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ORIGINAL ARTICLE

Relationship between availability of physiotherapy services and ICU costs

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ABSTRACT

Objective: To determine whether 24-h availability of physiotherapy services decreases ICU costs in comparison with the standard 12 h/day availability among patients admitted to the ICU for the first time. **Methods:** This was an observational prevalence study involving 815 patients ≥ 18 years of age who had been on invasive mechanical ventilation (IMV) for ≥ 24 h and were discharged from an ICU to a ward at a tertiary teaching hospital in Brazil. The patients were divided into two groups according to h/day availability of physiotherapy services in the ICU: 24 h (PT-24; n = 332); and 12 h (PT-12; n = 483). The data collected included the reasons for hospital and ICU admissions; Acute Physiology and Chronic Health Evaluation II (APACHE II) score; IMV duration, ICU length of stay (ICU-LOS); and Omega score. **Results:** The severity of illness was similar in both groups. Round-the-clock availability of physiotherapy services was associated with shorter IMV durations and ICU-LOS, as well as with lower total, medical, and staff costs, in comparison with the standard 12 h/day availability. **Conclusions:** In the population studied, total costs and staff costs were lower in the PT-24 group than in the PT-12 group. The h/day availability of physiotherapy services was found to be a significant predictor of ICU costs.

Keywords: Intensive care units; Respiration, artificial; Respiratory therapy; Hospital costs.

INTRODUCTION

The ICU is considered the most costly hospital department. For example, in Germany, it has been estimated that the ICU accounts for 20% of all hospital costs.[1] Because critical care is a crucial hospital service, the factors that impact ICU costs have been widely studied. The total cost per patient in the ICU depends largely on the severity of illness and the ICU length of stay (ICU-LOS).[2-4] However, there have been very few studies looking into cost of ICU in Brazil. Nangino et al.[5] calculated the financial impact of nosocomial infections in the ICU at a charitable hospital in the Brazilian state of Minas Gerais. The authors reported longer ICU-LOS, higher per-patient ICU expenditures, and higher per-day ICU expenditures for patients with infection than for those without. Nevertheless, it is important to consider the heterogeneity among countries, and even within a country, in terms of the allocation of resources, distribution of critical care services, personnel costs, drug prices, culture, and the ethical standards of the society in relation to health care.[6]

Prolonged ICU-LOS has been associated with a longer duration of invasive mechanical ventilation (IMV).[7] Approximately 33% of patients admitted to the ICU require IMV,[8,9] which has been associated with higher mortality,[10] a higher incidence of hospital-associated pneumonia,[11] and ICU-acquired muscle weakness.[12] The use of IMV is also associated with higher costs,[13] accounting for 12% of all hospital costs.[14] Therefore, it seems that strategies to improve the weaning process and reduce IMV duration would reduce costs[11] and improve long-term patient outcomes.[15]

The aim of physiotherapy in the ICU is to enhance the overall functional capacity of patients, as well as to restore respiratory and physical independence, thereby decreasing the risk of bed rest-associated complications.[15] However, it is important to understand that the role of physiotherapists in the ICU varies considerably among countries and depends on such factors as staffing levels, training, and expertise.[16] In Brazil, physiotherapists are in charge of respiratory care and employ mobilization techniques. Respiratory care includes lung expansion, bronchial hygiene, assisted cough, suction, oxygen delivery, implementing/monitoring noninvasive mechanical ventilation, adjusting/monitoring IMV, participating in the weaning process, and extubation.[17] Mobilization techniques consist in the following[18]: general exercises, such as passive, assisted, active, and resistive maneuvers;

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transference training; positioning the patient when sitting; and providing ambulation therapy as soon as possible.

