Journal of Intensive Care Medicine
Volume XX Number X
Month XXXX xx-xx
© 2008 Sage Publications
10.1177/0885066608318661
http://jicm.sagepub.com
hosted at
http://online.sagepub.com

A Microcosting Study of Intensive Care Unit Stay in the Netherlands

Siok Swan Tan, MSc, Leona Hakkaart-van Roijen, PhD, Maiwenn J. Al, PhD, Clazien A. Bouwmans, MSc, Marga E. Hoogendoorn, MSc, Peter E. Spronk, PhD, and Jan Bakker, PhD

The primary objective of this study was to estimate the actual daily costs of intensive care unit stay using a microcosting methodology. As a secondary objective, the degree of association between daily intensive care unit costs and some patient characteristics was examined. This multicenter, retrospective cost analysis was conducted in the medical-surgical adult intensive care units of 1 university and 2 general hospitals in the Netherlands for 2006, from a hospital perspective. A total of 576 adult patients were included, consuming a total of 2868 nursing days. The mean total costs per intensive care unit day were €1911, with labour (33%) and indirect costs (33%) as the most important cost drivers. An ordinary least squares analysis including age, Nine Equivalent of Nursing Manpower Use score/Therapeutic Intervention Scoring System score, mechanical ventilation, blood products, and renal replacement therapy was able to predict 50% of the daily intensive care unit costs.

Keywords: intensive care; microcosting; cost analysis; ICU stay; mechanical ventilation

Although intensive care unit (ICU) beds comprise less than 10% of hospital beds, ICUs consume 22% of total hospital costs in the United States.[1] Also, the costs of ICUs in the Netherlands have been estimated to represent approximately 20% of the total hospital budget,[2] with the cost per nursing day in between 3-fold and 5-fold more than in general wards.[3] Therefore, insight in the costs and cost drivers of ICU stay seems justified.

Several studies have assessed the costs of ICU services, but cost estimations on an ICU day vary extensively.[3-9] From a multicenter Australian study, Moran et al[4] reported that the mean costs per nursing day were found to be €1489 (adjusted to 2006). At the other extreme, the daily treatment costs in a Norwegian university hospital ICU were found to be €3097 (adjusted to 2006).[5]

Many studies have tried to explain the wide variations in actual differences between ICUs.[3,10,11] The patient case-mix is considered to have an important effect on the costs of ICU stay. Other potential factors influencing the differences in actual costs of ICU stay include medical practice patterns (eg, number of beds and the presence of a high-dependency unit), financial incentives, and relative and absolute prices between countries.[6,10-12] However, it has been argued that some of the observed differences are more related to methodological differences than to actual cost differences.[4,7,13]

An important cause for methodological differences concerns the level of accuracy that is addressed. In gross costing, cost components are defined at a highly aggregated level (eg, inpatient days only), whereas in microcosting, all relevant cost components are defined at the most detailed level.[14] The latter methodology allows for the identification of costs per individual patient and for insight in patient subgroups that might have a great share in the total

From the Erasmus MC University Medical Center, Institute for Medical Technology Assessment, Rotterdam (SST, LH-vR, MJA, CAB); Department of Intensive Care, Isala Clinics, Zwolle (MEH); Department of Intensive Care Medicine, Gelre Hospital (Lukas site), Apeldoorn (PES); and Department of Intensive Care, Erasmus MC University Medical Center, Rotterdam (JB), Netherlands.

Address correspondence to: Siok Swan Tan, MSc, Erasmus MC University Medical Center, Institute for Medical Technology Assessment, PO Box 1738, 3000 DR Rotterdam, Netherlands; e-mail: s.s.tan@erasmusmc.nl.

costs of the ICU. As this methodology is time consuming, especially when hospital information systems are absent or inaccurate, it has not been widely used in assessing the costs of ICU stay.

Microcosting studies have been performed in Australia[4] and United Kingdom.[9] However, a microcosting study for the Netherlands has not yet been performed. Therefore, the primary aim of the present study was to calculate the actual daily costs of ICU stay in the Netherlands using a microcosting methodology.

