

THESES OF DOCTORIAN DISSERTATION (PhD)

Cost analysis of intensive care

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INTRODUCTION AND LITERATURE REVIEW

Intensive care units are for those patients who have one- or more organ failure or they have very high risk for having one. Intensive care units also provide service for life threatening conditions in 24 hours continuous care. Depending of severity of illness at admission, the mortality of intensive care units varies between 10-25 %. The modern intensive care has moved to hospital wards as well, when experienced intensive care nurses screen those patients who are at risk of organ failure (outreach service). Thanks to this expanded role, the need for intensive care is not questioned by any specialties and the number of intensive care beds is on average 3-5 % of total hospital beds. As the population gets older and there are more invasive surgical procedures available, intensive care units have more workload and there is always a demand for more ICU beds. In order to increase the size of an ICU, it is necessary to know the cost of ICU care.

There are numerous publications about health care cost analysis abroad, despite of the fact that the health care cost spending is much higher in developed countries than in Hungary. As a former “Eastern Block” country, Hungary has significant economic difficulties to overcome. Although the total expenditure on health in percentage of Gross Domestic Product (GDP) is similar to former “Western” neighbour countries, the GDP per capita is less than half. Furthermore, the increase of GDP per capita spending might be similar between countries; it can only match the continuous rise in health care expenditure. This warrants the need for cost-effectiveness studies in our country, because the existence of European Union will equalize the price of health care products in long term.

The high cost of intensive care and its representation in rising health care costs is well known from international data. It is very difficult to quantify the total cost of intensive care services, but usually it takes about 20 % of total hospital budget. However, the intensive care population is not homogenous, a small proportion takes up the majority of resources. The increased daily cost only partially responsible for this, it is mainly caused by the extended length of stay and consequent high personnel

costs. Personnel costs takes up 60-70 % of total hospital costs according to international data. The severity of illness (e.g. APACHE II score) at ICU admission predicts the cost of intensive care. A small proportion of patients (8 %) use 50 % of intensive care resources, whereas a much larger group (92 %) responsible for the other 50 % of resource use. High cost patient group comprises mainly of severe sepsis cases, where the presence of resistant microorganisms causes prolonged length of stay and higher costs. On the basis of these data, I analysed general intensive care costs as well as the intensive care cost of severe sepsis.

Definitions

Health care costs can be calculated by two methods: “*top-down*” and “*bottom-up*” approach. In top-down method the resource use and cost is calculated retrospectively after a certain time, normally one financial year. Bottom-up approach means prospective data collection by resource use and after a certain time cost is allocated to each individual resource use. Bottom-up approach is more time-consuming, however it is more accurate than top-down approach.

Health care costs can be grouped by several different ways. One is to separate as direct costs (= patient related) and indirect costs (unrelated to direct patient care). Direct costs comprise for example the cost of drugs, consumables, and radiology. Indirect costs include for example the personnel costs, heating, hotel costs. These are permanent costs and apply to intensive care units even if there are no patients on the unit. Another mode of cost reporting is the “*cost block analysis*.” In this method, the cost is separated into 6 groups: (1) Capital equipment, (2) Estates, (3) Non-clinical support, (4) Clinical support, (5) Consumables and (6) Personnel costs. Each group can be further divided into subgroups, which makes possible to perform very detailed cost analysis. The first three groups comprise patient unrelated costs (=indirect costs).

In our study health care costs were analysed by top-down approach and we validated our data by bottom-up analysis on a small sample of patient. We analysed patient related costs only, e.g. clinical support, consumables and staff costs.

THE AIM OF MY WORK

1. To determine general intensive care costs. To analyse cost components by cost blocks, to calculate total intensive care costs, cost per ICU admission, cost per bed and cost per day.
2. To determine the incidence and mortality of severe sepsis. To analyse intensive care cost of severe sepsis, correlation between calculated cost block components and patient data.
3. To compare Hungarian intensive care cost data with international cost studies.

METHODS

Our work consisted of two studies.

1. General intensive care costs

The aim of our first study was to identify general intensive care costs. We recruited 13 intensive care units to this study, 5 university hospitals, 6 county hospitals and 2 city hospitals. Cost data were collected by cost blocks using a detailed questionnaire as below:

- a) Clinical support: radiology, biochemistry, and physiotherapy.
- b) Consumables: drugs, nutrition, blood products, disposables.
- c) Personnel: medical cost, nursing cost and other personnel cost.