Although growing interest in reducing costs for patients requiring long-term mechanical ventilation has led to the development of various models of care delivery, none of those models have been tested in scientifically rigorous studies.[19,20] Brazilian law requires that ICU teams include one physiotherapist for every 10 patients for at least 18 h/day.[17,21] However, financial pressures, coupled with increasing expectations from regulators, payers, and consumers are changing health care delivery systems. Integrated, outcome-based systems of care delivery are needed.[19] During the process of adapting to the law, ICU patients at our hospital were seen by a physiotherapist on a 12 h/day shift basis. Our hospital has chosen to implement a 24 h/day, rather than an 18 h/day, physiotherapy schedule, in order to facilitate the organization of routines and to match the hours of public transportation. Therefore, the current study aimed to investigate the benefits and costs of this change, comparing ICUs with 24-h availability of physiotherapy services and those with 12-h availability of physiotherapy services in terms of the costs incurred for patients admitted to the ICU for the first time.

METHODS

Procedures

This observational prevalence study was conducted at the *Hospital das Clínicas* of the University of São Paulo School of Medicine, in the city of São Paulo, Brazil. The hospital has 125 ICU beds distributed among 11 ICUs. Three ICUs with a total of 53 beds were provided with physiotherapy services for 24 h/day (PT-24 group), and eight ICUs with a total of 72 beds were provided with physiotherapy services for 12 h/day (PT-12 group).

All patients received physiotherapy in the ICU from the local staff, which comprised professionals certified to treat critically ill patients. Each physiotherapist treated an average of 10 patients during each 6-h shift. Physiotherapy sessions averaged 30 min in length, depending on the needs of the patient. During the data collection period, the physiotherapists continued their normal routine in the ICU, and no new treatment protocols were introduced.

Data were collected from December 1, 2009, to September 31, 2011. The study was approved by the local research ethics committee (Protocol no. 1159/07). The requirement for written consent was waived, because the study analysis was based on secondary data.

For the patients who met the inclusion criteria listed below, data were collected from patient charts. To facilitate access to clinical information, we collected data for the period from ICU admission until 48 h after discharge to a ward. All data were collected by four trained researchers.

Participants

The study included clinical and surgical patients who were between 18 and 90 years of age at their first admission to the ICU, had been on IMV for ≥ 24 h, and were subsequently discharged to a ward. In the case of surgical patients, we included only those who received IMV exclusively because of surgery. Mechanically ventilated patients were specifically chosen because this group is the most common target for ICU-LOS reductions, given the many available interventions that can shorten the duration of mechanical ventilation use.

Surgical patients with a history of neuromuscular disease, neurodegenerative disease, high spinal cord injury, or tetanus were excluded because of the possibility of prolonged mechanical ventilation. Burn patients were excluded because they were admitted exclusively to a PT-12 ICU and underwent multiple surgical procedures for resurfacing, making it impossible to draw comparison with patients who underwent other types of surgical procedures. Patients who had been referred from another facility were excluded, because of the difficulties of accessing the data of interest. We also excluded patients who were on IMV prior to surgery, not only because such patients represent a minority but also because they present multiple complications. Patients who remained in the ICU for more than three months were also excluded, as were obstetric patients, patients who were transferred out of the ICU to other institutions, patients who died in the ICU, and patients for whom the medical records were incomplete. Patients were included in the study only once, even if they were readmitted to the ICU after discharge.

Measures

The following information were collected from the medical records: age; gender; Acute Physiology and Chronic Health Evaluation II (APACHE II) score; IMV duration; ICU-LOS; number of respiratory and motor physiotherapy sessions during the ICU stay; and Omega score.[22]

The Omega system was created by the French Intensive Care Society.[22] The Omega score reflects the workload required for each indicated procedure. The Omega system, which is similar to the Therapeutic Intervention Scoring System,[23] has been shown to be highly accurate for estimating workloads and costs.[22] The Omega system evaluates 47 diagnostic or therapeutic procedures, divided into three categories. Omega 1 includes general procedures (e.g., intubation, vasoactive drug administration, and chest tubes), which are recorded only once during the ICU stay. Omega 2 includes diagnostic procedures and transport out of the unit (e.g., for radiography or endoscopy), which are recorded each time they are performed. Omega 3 includes procedures related to mechanical ventilation and monitoring, which are recorded daily throughout the ICU stay. The procedures listed in Omega 3 are closely related to physiotherapy practices in ICUs in Brazil. The total Omega score is obtained by calculating the sum of the scores for Omega 1, 2, and