Critically ill patients require therapies that can vary considerably in type, duration, and cost.[12] Therefore, it is desirable to have insight in the variables that are able to predict the daily cost of individual patients. Because the microcosting methodology is particularly appropriate to provide such an insight, the secondary objective of the current study was to examine the degree of association between daily ICU costs and the following routinely collected patient characteristics: age, sex, ICU length of stay, Nine Equivalent of Nursing Manpower Use (NEMS) score/ Therapeutic Intervention Scoring System (TISS-28) score, mechanical ventilation, blood products, renal replacement therapy, and sepsis. The ICU length of stay and the NEMS/TISS-28 score were included in the analysis to control the severity of illness of the patient. Mechanical ventilation, blood products, renal replacement therapy, and sepsis were included because several recent studies suggest that these variables are associated with increased costs.[6,15-18]

Methods

This microcosting study was conducted in 3 hospitals in the Netherlands in 2006, from a hospital perspective. A retrospective cost analysis of patients admitted to a 32-bed medical-surgical adult ICU was performed at a university hospital during a period of 7 weeks in 2006: from April 16 to May 15 and from June 5 to June 23. Besides, data were collected in 2 medical-surgical adult ICUs at general university-affiliated hospitals. The first had 10 beds. Because of capacity problems in the summers of 2005 and 2004, it was decided to retrospectively collect data for a period of 6 months in 2003: from January 1 to July 1 (general hospital 1). The second adult ICU had 22 beds, at which data were prospectively collected for a period of 1 week: from November 4, 2006 to November 10, 2006 (general hospital 2).

Total Population

Total costs for individual patients were determined by the identification of resource use and unit costs of direct and indirect cost components. Direct cost components involved diagnostics (medical imaging and laboratory services); consumables (drugs, fluids, and disposables); hotel and nutrition, and labor. Indirect cost components concerned overheads (general expenses, administration and registration, energy, maintenance, insurance, and the personnel costs of nonpatient services, such as management and administration) and capital (depreciation of buildings and inventory and interest).

Direct Cost Components

Total direct costs were determined by multiplying resource use by the corresponding unit prices for 2006.

Resource use. Data on resource use of diagnostics, drugs, fluids, hotel, and nutrition were acquired from either computerized patient data management systems ([PDMS]; the university hospital and general hospital 1) or patient records (general hospital 2). Annual resource use of disposables was divided by the annual number of nursing days to be able to appoint material use to nursing days. Resource use of ICU specialist time and indirect nursing time per nursing day were estimated by dividing the number of workable days per year by the number of nursing days per year. To estimate the direct nursing time per single nursing day, either the TISS-28 score (general hospitals) or a simplified version of the TISS-28 score, the NEMS score (the university hospital), was used. Time for consultations of nonICU medical staff attributable to each individual nursing day was prospectively collected using either patient record forms (the university hospital and general hospital 2) or computerized PDMS (general hospital 1).

Unit prices. Unit costs of diagnostics and disposables were obtained from (financial) hospital databases. Unit costs of drugs and fluids were derived from the administration of the hospital pharmacies. Annual costs on hotel and nutrition were taken from the annual accounts 2005 and divided by the annual number of nursing days to calculate unit costs per nursing day. Table 1 presents the unit costs of labor

Table 1. Unit Costs of Labor (Euro 2006 Per Minute)

	Unit Costs at at University Hospital (€ Per Min)	Unit Costs at at General Hospitals (€ Per Min)
Labor: ICU		
ICU specialist	1.10	2.46
ICU fellow	0.48	0.54
ICU nurse	0.41	0.41
Labor: consultations		
Medical specialist	1.10	2.46
Fellow	0.48	0.54
Pharmacist	1.05	1.05
Physiotherapist	0.64	0.64
Laboratory technician	0.48	0.51
Nutrition specialist	0.48	0.48

NOTE: ICU = intensive care unit.

per minute. Unit costs of labor were based on standardized costs per day or per minute, which equaled the normative income divided by the number of workable days or minutes per year. Because medical specialists in general hospitals work in independent corporations and are not on the payroll of the hospital, the normative income for these medical specialists were based on a national rate that also includes some overhead costs. Normative incomes of other staff categories were based on collective labor agreements.

Indirect Cost Components

Annual overhead and capital costs were taken from the annual accounts 2005 and divided by the direct costs, excluding medical specialist costs in general hospitals. Thus, indirect costs were allocated to patients using a marginal markup percentage.

In addition to descriptive statistics, analyses of variance were used to investigate cost differences between the hospitals.

Patient Subgroups

Total costs of 4 patient subgroups were compared with those of the total population by means of 2-sample *t* tests: patients requiring mechanical ventilation, patients requiring blood (derived) products, patients requiring renal replacement therapy, and patients with sepsis.