Medical Economics and Research Centre (MERCs), Sheffield, England designed the questionnaire used in our study, and we gained permission to use it with some modification to Hungarian custom. Using this standardised questionnaire made international data comparison possible. The questionnaires were sent out in March 2001 and they collected year 2000 cost data. The head of each participating units was responsible for data accuracy, and there was a voluntary nominated junior doctor who performed data collection. On top of general patient data, each ICU listed Top 10 drugs, which was those 10 drugs, where the most money was spent in the study year.

2. Intensive care cost of severe sepsis

In our second study, we analysed the intensive care cost of severe sepsis. First we accessed the Hungarian National Health Fund (GYOGYINFOK) database and collected data on the incidence and mortality of sepsis in Hungary. Our search criteria were those patients, who were treated in intensive care unit and they had at least one septic ICD (International Code of Diseases) code. In the second part of this study, we collected data on the cost of severe sepsis treated in intensive care unit by using cost block method. We involved 6 intensive care units in this study, which identified 60 severe sepsis patients. They collected resource use of clinical support and

consumables retrospectively from medical and nursing data. There were altogether 59 different resources collected for day 1, 2, 3 and rest of time. On top of these resource uses, the total drug consumption of each patient was collected as well on daily basis. To validate retrospective data, the participating intensive care units performed prospective data collection as well for one month.

Resource use was collected by using a questionnaire, which was sent out in May 2002 to each participating ICU. Retrospective data collection was started in 15th August 2002; each unit identified the first 10 patient treated with severe sepsis. Inclusion criteria's were as international standards used for definition of severe sepsis. They excluded those patients, who:

- Died within 24 hours after ICU admission.
- Suffered from acute pancreatitis.
- Has known malignant disease and life expectancy was less then 3 months.

Prospective data collection was between 15 August and 15 September 2002. Each unit included those patients, who were admitted with severe sepsis during this time period. The same questionnaire as above was used for data collection.

Statistical analysis

Data were extracted from collected questionnaires then costing data and resource use were entered into Excel spreadsheet. Authors attributed costs to each resource use and then summary data were separated into cost blocks. SPSS 10.0 software was used for statistical analysis. Non-parametric data were expressed as median and interquartile range (IQR). In accordance with literature evidence, cost data were expressed as mean and standard deviation.

RESULTS

1. General intensive care costs

There were altogether 9 313 patients included in this study who were treated in the participating intensive care units in year 2000. Median number of beds was 12 (IQR 9-14), median bed occupancy was 67 % (IQR 62-79). Median length of stay was found 5 days (IQR 3-6.4) and the mortality 21 % (IQR 11-26). Annual total median cost of an intensive care bed was 30 990 Euro (SD 12 573), median cost per patient was 144 Euro (SD 63). Cost block analysis showed that the most expensive cost block was drugs and fluids in Hungary, it accounted for 35.8 % of total cost. The list of Top 10 drugs was grouped into 7 categories: antibiotics, cardiovascular drugs, anticoagulants, sedation, antifungals, fluids and others. In subgroup analysis, 41 % of total drugs and fluids costs were spent on antibiotics, followed by fluid costs (19 %).

Based on year 2000 costing data, participating intensive care units spent 8.1 % on clinical support, 59.4 % on consumables and 32.5 % on personnel.

2. Cost of severe sepsis

According to Hungarian Health Fund (GYOGYINFOK) database, intensive care units treated 2 659 patients with sepsis in Hungary in year 2001. Median age was 52 years (IQR 42-69) and median length of stay was 14.5 days (IQR 42-69). After intensive care discharge, patients were treated in hospital for a further 18.1 days (IQR 14-26) and 28 days mortality was found 42.7 %.

Based on data of 70 patients with *severe* sepsis from participating intensive care units, the median age was found to be 53 years (IQR 44-69). Median length of stay was 15.5 days (IQR 8-20), median number of days on mechanical ventilation was 10.1 days (IQR 4-14), median APACHE II score was 20.6 (IQR 15-26). 28 days mortality in this patient population was 64 %. The source of infection with severe sepsis was divided into organ systems and the most frequent cause was respiratory system (42 %), followed by abdominal origin (40 %), then soft tissue (11 %) and

genito-urinary system (11 %). Respiratory and soft-tissue originated infections were in equal proportion between those who died and survived. Abdominal infections were less frequent, soft tissue infections were more frequent in those patients who survived severe sepsis.