3.[22] After calculating the Omega score, we converted the estimated cost to French francs (FF), using the regression equations reported by Sznajder et al.[22] Those authors developed three regression equations to estimate the costs in FF:

Direct costs = 211.68 × *total Omega score* + 1,191.5

Medical costs = 124.4 × *total Omega score*

Nursing staff costs = 67 × *total Omega score*

Statistical analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences, version 15.0 (SPSS Inc., Chicago, IL, USA) and the program R for Windows, version 3.2.3 (R Development Core Team—www.r-project.org). The descriptive analyses of the continuous variables were presented as the mean ± standard deviation, median (interquartile range), or absolute and relative frequency, as appropriate according to the distribution of the data. Normality tests revealed nonparametric distributions for most of the variables in both groups (PT-12 and PT-24). Therefore, the Mann-Whitney U test was used in order to compare the difference between the two groups.

Standard multiple linear regression analysis was performed in order to develop a model for predicting ICU costs based on the h/day availability of physiotherapy services in the ICU (PT-12 = 0; PT-24 = 1); APACHE II score; surgical procedure[4] (no = 0; yes = 1); and ICU-LOS, in days.[2-4] Those variables were selected on the basis of clinical criteria. Prior to interpreting the results of the multiple regression analysis, we evaluated some assumptions. Stem-and-leaf plots and box plots indicated that the variables in regression were not normally distributed, which required logarithmic transformation of the variables. The level of significance was set at $p < 0.05$.

RESULTS

We evaluated a total of 10,654 records of patients admitted to the ICU during the study period (Figure 1). Of those 10,654 patients, 815 met the inclusion criteria: 483 in the PT-12 group and 332 in the PT-24 group.

The general characteristics of the patients are shown in Table 1. The h/day availability of physiotherapy services was not determined by the type of ICU (surgical or clinical). The proportions of surgical patients in the PT-12 and PT-24 groups are also presented in Table 1. In both groups, males predominated. There was no statistical difference between the groups in terms of the severity of illness, as determined by the APACHE II score, at ICU admission ($p = 0.65$). However, the patients in the PT-24 group were significantly older than were those in the PT-12 group ($p < 0.001$). In addition, the duration of IMV was significantly shorter in the PT-24 group than in the PT-12 group ($p < 0.001$), as was the ICU-LOS ($p = 0.013$).

Table 2 presents the ICU costs calculated for the PT-12 and PT-24 groups. The Omega 3 score was significantly lower in the PT-24 group than in the PT-12 group ($p=0.005$), as were the total Omega score, total costs, medical costs, and staff costs ($p = 0.010$ for all).

Standardized regression coefficients (β) and squared semipartial correlations (sr^2) for each predictor in the multiple linear regression model are shown in Table 3. The h/day availability of physiotherapy services in the ICU, APACHE II score, and ICU-LOS were all found to be significant predictors of ICU costs. The model was able to account for 72% of the variance in ICU costs ($p = 0.05$; $R^2 = 0.72$): ICU costs(y) = 4.800 + 0.010*(APACHE II score) + 0.045*(ICU-LOS) − 0.070*(h/day availability of physiotherapy services).

DISCUSSION

Our findings suggest that the estimated cost per patient in a first admission to the ICU is reduced when physiotherapy services are available around the clock rather than for only 12 h per day. That conclusion is based on the lower Omega 3 and total Omega scores, as well as the lower direct, medical, and nursing staff costs associated with the PT-24