Regression Analyses

Patients of all hospitals were included in an ordinary least squares (OLS) regression analysis to explore the degree of association between daily ICU costs and routinely collected patient characteristics. Total costs were taken as the dependent variable and age, sex (men, yes/no), ICU length of stay, NEMS/TISS-28 score, mechanical ventilation (yes/no), blood products (yes/no), renal replacement therapy (yes/no), and sepsis (yes/no) as explanatory variables. Pearson correlation coefficients, obtained from simple binomial regression analyses, investigated the ability of the patient characteristics to predict daily costs of ICU stay.

Statistical analyses were conducted with the statistical software programmes SPSS for Windows version 13.0 (SPSS Inc, Chicago, Illinois). In all cases, $P < .05$ was taken as statistically significant. All costs were based on Euro 2006 cost data. Where necessary, costs were adjusted to 2006 using the general price index from the Dutch Central Bureau of Statistics.

Results

The characteristics of the hospital patient samples are summarized in Table 2. A total of 576 admissions, mean age ± SD = 62 ± 15 years, 56% men, were recorded, of which 242 at the university hospital, and 304 and 30 at the general hospitals 1 and 2, respectively. These admissions related to 2868 nursing days (1000 at the university hospital and 1750 and 118 at the general hospitals 1 and 2, respectively).

Total Population

An overview of descriptive statistics at the hospital level is given in Table 3. The mean total costs per ICU day were €1805 in the university hospital compared to €2176 and €1753 in the general hospitals resulting in average daily costs of €1911 ± 230 ($P <$ .001). A substantial cost variation was found in the total costs obtained for individual patients (range, €751- €11 116). Even though the distribution of costs varied by cost component, labor and overheads and capital were the most important cost drivers in all patients.

Table 2. Patient Characteristics of the Hospital Patient Samples

	University Hospital (n = 242)	General Hospital 1 (n = 304)	General Hospital 2 (n = 30)
Age, mean ± SD, y	54 ± 15	64 ± 18	58 ± 16
Sex, male/female, n (%)	133/109 (55/45)	176/128 (58/42)	16/14 (53/47)
ICU stay, mean ± SD (min-max), d	6.0 ± 5.6 (1-30)	5.9 ± 12.2 (1-148)	3.8 ± 5.7 (1-8)
NEMS/TISS-28, mean ± SD	27 ± 8	29 ± 9	29 ± 9
Mechanical ventilation, n (%)	180 (74)	177 (58)	19 (63)
Blood (derived) products, n (%)	93 (38)	181 (60)	12 (40)
Renal replacement therapy, n (%)	9 (4)	18 (6)	1 (3)
Sepsis, n (%)	12 (5)	41 (13)	1 (3)
Admission diagnosis, n (%)			
Cardiovascular	27 (18)	146 (47)	10 (33)
Gastrointestinal	26 (18)	54 (17)	6 (20)
Hematological	0 (0)	2 (1)	0 (0)
Metabolic	1 (1)	8 (3)	0 (0)
Neurological	33 (22)	22 (7)	4 (13)
Renal	2 (1)	8 (3)	1 (3)
Respiratory	27 (18)	67 (22)	9 (30)
Unknown	32 (22)	3 (1)	0 (0)

NOTES: SD = standard deviation; ICU = intensive care unit; NEMS = Nine Equivalent of Nursing Manpower Use score; TISS = Therapeutic Intervention Scoring System score.

Table 3. Mean Total Costs of Cost Components of a Patient Day at a Medical-Surgical Intensive Care Unit (Euro 2006)

	University Hospital	General Hospital 1	General Hospital 2	Total Population Hospital Sample (n = 3)	
				Mean	SD
Diagnostic procedures					
Medical imaging services	58	67	119	81	33
Laboratory services	188	125	120	144	38
Consumables					
Drugs	140	145	137	141	4
Fluids	127	141	145	138	9
Disposables	3	32	62	32	29
Hotel and nutrition	87	83	42	71	25
Labor: ICU					
ICU specialist	74	188	163	142	60
ICU fellow	70	20	84	58	34
ICU nurse	382	541	330	418	110
Consultations					
Medical specialist	9	9	8	9	1
Fellow	6	5	4	5	1
Pharmacist	1	1	0	1	1
Physiotherapist	0	1	1	1	0
Laboratory technician	1	2	3	2	1
Nutrition specialist	0	1	1	0	0
Overheads	561	494	419	491	71
Capital	96	322	115	177	125
Total	1.805	2.176	1.753	1.911	230

NOTES: SD = standard deviation; ICU = intensive care unit.

