

BMJ Open The intermediate care unit as a cost-reducing critical care facility in tertiary referral hospitals: a single-centre observational study

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ABSTRACT

Objectives To determine whether and to what extent the surgical intermediate care unit (IMCU) reduces healthcare costs.

Design Retrospective cohort study.

Setting The mixed-surgical IMCU of a tertiary academic referral hospital.

Participants All admissions (n=2577) from 2012 to 2015.

Primary and secondary outcome measures The outcome measure was the hypothetical cost savings due to the presence of the IMCU. For this, each admission day was classified as either low-acuity or high-acuity, based on the Therapeutic Intervention Scoring System-28, the required specific nursing interventions and the indication for admission at the IMCU. Costs (2018) used were €463 per hospital ward, €1307 per IMCU and €2224 per intensive care unit (ICU) admission day. Savings were calculated by subtracting the actual IMCU costs from the hypothetical costs in the absence of the IMCU.

Results There were 9037 admission days (n=2577 admissions) at the IMCU. The proportion of high-acuity admissions was 87.6%. Total costs at the IMCU were €11.808 888. Total hypothetical costs in absence of the IMCU were €18.115 284. Total cost savings were thus €6.306 395, or €1.576 599, per year.

Conclusions The surgical IMCU may substantially reduce societal healthcare costs, making it a cost saving alternative to ICU care. Constant adequate triage is essential to optimise its potential.

INTRODUCTION

Intermediate care units (IMCUs) are increasingly used for their potential to optimise hospital throughput, reduce the pressure on intensive care unit (ICU) beds and reduce ICU mortality.^{1,2} These IMCUs are logistically situated between the hospital ward and the ICU and are either integrated into the ICU or separately located as a stand-alone unit.^{3,4}

However, whether IMCUs reduce healthcare costs is debatable.^{1,5,6} The main argument in favour of its economic benefit is that these units would reduce the number of required and more expensive ICU beds, that is, through admitting ‘high-acuity’

Strengths and limitations of this study

- The use of the performed nursing interventions at the intermediate care unit (IMCU) is a direct, novel method to denote whether an admission day was high-acuity (ie, otherwise in need of intensive care unit care) or low-acuity.
- Multiple sensitivity analyses were performed to assess the robustness of the key assumptions made (ie, the single imputation of missing values and excluding the subjectively measured admission indication).
- Downstream costs incurred by the presence (or the absence) of the IMCU are not accounted for.
- The obtained proportion of high-acuity patients (and thus the cost savings) is susceptible to the organisation of the IMCU and hence, the findings in this study may not be directly generalisable to other IMCUs.

patients from the ward who would otherwise be cared for at the ICU. In contrast, IMCUs may also actually *increase* healthcare costs due to the admission of patients who would otherwise be cared for at the hospital ward, that is, low-acuity patients.¹ Previous economic evaluation studies have been performed but were found to be of insufficient quality,⁷ focused on specific patient groups⁸ or solely analysed the influence of having an IMCU on the costs in the ICU population.⁹ And although the latter approach is insightful, it fails to account for costs of patients for whom ICU admission is prevented.

As the debate on the economic benefit of the IMCU boils down to whether admissions are low-acuity or high-acuity admissions, it is important to distinguish between which admissions are regarded as low-acuity and high-acuity. Towards this end, the specific nursing interventions (eg, peripheral arterial catheter, central venous line monitoring, etc) and overall nursing workload can be used. Taken together, this identifies patients who need care delivery that is not possible at a ward. Through

this approach, we aim to determine whether and to what extent the IMCU reduces healthcare costs.