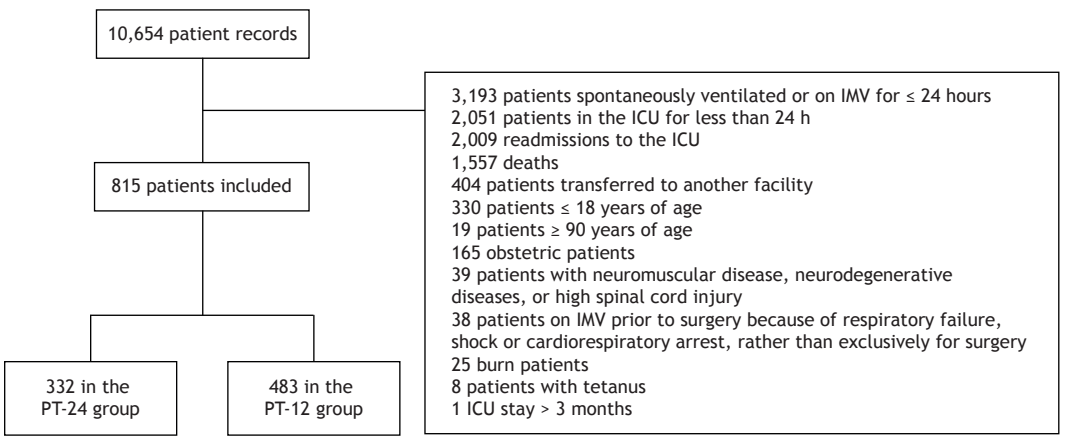

Figure 1. Flowchart of the selection process. PT-24: ICUs provided with physiotherapy services for 24 h/day; and PT-12: ICUs provided with physiotherapy services for 12 h/day.

Table 1. General characteristics of the patients.

Variable	General	PT-12	PT-24	p
N or n (%)	815 (100)	483 (59.3)	332 (40.7)	< 0.001
Age (years), mean ± SD	50.0 ± 17.9	46.7 ± 17.4	54.8 ± 17.4	< 0.001
Male gender, n (%)	510 (62.6)	316 (65.4)	194 (58.4)	0.053
APACHE II score, median (IQR)	14.0 (11.0-20.0)	14.0 (11.0-19.0)	15 (10.7-20.0)	0.650
Surgical patients, n (%)	556 (68.2)	297 (61.5)	259 (78.0)	< 0.001
IMV duration (days), median (IQR)	6.0 (3.0-12.0)	6.0 (4.0-12.5)	5.0 (3.0-9.2)	< 0.001
ICU-LOS (days), median (IQR)	14.0 (8.0-23.0)	15.0 (9.0-24.0)	13.00(8.0-22.0)	0.013

PT-12: ICUs provided with physiotherapy services for 12 h/day; PT-24: ICUs provided with physiotherapy services for 24 h/day; IQR: interquartile range; APACHE II: Acute Physiology and Chronic Health Evaluation II; IMV: invasive mechanical ventilation; and ICU-LOS: intensive care unit length of stay.

Table 2. Omega scores and estimated ICU costs for the two groups evaluated.[a]

Variable	PT-12	PT-24	p
Omega 1 score	37.0 (30.0-45.0)	38.0 (31.7-45.2)	0.070
Omega 2 score	46.0 (24.2-79.0)	40.0 (20.0-75.5)	0.265
Omega 3 score	228.0 (132.0-417.5)	192.0 (99.5-382.5)	0.005
Total Omega score	330.0 (199.5-526.5)	281.5 (167.7-494.5)	0.010
Direct costs (FF)	71,045.9 (43,421.7-112,641.0)	60,779.4 (36,700.8-105,867.3)	0.010
Medical costs (FF)	41,052.0 (24,817.8-65,496.6)	35,018.6 (20,868.1-61,515.8)	0.010
Staff costs (FF)	22,110.0 (13,366.5-35,275.5)	18,860.5 (11,239.2-33,131.5)	0.010

PT-12: ICUs provided with physiotherapy services for 12 h/day; PT-24: ICUs provided with physiotherapy services for 24 h/day; and FF, French francs. [a]Values presented as median (interquartile range).

Table 3. Independent variables for predicting ICU costs in the multiple linear regression model.

