and elsewhere.[3 35 52–54] A recent European study showed that adherence to guidelines on malnutrition management in 15 hospitals was generally good, which led to improved nutritional care in hospitals.[55] Based on our modelled findings, we anticipate that increased attention to nutritional support during and after hospitalisation may yield marked benefits both in terms of health outcomes and cost savings.

CONCLUSION

In conclusion, our modelling analysis predicted that in-hospital nutritional support for medical inpatients who are malnourished or at nutritional risk can yield significant cost-benefits along with previously reported gains in terms of health outcomes.[4] Together, these positive effects provide a compelling rationale for hospitals to follow comprehensive nutrition care pathways—including screening for malnutrition risk, assessment of causes and severity of malnutrition, and provision of nutrition-focused support during and after hospitalisation.[52 53 56]

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