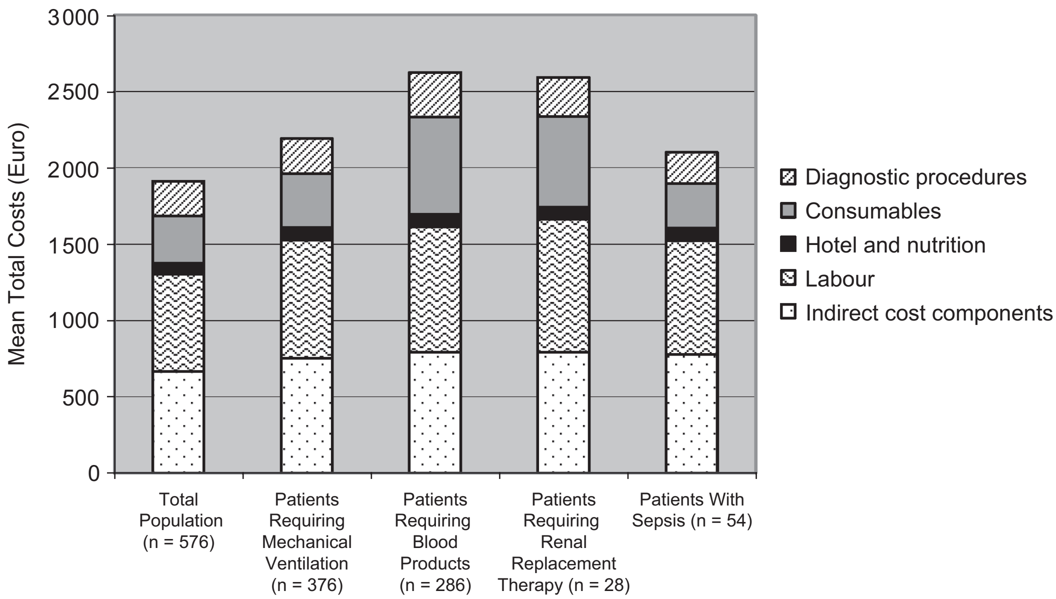

Figure 1. Distribution of cost components for the total population and subpopulations (Euro 2006).

Direct Cost Components

Labor costs accounted for one-third of the total costs (€635 ± 117; Table 3). Although the labor costs of ICU specialists were lower in the university hospital compared with the general hospitals, their resource use appeared to be very similar (71 vs 77 and 67 minutes) because the cost variation of ICU specialists between hospitals was primarily caused by a difference in unit costs (€1.10 per minute in the university hospital vs €2.46 per minute in the general hospitals; Table 1).

The distribution of labor costs by other ICU staff categories was somewhat different in general hospital 1 compared with the other hospitals. Although the university hospital and general hospital 2 employed 20 and 9 ICU fellows, respectively, general hospital 1 employed only one. This was reflected in the resource use of ICU fellows, which was a manifold lower in general hospital 1 than in the other hospitals (37 minutes vs 149 and 157 minutes). Conversely, the share of costs for ICU nurses in general hospital 1 was considerably higher (€541 vs €382 and €330; Table 3).

The share of patients receiving medical imaging services and laboratory services amounted to 88% and 93%, respectively. Medical imaging services were double the costs in general hospital 2 (€119) compared with the other 2 hospitals (€58 and €67; Table 3). Laboratory services were much higher in the university hospital (€188) compared with the other hospitals (€125 and €120; Table 3).

Hotel and nutrition represented only 4% of the daily ICU costs (€71 ± 25; Table 3).

Indirect Cost Components

In all these 3 hospitals, the proportion of overheads and capital accounted for one-third of the total costs (€669 ± 141; Table 3).

Patient Subgroups

Figure 1 presents the distribution of cost components for the total population and 4 patient subgroups. The cost estimates for patients requiring mechanical ventilation (€2110 ± 204; $P < .001$), blood products (€2625 ± 968; $P < .001$), and renal replacement therapy (€2594 ± 1.004; $P = .006$) were significantly higher than that of the total population. However, no significant cost differences were found for patients with sepsis ($P = .304$).