Variable	β	sr^2	p	95% CI	
				Lower	Upper
APACHE II score (points)	0.010	0.002	< 0.001	0.006	0.014
Surgery (no = 0; yes = 1)	0.019	0.031	0.530	−0.042	0.082
ICU-LOS (days)	0.045	0.001	< 0.001	0.044	0.048
PT availability (12 h/day = 0; 24 h/day = 1)	−0.070	0.029	0.017	−0.127	−0.013

APACHE II: Acute Physiology and Chronic Health Evaluation II; ICU-LOS, intensive care unit length of stay; and PT, physiotherapy.

condition.[24] We also demonstrated that IMV duration and ICU-LOS were shorter in the PT-24 group. In addition, APACHE II scores, ICU-LOS, and the h/day availability of physiotherapy services were found to be significant predictors of ICU costs. In particular, the relationship between the h/day availability of physiotherapy services and ICU costs was inversely proportional, meaning that the more physiotherapy patients receive during their first ICU stay, the lower are the hospital costs. However, higher APACHE II scores and prolonged ICU-LOS were found to translate to higher hospitalization costs. To our knowledge, this is the first study to examine ICU costs based on the h/day availability of physiotherapy services.

Although the Omega score has not been validated for use in Brazil (i.e., with Brazilian currency), it was chosen because it is easy to use and reflects the workloads associated with caring for critically ill patients.[25] In addition, the Omega 3 score is based on procedures that are closely related to those employed by physiotherapists working in ICUs in Brazil. The need for cost calibration is inherent to all methods used to estimate costs in critical care,[25] such as the Therapeutic Intervention Scoring System[23] and activity-based costing.[26] When comparing results for different countries, factors such as the exchange rate must be considered, and the measurements must reflect purchasing power—comparing costs and resources rather than expenses.[27]

The Omega 3 score evaluates procedures such as mechanical ventilation and continuous surveillance in the ICU. In the current study, the Omega 3 score was lower in the PT-24 group than in the PT-12 group, because of the shorter IMV duration and ICU-LOS in the former. In Brazil, the role of the physiotherapist in the ICU includes implementing and monitoring noninvasive mechanical ventilation; adjusting and monitoring IMV; participating in the weaning process; and extubation. In the current study, round-the-clock ICU availability of physiotherapy services was found to accelerate weaning and to improve IMV management, thereby decreasing the IMV duration, in comparison with ICU availability of physiotherapy services for only 12 h per day. In addition, it is well known that IMV duration is an independent predictor of hospital and ICU costs.[13] Our results are in line with those of a similar study, comparing 24 h/day and 6 h/day availability of physiotherapy services for ICU patients in Brazil.[28] That study showed that round-the-clock availability of physiotherapy services reduces the ICU-LOS, IMV duration, pulmonary infection

rate, and mortality rate. However, the authors of that study did not include a cost analysis of physiotherapy services, as some other authors have done.[29]

As previously mentioned, the total Omega score is the sum of the Omega 1, Omega 2, and Omega 3 scores. Because there were no differences between our two groups in terms of the Omega 1 or Omega 2 score, differences in the Omega 3 scores account for the difference in the total Omega score. The regressions postulated by Sznajder et al.[22] are based on the use of the total Omega score to calculate the total, medical, and staff costs. It is important to note that the Omega system does not include the workload of the physiotherapist. In our study, both groups were given access to a physiotherapist from the multidisciplinary team for either 12 h/day or 24 h/day. Therefore, it should also be noted that providing round-the-clock physiotherapy services contributed to reducing the overall workload of the team, as reflected in the significant differences between the two groups in terms of medical and staff costs.

Despite our positive results, there are still conflicting data in the literature regarding the impacts that respiratory care and chest physiotherapy have on clinical outcomes and cost analyses. One previous report showed that chest physiotherapy delivered twice a day to patients who had been on IMV for at least 48 h was independently associated with a reduction in the incidence of ventilator-associated pneumonia.[29] In a study conducted in Spain, Varela et al.[30] also reported that providing chest physiotherapy for pulmonary lobectomy patients on the ward can shorten hospital stays, resulting in savings equivalent to FF 41,084.69. However, studies conducted in other countries, such as Australia and England, have shown that, among critically ill patients admitted to medical or surgical ICUs, physiotherapy has no effect on the frequency of ventilator-associated pneumonia,[31] mortality, ICU-LOS,[29,30,32] or IMV duration.[29,31,33]

It is particularly challenging to perform outcome studies of physiotherapy in the ICU. The population admitted to the ICU is quite diverse, and the combination of patient characteristics, socioeconomic profile, clinical conditions, and ICU setting can alter outcomes in the critical care area. The most well-accepted recommendations regarding physiotherapy in ICU are related to the weaning process.[31] For example, the European Respiratory Society and the European Society of Intensive Care Medicine recommend the active participation of a physiotherapist in the weaning process,[32,34] because it can optimize weaning from IMV, as was shown in the current study.