METHODS

Study design and setting

This observational cohort study was conducted at the surgical IMCU of the University Medical Center in Utrecht, a tertiary academic referral hospital in the Netherlands. This stand-alone, mixed-surgical IMCU provides extensive haemodynamic and respiratory monitoring and support, including inotropic use and supplementary oxygen, for both step-down (from the ICU or recovery) and step-up (from the emergency room or hospital ward) admissions. It has a nurse-to-patient ratio of 1:1.5, while the ICU has a nurse staffing of 1:1. This relatively high nurse-to-patient ratio allows for the admittance of more complex patients that require a high nursing workload.¹⁰ Nursing at the IMCU is performed by specific IMCU-trained nurses, while in the ICU specific ICU-trained nurses are present. The limitations of the IMCU are non-invasive and invasive mechanical ventilation and continuous renal replacement therapy. Triage for admission is performed by the responsible medical team of the IMCU in collaboration with the admitting specialist. The efficiency and safety of the here-described IMCU is more extensively described in previous publications.^{10 11} It should be noted that, if IMCUs are not safe, they should not be used, regardless of their (potential) economic benefits.

A general mixed-specialty closed format ICU run by intensivists is available for consultation and take over if necessary. The occupancy rate of ICUs in our country is 86.7% (IQR 76.7%–95.1%).¹²

All admissions to this IMCU between 1 January 2012 and 31 December 2015 were included in the study. According to the institutional review board, the study was not subject to the Medical Research Involving Human Subjects Act and therefore the necessity of informed consent was waived (protocol number 17–326/C).

Definition of admission days

An admission day was defined as a calendar day in which a patient is admitted at the IMCU, provided that the patient is admitted for at least one night (defined as admission before 00:00 hours and transfer after 07:00 hours). A calendar day does not count as an admission day if the patient was admitted after 20:00 hours. This definition is also used in the reimbursement system of the Netherlands.

Low-acuity and high-acuity admissions

The classification of a low-acuity versus high-acuity admission day was based on the daily registered Therapeutic Intervention Scoring System (TISS-28),¹³ specific nursing interventions performed (based on the TISS-28), and the indication for admission. High-acuity was defined as those admissions which—in the absence of the IMCU—would have required ICU admission (table 1).

More specifically, admissions were considered high-acuity if admitted patients required a substantial nursing workload, defined as a TISS-28 of 18 points or more, that is, >3 hours of direct patient-related nursing workload per nursing shift. These patients were considered unsafe and undesired to admit at the general ward (with a nurse-to-patient ratio of 1:5). Especially since the true nursing workload is likely higher than the TISS indicates,

Table 1 Classification of high-acuity admissions at the intermediate care unit (IMCU)

Criteria high-acuity IMCU admission

Nursing workload	TISS-28 \geq 18 (\geq 3 hours direct patient-related nursing workload per 8 hours nursing shift)
Single specific nursing interventions (TISS-28)	Vasoactive medication Intravenous fluid replacement of large fluid losses under pressure Peripheral arterial catheter Status after cardiopulmonary resuscitation (<24 hours) Haemofiltration (intermittent) Active diuresis (eg, furosemide>0.5 mg/kg/day) due to cardiac overload Treatment complicated acidosis or alkalosis in acute or life-threatening situations Specific interventions (cardioversion, endoscopy, assisting thorax tube placement)
Specific admission indications	Cardiac monitoring (telemetry) Blood pressure control (telemetry) Respiratory support (>5 L O ₂) Bleeding—observation/support

Sepsis—support.

Criteria used to define whether an admission was high-acuity or not. If one or more of the criteria are present, the admission is classified as high-acuity.

TISS-28, Therapeutic Intervention Scoring System-28.¹³

as the TISS-28 is developed for the ICU and thus does not include common IMCU (or hospital ward) nursing interventions, such as psychiatric guidance, physiotherapy and stimulation of enteral feeding. Admissions were also defined as high-acuity if patients received single specific nursing interventions which could not be performed at the general hospital ward (eg, vasoactive medication, peripheral arterial catheter) and if patients had specific indications (diagnoses) for admission at the IMCU for which a patient could not have been admitted to the hospital ward, such as cardiac monitoring or extensive respiratory support ($>5\text{ L O}_2$).