Regression Analyses

Table 4 shows 2 models of the OLS regression that were constructed to examine the degree of association

Table 4. Regression Models to Explain Mean Total Costs (n = 576)

	Model 1 $R^2 = 0.503$		Model 2 $R^2 = 0.501$	
Independent Variable	Coefficient	SE	Coefficient	SE
Patient characteristics				
Age	−3.06	0.84[a]	−3.45	0.82[a]
Sex	19.49	24.42		
ICU length of stay	−0.59	0.31[b]		
TISS score	43.47	1.77[a]	43.65	1.74[a]
Mechanical ventilation	−115.71	32.11[a]	−132.82	31.06[a]
Blood (derived) products	441.36	27.93[a]	447.67	27.86[a]
Renal replacement therapy	193.76	52.89[a]	207.44	52.60[a]
Sepsis	−29.51	29.51		

NOTES: SE = standard error; ICU = intensive care unit; TISS = therapeutic intervention scoring system.
[a]$P < .01$.
[b].05 > P > .10.

between total costs and the patient characteristics. Model 1 included all patient characteristics, of which sex ($P = .425$), ICU length of stay ($P = .060$), and sepsis ($P = .317$) were not significantly associated with daily ICU costs. When these variables were left out (model 2), age, NEMS/TISS-28 score, mechanical ventilation, blood products, and renal replacement therapy remained significantly related to total costs. Overall, this analysis explained 50% of the average daily ICU costs. Requirement of mechanical ventilation was associated with a cost decrease of €132.82 ($P < .001$), whereas 1 additional year of age corresponded to a decrease of €3.45 ($P < .001$). However, when the NEMS/TISS-28 score was not included as a control variable, cost increases in age and mechanical ventilation were observed. The latter finding was reinforced by the superior ability of the NEMS/TISS-28 score to predict total costs ($R^2 = 0.373$; Figure 2) over mechanical ventilation ($R^2 = 0.125$) and age ($R^2 = 0.012$). Binomial regression analyses showed a cost increase of €451.66 ($P < .001$) for mechanical ventilation and €4.42 ($P < .001$) age.

Finally, a positive correlation of daily ICU costs with the use of blood products ($R^2 = 0.232$) was demonstrated. No substantial correlation was found between daily costs and any of the other variables.

Discussion

This is the second microcosting study on the costs of ICU stay in Europe following the study of Edbrooke et al.[9] Average daily direct costs were €1243 ± 108. Indirect costs were €669 ± 141, contributing to the daily ICU costs of 1 ICU day of €1911 ± 230. These results are in agreement with the costs of ICU stay as calculated by Edbrooke et al.[9] They found the daily ICU costs to be €2074 (adjusted to 2006), with labor contributing to 24% of the mean costs (vs 33% in our study). Furthermore, they also observed substantial cost variation in the cost components obtained for individual patients.

Compared with the daily costs of patients not requiring mechanical ventilation, daily costs of patients requiring mechanical ventilation were 29% more costly (P < .001). This finding is similar to that of Dasta et al[6] who found a cost increase of 32% (increases of 62% on the first day, 37% on the second day, and 25% on subsequent days of admission). Compared to the total population, the daily costs of patients requiring mechanical ventilation were 15% more costly (P < .001). Similarly, blood products, renal replacement, and sepsis in critically ill patients were associated with cost increases of 37% (P < .001), 36% (P = .006), and 10% (P = .304), respectively.

The OLS regression analyses indicate that daily NEMS/TISS-28 scores are able to predict 37% of the daily costs. This percentage is similar to that observed by de Keizer et al[19] (40%) but surprisingly low compared with studies carried out by Graf et al[8] (92%) and Moran et al[4] (81%). Despite the high correlations found in these studies, Edbrooke et al[11] suggested that high variance in patient specific daily costs makes the predictive power of the TISS score poor.