The lack of agreement across studies could be related to the complexity of patient health conditions and the diversity of the health care systems in different settings and countries. For example, our hospital is a referral center for South America and a tertiary teaching hospital. Consequently, patients who present to our hospital have multiple comorbidities, are severely ill, and have a prolonged ICU-LOS. We found that, in addition to reducing IMV duration and ICU-LOS, greater availability of physiotherapy services was a significant predictor of reduced ICU costs, as were lower APACHE II scores and shorter ICU-LOS.

Despite the importance of the results, our study has some limitations that should be considered. First, the Omega system has not been validated for use in Brazil, and conversion to the local currency to estimate the financial savings for Brazilian hospitals cannot occur without a cost calibration. Therefore, the interpretation of these data should consider the cost variation between the two dates, 1992 (when the Omega system was devised) and 2011 (when the data collection process for the current study was finalized), based on inflation indices (e.g., consumer price indices), which represent the evolution of the cost of living. Inflation over that period in France was 37.92%. In 1992, 6.9 FF would have been equal to 1 euro. Second, the study was not designed to examine quality improvements (pre- and post-intervention). We compared different ICUs at the same time during the transition to 24-h physiotherapy shifts at our hospital. As a result, the data were not collected from standardized groups. Third, because the study was conducted at a general hospital, heterogeneous diagnoses could have interfered with our results. Nevertheless, the role of the physiotherapist and the clinical routine are the same in all units; we considered it more important to differentiate between clinical and surgical patients than to determine patient diagnoses. It is also worth noting that the severity of illness was similar in both of the groups in our sample. In addition, we excluded all patients with a higher probability of prolonged ICU-LOS; however, the literature indicates that mechanical ventilation weaning times are longer in such patients, due to previous disease, rather than to respiratory failure (the reason for intubation).[7,10] Another limitation is related to the potential lack of external validity of our findings, given the extensive list of exclusion criteria. Finally, some authors have questioned the use of log transformation and its implications for data analysis, arguing that the results of standard statistical tests performed on log-transformed data are often not relevant for the original, non-transformed data.[35,36] However, log transformation is one of the most popular methods of transforming skewed data in order to approximate normality. If the original data follow a log-normal or approximately log-normal distribution, which was the case in our study, then the log-transformed data follow a normal or near normal distribution (the log transformation does in fact reduce or eliminate skewness).[34,37]

In the population studied, ICUs with round-the-clock availability of physiotherapy services presented lower IMV durations and ICU-LOS, as well as lower total, medical, and staff costs, in comparison with ICUs in which physiotherapy services were available for the standard 12 h/day. Providing ICU patients with 24-h access to physiotherapy services was found to be a significant predictor of lower ICU costs.