Mean cost of severe sepsis (direct costs and personnel costs) per patient day was calculated to be 337 Euro (SD 73). Mean drug cost per patient day was 123 Euro (SD 79) and mean cost of disposables per patient day was 66 Euro (SD 36). Adding estimated hotel costs of the participating units, we found that the mean cost of severe sepsis per day on intensive care unit is 434 Euro (SD 108).

There was no statistical difference between day 1 cost of consumables (=disposables, blood products and nutrition) and drugs of severe septic patients (120 Euro vs. 108 Euro, $p=0,237$), however, in terms of mean cost per stay, drug cost per day was almost double then consumables cost (66 Euro vs. 123 Euro, $p=0,003$). Day 1 cost of cost blocks was different between survivors and non-survivors: drugs and blood products spending was significantly higher in non-survivors: $p=0.004$, $p=0.047$ respectively. Direct cost per day on day 1 was 287 Euro in non-survivors as compared to 162 Euro in survivors ($p=0.020$).

DISCUSSION

1. General cost of intensive care

Mean cost per patient day by data from 9 313 patients was 144 Euro. The most expensive cost component was found to be drugs (35.9 %), followed by personnel costs (32.4 %). Is it more or less? It is very difficult to make international cost comparison, since data collection is not standardized and it is not easy to express differences in purchasing power between countries. There are several methods suggested in literature, an interesting one is the “Big Mac index”. By using this, the price differences between two countries are compared by the cost of McDonald’s Big Mac Sandwich. Since in our first study we used the questionnaire of National Cost Block, England, I could make international comparison between Hungary and England. Edbrooke et al analysed costing data of 28 intensive care units in the same year in England and they found that in proportion, clinical support services took similar share of total cost (9.5 % vs. 8.1 %). Personnel costs in England took 62.6 % - it was 32.5 % in Hungary -, consumables took on average 27.9 % in England whereas 59.4 % in Hungary. Drug costs have some differences as well between countries: sedation cost is much higher (40 %) and antibiotic spending is much lower (20 %) in England than in Hungary. The higher number of ventilated patient explains the higher cost of sedation in England: it is 64.2 % according to national data. By comparison, the proportion of ventilated patients amongst Hungarian ICU patients is 32.5 %. The lower antibiotics proportion can be explained by the widespread use of antibiotics protocols and regular microbiologist input in England.

According to literature data, personnel cost accounts for 60-70 % of total cost in developed countries. The much lower personnel cost found in our study is not surprising if we take into account the differences of wages between Hungary and England. I used Purchasing Power Parities (PPP) data to compare the two countries. The value of the customer basket was £0.65 in England and 95.2 Ft in Hungary in Year 2000, therefore, the PPP quotient was 2.6. This means, that in any cost comparison, if the quotient is closer to 2.6, than the cost of services is quite similar.

The quotient for annual mean cost per bed is 13.2 and per patient day is 9.7 between Hungary and England. The huge difference found is explained by the significant national wage differences; however, it is not just the higher individual wage in England, but the higher number of intensive care nurses per bed there as well. According to National Institute data, the median number of intensive care nurses per bed is 2.1 in Hungary and 6.2 in England. In a study by Havill et al, the number of nurses/the number of nursing hours showed very good correlation with intensive care costs ($r^2=0,98$). The lower number of nurses per bed almost certainly contributes to the higher mortality of severe sepsis found in our study. The quotient of drug cost per patient day is 3.3 between Hungary and England; since it is very close to the PPP quotient, in terms of drugs intensive care patients receive similar care in Hungary.

The very low personnel cost in Hungary has other consequences as well: the number of intensive care beds has minimal effect on hospital budget, since the majority of intensive care costs is direct (=patient related) costs. Improving bed occupancy rate from costing point of view, therefore, is not indicated. The Hungarian hospital reimbursement system (Diagnosis Related Group, DRG) however, forces hospitals to improve bed occupancy rate. Once personnel costs will take majority of ICU budget, high bed occupancy rate will be cost-effective as well.

Intensive care costs were analysed according to the level of care as well and I found that the cost of ICU bed in university hospitals is higher than in county or city hospitals. The difference between university and city hospitals ($p=0.023$) and between county and city hospitals ($p=0.034$) is statistically significant. The higher cost of university and county hospitals is explained by the severity of patients, which is indicated by the lowest drug cost in city hospitals. Unfortunately, we did not collect scoring data (e.g. APACHE II) in this study.

We did not collect capital equipment cost in our cost block analysis; although it is not patient related cost, its value is very informative. European Society of Intensive Care guideline recommends to calculate capital equipment costs with 7 years of depreciation; it means this value is negligible in Hungary. As an example, the average age of the anaesthetic machines in my hospital is 14 years, the oldest one in use was purchased in 1972.