The regression analyses further suggest that ICU length of stay is unable to predict daily ICU

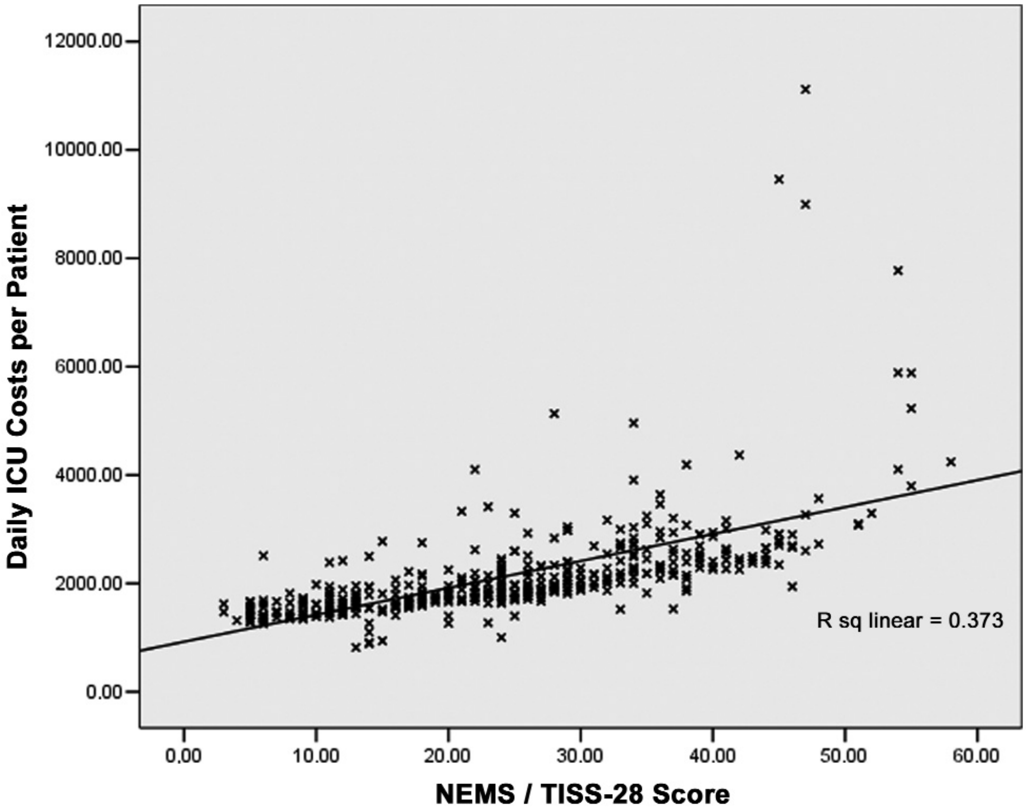

Figure 2. Relationship of NEMS/TISS-28 score and daily ICU costs per patient (Euro 2006). NEMS indicates Nine Equivalent of Nursing Manpower Use score; TISS-28, Therapeutic Intervention Scoring System score; ICU, intensive care unit.

costs (R^2 = 0.004). However, ICU length of stay showed a strong power to predict total ICU costs for an individual patient (R^2 = 0.984), comparable to other adult ICU studies.[4,8,20,21]

This study has several limitations. First, resource use data of general hospital 1 were derived in 2003, whereas for the other hospitals, the data were obtained in 2006. After application of the general price index, mean costs of general hospital 1 were, €147 ± 1108 (P = .002), higher than those of the total population. However, this cost increase might have been caused by the introduction of newer therapies and changes in staff occupation.

Second, daily ICU costs of general hospital 2 were based on only 1 week in 2006.

However, of all 1427 admissions in this hospital in 2006, the mean age (56 ± 21 years), the percentage of men (55%), the average length of ICU stay (4.5 ± 7.6 days), the average TISS-28 score (27 ± 12), the percentage of mechanical ventilation days (52%), and average number of mechanical ventilation days per patient (7.0 ± 11.2 days) were comparable to corresponding figures of this 1 week (Table 2).

Lastly, analyses on renal replacement therapy were conducted for the general hospitals only because no information on renal replacement therapy could be obtained from the databases of the university hospital.

Even though our study included the ICUs of only 3 hospitals, there are indications that these ICUs may be accurate representatives to Dutch ICUs. A national survey, carried out by the Dutch Association for Intensive Care to investigate the supply and demand of ICU services in the Netherlands in 2002, showed that approximately 35% of the available ICU beds were concentrated in university hospitals (33% in our study). In addition, the survey revealed that the overall TISS score of Dutch ICUs varied between 14 and 35 (between 24 and 29 in our study) and that the average length of ICU stay amounted to 5.5 days in university hospitals and 3.6 days in general hospitals (6.0 and 4.9

days respectively in our study). More than 45% of the nursing days were mechanical ventilation days in a majority of Dutch ICUs (65% in our study). Besides, the 3 hospitals in our study were located at different regions in the Netherlands.