REFERENCES

1. Chalfin DB. Cost-effectiveness analysis in health care. Hosp Cost Manag Account. 1995;7(4):1-8.
2. Teres D, Rapoport J, Lemeshow S, Kim S, Akhras K. Effects of severity of illness on resource use by survivors and nonsurvivors of severe sepsis at intensive care unit admission. Crit Care Med. 2002;30(11):2413-9. https://doi.org/10.1097/00003246-200211000-00002
3. Moerer O, Schmid A, Hofmann M, Herklotz A, Reinhart K, Werdan K, et al. Direct costs of severe sepsis in three German intensive care units based on retrospective electronic patient record analysis of resource use. Intensive Care Med. 2002;28(10):1440-6. https://doi.org/10.1007/s00134-002-1429-9
4. Jacobs P, Edbrooke D, Hibbert C, Fassbender K, Corcoran M. Descriptive patient data as an explanation for the variation in average daily costs in intensive care. Anaesthesia. 2001;56(7):643-7. https://doi.org/10.1046/j.1365-2044.2001.02052.x
5. Nangino GO, Oliveira CD, Correia PC, Machado NM, Dias AT. Financial impact of nosocomial infections in the intensive care units of a charitable hospital in Minas Gerais, Brazil. Rev Bras Ter Intensiva. 2012;24(4):357-61. https://doi.org/10.1590/S0103-507X2012000400011
6. Jayaram R, Ramakrishnan N. Cost of intensive care in India. Indian J Crit Care Med. 2008;12(2):55-61. https://doi.org/10.4103/0972-5229.42558
7. Kramer AA, Zimmerman JE. A predictive model for the early identification of patients at risk for a prolonged intensive care unit length of stay. BMC Med Inform Decis Mak. 2010;10:27. https://doi.org/10.1186/1472-6947-10-27
8. Esteban A, Anzueto A, Frutos F, Alía I, Brochard L, Stewart TE, et al. Characteristics and outcomes in adult patients receiving mechanical ventilation: a 28-day international study. JAMA. 2002;287(3):345-55. https://doi.org/10.1001/jama.287.3.345
9. Hebert PC, Blajchman MA, Cook DJ, Yetisir E, Wells G, Marshall J, et al. Do blood transfusions improve outcomes related to mechanical ventilation? Chest. 2001;119(6):1850-7. https://doi.org/10.1378/chest.119.6.1850
10. Seneff MG, Zimmerman JE, Knaus WA, Wagner DP, Draper EA. Predicting the duration of mechanical ventilation. The importance of disease and patient characteristics. Chest. 1996;110(2):469-79. https://doi.org/10.1378/chest.110.2.469
11. Kollef MH. What is ventilator-associated pneumonia and why is it important? Respir Care. 2005;50(6):714-21; discussion 721-4.
12. De Jonghe B, Sharshar T, Lefaucheur JP, Authier FJ, Durand-Zaleski I, Boussarsar M, et al. Paresis acquired in the intensive care unit: a prospective multicenter study. JAMA. 2002;288(22):2859-67. https://doi.org/10.1001/jama.288.22.2859
13. Dasta JF, McLaughlin TP, Mody SH, Piech CT. Daily cost of an intensive care unit day: the contribution of mechanical ventilation. Crit Care Med. 2005;33(6):1266-71. https://doi.org/10.1097/01.CCM.0000164543.14619.00
14. Wunsch H, Linde-Zwirble WT, Angus DC, Hartman ME, Milbrandt EB, Kahn JM. The epidemiology of mechanical ventilation use in the United States. Crit Care Med. 2010;38(10):1947-53. https://doi.org/10.1097/CCM.0b013e3181ef4460
15. Hall JB. Creating the animated intensive care unit. Crit Care Med. 2010;38(10 Suppl):S668-75. https://doi.org/10.1097/CCM.0b013e3181f203aa
16. Stiller K. Physiotherapy in intensive care: towards an evidence-based practice. Chest. 2000;118(6):1801-13. https://doi.org/10.1378/chest.118.6.1801
17. Jones AY, Hutchinson RC, Oh TE. Chest physiotherapy practice in intensive care units in Australia, the UK and Hong Kong. Physiother Theory Pract. 1992;8(1):39-47. https://doi.org/10.3109/09593989209108078
18. Pires-Neto RC, Lima NP, Cardim GM, Park M, Denehy L. Early mobilization practice in a single Brazilian intensive care unit. J Crit Care. 2015;30(5):896-900. https://doi.org/10.1016/j.jcrc.2015.05.004
19. Hopkins RO, Spuhler VJ, Thomsen GE. Transforming ICU culture to facilitate early mobility. Crit Care Clin. 2007,23(1): 81-96. https://doi.org/10.1016/j.ccc.2006.11.004