2. Cost of severe sepsis

The incidence and cost of severe sepsis in Hungary is not known; there are no published data available. According to international data, the incidence of sepsis has increased in the last 10 years (there are 750 000 cases per year in United States) and the number of patients died of sepsis is similar to the number of patients died in acute myocardial attack. 2-3 % of hospital patients and 10-15 % of intensive care patients will suffer from severe sepsis/septic shock during their length of stay.

The mortality of severe sepsis found in our study was very high (64 %), international data describes 30-50 % hospital mortality. We did not analyse the causes of higher mortality in Hungary, but from the similar admission APACHE II scores between survivors and non-survivors we assume higher proportion of nosocomial infections.

The cost of severe sepsis in Hungary is more than three times higher than average intensive care costs. The higher cost is mainly caused by the much longer length of stay (15.5 days vs. 5 days) – there is no difference in proportion of drug cost: 36.5 % vs. 38.9 %. The high cost of disposables on day 1 is explained by the use of cannulas, catheters, tubes etc. on admission. According to our data, drug cost takes the majority of severe sepsis costs and personnel cost is much lower. International data show opposite, since in developed countries personnel cost accounts for 60-70 % of severe sepsis cost as well. The importance of this finding is, that in developed countries drugs only account for 11-15 % of ICU cost and reducing drug cost budget has no weighted effect on ICU budget: 10 % drug budget cut only means 1.5 % total cost reduction.

In a study by Edbrooke et al from England, the cost of severe sepsis was found 6.5 times more than average intensive care cost. The cost per patient day in their study was 1080 Euro. They divided septic patients according to the time course of the disease: Group 1 had sepsis on ICU admission, in Group 2 sepsis was diagnosed on day 2, and in Group 3 sepsis was diagnosed after 2 days of ICU admission. They found that Group 1 costs were 2 times, Group 2 costs were 8 times and Group 3 costs

were 11 times higher than average ICU costs. In conclusion, severe sepsis should be diagnosed as early as possible from cost-effectiveness point of view as well.

Severe sepsis has implications on high cost not only in intensive care: in an Italian study they found that hospital costs of severe sepsis survivors is two times more than the cost of other patients discharged from ICU. There are changes to life expectancy after surviving severe sepsis as well: depending on age and comorbidities, it is about half of previous life expectancy, which can be further worsened by the quality of life measures. These data again support the above conclusion that severe sepsis should be diagnosed and treated in intensive care unit as soon as possible.

Mean intensive care cost per day of severe sepsis is 434 Euro and mean total cost of severe sepsis (length of stay 15.5 days) is 6 727 Euro per patient. The DRG reimbursement of severe sepsis is much lower at present; therefore, it can only be reimbursed by individual case. This finding confirms that intensive care costs are undervalued in the Hungarian DRG system. According to the Hungarian National Health Fund database, the number of patients treated with sepsis in intensive care units was 2 161 in Year 2001 in Hungary – combining this with our costing data describes the national cost of sepsis per year: it is approximately 17.9 M Euro. It is only intensive care cost, so the actual national cost of sepsis is almost certainly much higher.

Although the aim of my work was to analyse intensive care costs, general patient data analysis showed interesting data as well. Our first study proved, that intensive care units are not standardised in Hungary: mortality data ranges were between 10 and 70 %, bed occupancy rates were between 38 to 94 %. University intensive care units treat more patients and have lower mortality – these units probably admit higher proportion of routine postoperative care cases. I hope that our data will help to improve intensive care reimbursement and also will help to achieve nationwide standards in intensive care.

SUMMARY

Introduction. Intensive care is regarded as a very expensive specialty. The increasing awareness of health care costing in recent years requires analysing the resource use then using it economically. The analysis of health cost is to be followed by cost-effectiveness analysis. There are numerous publications on health cost analysis abroad, however, there are only very few published studies from Hungary. The basis of my work consisted of two studies: first we analysed the general cost of intensive care then we attempted to determine the cost of severe sepsis.

Methods. Health cost data can be collected by “top-down” and “bottom-up” methods. Using top-down methods, the cost of intensive care is calculated retrospectively from the annual resource use or costing reports. Bottom up approach collects the resource use prospectively then attributes cost to each resource. We used top-down approach, in which the annual cost of intensive care was grouped by Cost Block Method: (1) capital equipment, (2) estates, (3) non-clinical support, (4) clinical support, (5) consumables and (6) staff costs. In our first study, we involved 9313 patients from 13 ICUs and analysed the annual cost of intensive care. In our second study, we determined the cost of severe sepsis in intensive care by data from 70 patients in 6 ICUs. In this study, there was not only retrospective (top-down), but prospective (bottom-up) data collection as well. There were altogether 59 different resources collected on top of staff costs.