In conclusion, we found the average daily ICU costs to be €1911 ± 230 for the total population, with significant cost increases in patients requiring mechanical ventilation, blood products, or renal replacement therapy. The derived costs were comparable to the reference costs of €1779[3] (adjusted to 2006) for an ICU day in the Netherlands.

Acknowledgments

The authors would like to thank the employees of the clinical and financial departments of the Erasmus MC University Medical Center (Rotterdam), the Gelre Hospitals (Apeldoorn), and the Isala Clinics (Zwolle) who provided resource use and cost data for the study. They particularly thank Anita Jager, Luc Knap, Guido Lansbergen, Nitolanda van Rijn, and Marjan Streutker. The authors are grateful to Hans Tamminga and Robert Welte for their contribution to this study. This study was supported by GlaxoSmithKline.

References

1. Halpern NA, Bettes L, Greenstein R. Federal and nationwide intensive care units and healthcare costs: 1986-1992. *Crit Care Med.* 1994;22:2001-2007.
2. van Dijk FE, van der Werken C. What are the costs of an intensive care patient? The direct costs of a surgical patient per ICU-admission and per inpatient day. *Med Contact.* 1998;53:1154-1156.
3. Oostenbrink JB, Koopmanschap MA, Rutten FF. Standardisation of costs: the Dutch Manual for Costing in economic evaluations. *Pharmacoeconomics.* 2002;20: 443-454.
4. Moran JL, Peisach AR, Solomon PJ, Martin J. Cost calculation and prediction in adult intensive care: a ground-up utilization study. *Anaesth Intensive Care*. 2004;32:787-797.
5. Flaatten H, Kvale R. Cost of intensive care in a Norwegian University hospital 1997-1999. *Crit Care*. 2003;7:72-78.
6. 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;33:1266-1271.
7. Rechner IJ, Lipman J. The costs of caring for patients in a tertiary referral Australian intensive care unit. *Anaesth Intensive Care*. 2005;33:477-482.
8. Graf J, Graf C, Janssens U. Analysis of resource use and cost-generating factors in a German medical intensive care unit employing the Therapeutic Intervention Scoring System (TISS-28). *Intensive Care Med*. 2002;28:324-331.
9. 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;23:645-650.
10. Bertolini G, Rossi C, Brazzi L, et al. The relationship between labour cost per patient and the size of intensive care units: a multicentre prospective study. *Intensive Care Med*. 2003;29:2307-2311.
11. Edbrooke DL, Ridley SA, Hibbert CL, Corcoran M. Variations in expenditure between adult general intensive care units in the UK. *Anaesthesia*. 2001;56:208-216.
12. 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;56:643-647.
13. Elliott D. Costing intensive care services: a review of study methods, results and limitations. *Aust Crit Care*. 1997;10:55-63.
14. Drummond MF, Sculpher MJ, Torrance GW, O'Brien BJ, Stoddart GL. *Methods for the Economic Evaluation of Health Care Programmes*. 3rd ed. New York, NY: Oxford University Press; 2005.
15. Bakker J, Levi M, van Hout BA, van Gestel A. Sepsis, a complicated syndrome with major medical and social consequences. *Ned Tijdschr Geneeskd*. 2004;148: 975-978.
16. Berbece AN, Richardson RM. Sustained low-efficiency dialysis in the ICU: cost, anticoagulation, and solute removal. *Kidney Int*. 2006;70:963-968.
17. Burchardi H, Schneider H. Economic aspects of severe sepsis: a review of intensive care unit costs, cost of illness and cost effectiveness of therapy. *Pharmacoeconomics*. 2004;22:793-813.
18. Manns B, Doig CJ, Lee H, et al. Cost of acute renal failure requiring dialysis in the intensive care unit: clinical and resource implications of renal recovery. *Crit Care Med*. 2003;31:449-455.
19. de Keizer NF, Bonsel GJ, Al MJ, Gemke RJ. The relation between TISS and real paediatric ICU costs: a case study with generalizable methodology. *Intensive Care Med*. 1998;24:1062-1069.
20. Rapoport J, Teres D, Zhao Y, Lemeshow S. Length of stay data as a guide to hospital economic performance for ICU patients. *Med Care*. 2003;41:386-397.
21. Stricker K, Rothen HU, Takala J. Resource use in the ICU: short- vs. long-term patients. *Acta Anaesthesiol Scand*. 2003;47:508-515.