20. Burns SM, Daly B, Tice P. Being led down the critical pathway: a perspective on the importance of care managers vs critical pathways for patients requiring prolonged mechanical ventilation. Crit Care Nurse. 1997,17(6):70-5.
21. Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária [homepage on the Internet] Brasília: o Ministério; [cited 2015 Jun 20]. Resolução no. 7; 2010 Feb 24. [about 10 screens]. Available from: http://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2010/res0007_24_02_2010.html
22. Sznajder M, Leleu G, Buonamico G, Auvert B, Aegerter P, Merlière Y, et al. Estimation of direct cost and resource allocation in intensive care: correlation with Omega system. Intensive Care Med. 1998;24(6):582-9. https://doi.org/10.1007/s001340050619
23. Keene AR, Cullen DJ. Therapeutic Intervention Scoring System: update 1983. Crit Care Med. 1983;11(1):1-3. https://doi.org/10.1097/00003246-198301000-00001
24. Guccione A, Morena A, Pezzi A, Iapichino G. The assessment of nursing workload. Minerva Anestesiol [Article in Italian]. 2004;70(5):411-6.
25. Understanding costs and cost-effectiveness in critical care: report from the Second American Thoracic Society workshop on outcomes research. Am J Respir Crit Care Med. 2002;165(4):540-50. https://doi.org/10.1164/ajrccm.165.4.16541
26. Edbrooke DL, Stevens VG, Hibbert CL, Mann AJ, Wilson AJ. A new method of accurately identifying costs of individual patients in intensive care: the initial results. Intensive Care Med. 1997;23(6):645-50. https://doi.org/10.1007/s001340050388
27. Edbrooke N, Negrini D, Edbrooke D. International comparisons of health care costs: are they important in intensive care and how should they be achieved? In: Vincent JL, editor. Yearbook of Intensive Care & Emergency Medicine. London: Springer Verlag; 2004.
28. Castro AA, Calil SR, Freitas SA, Oliveira AB, Porto EF. Chest physiotherapy effectiveness to reduce hospitalization and mechanical ventilation length of stay, pulmonary infection rate and mortality in ICU patients. Respir Med. 2013;107(1):68-74. https://doi.org/10.1016/j.rmed.2012.09.016
29. Ntoumenopoulos G, Presneill JJ, McElholum M, Cade JF. Chest physiotherapy for the prevention of ventilator-associated pneumonia. Intensive Care Med. 2002; 28(7):850-6. https://doi.org/10.1007/s00134-002-1342-2
30. Varela G, Ballesteros E, Jiménez MF, Novoa N, Aranda JL. Cost-effectiveness analysis of prophylactic respiratory physiotherapy in pulmonary lobectomy. Eur J Cardiothorac Surg. 2006;29(2):216-20. https://doi.org/10.1016/j.ejcts.2005.11.002
31. Patman S, Jenkins S, Stiller K. Physiotherapy does not prevent, or hasten recovery from, ventilator-associated pneumonia in patients with acquired brain injury. Intensive Care Med. 2009;35(2):258-65. https://doi.org/10.1007/s00134-008-1278-2
32. Templeton M, Palazzo MG. Chest physiotherapy prolongs duration of ventilation in the critically ill ventilated for more than 48 hours. Intensive Care Med. 2007;33(11):1938-45. https://doi.org/10.1007/s00134-007-0762-4
33. Clini E, Ambrosino N. Early physiotherapy in the respiratory intensive care unit. Resp Med. 2005;99(9):1096-104. https://doi.org/10.1016/j.rmed.2005.02.024
34. Gosselink R, Bott J, Johnson M, Dean E, Nava S, Norrenberg M, et al. Physiotherapy for adult patients with critical illness: recommendations of the European Respiratory Society and European Society of Intensive Care Medicine Task Force on Physiotherapy for Critically Ill Patients. Intensive Care Med. 2008;34(7):1188-99. https://doi.org/10.1007/s00134-008-1026-7
35. Feng C, Wang H, Lu N, Chen T, He H, Lu Y, TU XM. Log-transformation and its implications for data analysis. Shanghai Arch Psychiatry. 2014;26(2):105-9.
36. Norris AE, Aroian KJ. To transform or not transform skewed data for psychometric analysis: that is the question! Nurs Res. 2004;53(1):67-71. https://doi.org/10.1097/00006199-200401000-00011
37. Bland JM, Altman DG, Rohlf FJ. In defence of logarithmic transformations. Statist Med. 2013;32(21):3766-8. https://doi.org/10.1002/sim.5772