Results. The median cost per patient day in intensive care units was found to be 144 Euro (SD 63); median length of stay was 5 days (IQR 3-6,4). Clinical support services were accounted for 8.1 % of resources, consumables for 59.4 % and staff costs for 32.5 %. Drugs and fluids account for 38.9 % of total ICU cost, it means 52 Euro per patient day. The average daily ICU direct cost per patient of severe sepsis is 337 Euro (SD 73), the median length of stay 15.5 days (IQR 8-20). The mortality of severe sepsis was found to be 64 %. The cost block analysis showed that by treating severe sepsis, we spend less on clinical support and more on consumables. Personnel cost in proportion was found lower, only 26,3 %. Drugs and fluids take 40,6 % of severe

sepsis cost, it means 123 Euro (SD 79) per patient day. Non-survivors of severe sepsis had shorter length of stay and higher daily costs compared to survivors.

Discussion. This work has proven that there are major differences in cost components of intensive care in Hungary compared to other European countries. Staff cost takes much less and the drug cost takes relatively higher proportion of a Hungarian ICU budget, which makes the direct costs more important. The very low staff cost in Hungary is due to low salaries, but the lower number of nurses per bed contributes to this as well. We found that severe sepsis has very high mortality and considerable longer length of stay in Hungary. Our study confirmed the very low reimbursement of health care costs in Hungary: the cost per ICU admission of severe sepsis in intensive is much higher than the current DRG reimbursement of severe sepsis.

PUBLICATIONS

Original publications used for this PhD work:

a) Published articles:

1. Dr. Csomós Á, Dr. Ökrös I:
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2. Dr. Csomós Á, Dr. Hoffer G, Dr. Fülesdi B, Dr. Ludwig E:
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Impact factor: 3,034

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5. Dr. Csomós Á, Dr. Hoffer G:
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b) Accepted manuscripts, in process of publication:

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Impact factor: 1,413

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c) Manuscripts under review:

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Impact factor:

Total impact factor: 6,385

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3. A Csomos, G Hoffer:
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Total impact factor: 2,199

KÖSZÖNETNYILVÁNÍTÁS

I hereby would like to express my sincere thanks to those intensive care units, which participated in our studies:

General intensive care costs:

1. Debrecen University, Surgical Institute No. 2, Debrecen
Head of Department: Prof. Éva Uray
2. Debrecen University, Medical Institute No.1, Debrecen
Head of Department: Prof. Éva Uray
3. Semmelweis University, Surgical Institute No. 1, Budapest
Head of Department: Prof. Katalin Darvas
4. Szeged University, Institute of Anaesthesia and Intensive Care, Szeged
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5. Pécsi University, Institute of Anaesthesia and Intensive Care, Pécs.
Head of Department: Prof. Lajos Bogár
6. Kenézy County Hospital, Debrecen
Head of Department: Dr. Zoltán Szentkereszty
7. Markhot County Hospital, Eger
Head of Department: Dr. Júlia Szamaránszky
8. Petz Aladar County Hospital, Győr
Head of Department: Dr. Béla Gartner
9. BAZ County Hospital, Miskolc
Head of Department: Dr. Ilona Ökrös
10. Markusovszky County Hospital, Szombathely
Head of Department: Dr. Balázs Morvay
11. Réthy Pál County Hospital, Békéscsaba
Head of Department: Dr. Terézia Szabó
12. Semmelweis City Hospital, Miskolc
Head of Department: Dr. Géza Nagy
13. Erzsébet City Hospital, Sopron
Head of Department: Dr. Árpád Félegyházi

Cost of severe sepsis:

1. Semmelweis University, Institute of Transplant Surgery, Budapest
Head of Department: Dr. Tibor Gondos
2. Kenézy County Hospital, Debrecen
Head of Department: Dr. Zoltán Szentkereszty
3. Markhot County Hospital, Eger
Head of Department: Dr. Ákos Csomós
4. BAZ County Hospital, Miskolc
Head of Department: Dr. Ilona Ökrös
5. Jóna András County Hospital, Nyíregyháza
Head of Department: Dr. Júlia Kiss
6. Pécsi University, Institute of Anaesthesia and Intensive Care, Pécs
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