Costs of admission at the intermediate and intensive care unit

The costs per admission day (based on the costs of 2016, in US\$) for the hospital ward, IMCU and ICU were calculated by dividing the total annual costs of each unit by the annual number of admission days at each unit, using the attributable costing approach.¹⁴ Total costs were based on hospital operating costs, including costs related to nurse staffing (77% of total costs at the IMCU). As the majority of hospital—IMCU and ICU—costs are fixed ($>80\%$), we used these *average* costs as opposed to the *marginal* costs, that is, the costs of an extra admission day.¹⁵

Due to business purposes and negotiations with insurance companies, exact costs per admission day cannot be provided in this article. Instead, we report the actual ratio of hospital ward, IMCU and ICU costs relative to each other, which was 1:2.8:4.8. Subsequently, we used the reimbursed fee per ICU day (€2 223 59) in the Netherlands in 2018 to arrive at the approximate (hypothetical) costs of €463 per hospital ward, €1307 per IMCU and €2224 per ICU day. These costs reflect the costs which the society needs to pay for care at the hospital ward, IMCU or ICU.

Statistical analyses

The proportion of high-acuity admission days at the IMCU was calculated by dividing the total number of high-acuity admission days with the total number of (high-acuity and low-acuity) admission days. Total costs for the hypothetical scenario of not having an IMCU were obtained by multiplying the number of low-acuity admission days with the costs per hospital ward admission day, and multiplying the number of high-acuity admission days with the costs per ICU admission day. The potential cost savings were obtained through subtracting the hypothetical costs from the actual costs.

Missing values were imputed with measurements of the day before or, if this measurement was not available, were imputed with measurements of the admission day after the missing value occurred. The residual missing cases for which there were no measurements the day before or after were excluded from the analysis of determining the proportion of high-acuity admissions. The reason for the missing values was hypothesised to be largely due to time constraints of the evening nurses, which likely occurred when more severely ill patients were admitted. This

assumption therefore may lead to an underestimation of the proportion of high-acuity patients as compared with the actual proportion.

As the results of this study highly depend on the calculation of the proportion of high-acuity patients, several sensitivity analyses were performed to test the effect of these assumptions. Therefore, cost savings were calculated when the high-acuity proportion was calculated (a) using only the original (non-imputed) admission days, to analyse the effect of the single imputation, (b) excluding admission indications as criteria for high-acuity, to analyse the influence of these possibly subjective admission indications and (c) using a total TISS cut-off value of 23 (≥ 4 hours/shift) instead of 18, to analyse the influence of a possible lower nurse-to-patient ratio at the general ward. Where applicable, the reporting of this article follows the Strengthening the Reporting of Observational Studies in Epidemiology statement (online supplementary appendix 1).¹⁶

Patient and public involvement

Patients and/or the public were not involved in this study.

RESULTS

There were 9037 admission days ($n=2577$ admissions) at the IMCU. The mean age of admitted patient was 61 (SD 16.8). Of all admitted patients, 1344 (64.6%) were male. Missing values per admission day were imputed with measurements of the day before and after ($n=2660$, 29.4%). Remaining missing cases ($n=997$, 11.0%) were excluded from the analysis of determining the proportion of high-acuity admission days. This led to a proportion of 87.6% ($n=7040$) high-acuity admission days.

Total costs at the IMCU were €11,808 888, or €2,952 222, per year. Total hypothetical costs in the absence of an IMCU were €18,115 284, or €4,528 821, per year. Total cost savings were thus €6 306 395, or €1 576 599, per year. An application to determine IMCU potential costs savings in situations with different cost ratios and different proportions of high-acuity admissions can be found at <https://intermediate-care.shinyapps.io/cost-efficiency/>. Furthermore, in the here described IMCU setting the break-even point is reached at 48% high-acuity admissions.

The cost savings using only the original (non-imputed) admission days were €1 558 965 per year. Without considering the admission indications as high-acuity admission days, this was €1 466 032 per year. A TISS cut-off of 23 (>4 hours direct patient-related work per nursing shift) yielded a cost reduction of €1 301 935 per year.

DISCUSSION

Our study is the first to show that the IMCU could substantially decrease healthcare costs, provided that the majority of admission days at the IMCU is high-acuity ($>48\%$). This economic benefit is present even if different medical

criteria are used to determine this high-acuity proportion (see online tool <https://intermediate-care.shinyapps.io/cost-efficiency/>).

These findings are in line with a previous study among patients with chronic obstructive pulmonary disease exacerbations, which also found that the IMCU reduces healthcare costs in this specific subpopulation.⁸ This can be explained by the lower fixed costs (lower nursing costs) of the IMCU as compared with the ICU. Furthermore, this study supports an ICU-based study which observed an increase in ICU costs per ICU admission day in the presence of the IMCU. Since the IMCU already treats high-acuity IMCU patients, the ICU admits more complex (and expensive) patients (high-acuity ICU), which increases the cost per ICU admission day.⁹

These findings stand in contrast with a previous study which suggested that the IMCU admits a substantial amount of low-acuity patients.¹ However, this (US-based) study did not differentiate between location of the intermediate care beds (standalone vs incorporated within the ICU) and staffing formats. This proportion of high-acuity patients and thus economic benefit may well differ between differently organised IMCUs.³ It might be that the economic benefit is less in IMCUs which are integrated into ICUs.

This has important implications, as it enhances the implementation and preservation of IMCUs. Furthermore, it may serve as an argument for the reimbursement of the IMCU, as currently IMCU beds are not always reimbursed separately. With the further implementation of IMCUs, an important contribution could be made to maintain control over critical care healthcare costs.

This study has multiple strengths. First of all, it is the first to use the 'high-acuity approach', including all IMCU admissions. Second, the criteria (TISS-28) were routinely and daily measured over a 4-year time period leading to almost 10 000 admission days. Third, healthcare cost reductions were observed even if the proposed high-acuity criteria are altered, which strengthen the reported conclusions.

These results should be interpreted in the light of several limitations. First, cost calculations are based on averages per admission day and therefore do not necessarily reflect real patient-specific costs per admission day. For example, at the IMCU the high-acuity IMCU admissions would likely cost more than the low-acuity IMCU patient and, in the absence of an IMCU, may cost less than a more complex ICU patient. However, as >80% of hospital costs (mainly nursing costs) are fixed, the deviations from the average unit-specific costs (due to the variable costs) could also have a marginal effect on the cost reduction of the IMCU.¹⁵

Second, we did not model entire patient trajectories of hospital stay and therefore we did not incorporate the effect of the IMCU or ICU on total hospital (or critical care) days and costs, for example, it may be that, in the absence of the IMCU, the same ICU-admitted patients are discharged from the hospital earlier, reducing total

costs. Third, it is important to realise that this study does not account for patient outcomes (eg, mortality), but we have shown before that within this study period patient outcomes were satisfactory, that is, adverse events (IMCU mortality and ICU transfer) were uncommon.¹¹ Fourth, since the organisation of intermediate care differs per hospital, adequate triage to mainly admit high-acuity patients is essential to justly generalise these results to other intermediate care settings. Lastly, this study assumes that (high-acuity) patients truly required the care that they received.

CONCLUSION

The IMCU may substantially reduce societal healthcare costs and therein is a cost-saving alternative to ICU care. Constant adequate triage is essential to optimise its potential.

Contributors All named authors made substantial contributions to this study. JP, FH and LL were responsible for the study conception and design. JP performed the analyses. JP, FH and LP were responsible for data interpretation. JP drafted and prepared the manuscript. The manuscript was critically revised by all authors. All authors read and approved the final version.

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