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Research Article

Association between nursing cost and patient outcomes in intensive care units: A retrospective cohort study of Belgian hospitals

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ABSTRACT

Introduction: Hospitals with better nursing resources report more favourable patient outcomes with almost no difference in cost as compared to those with worse nursing resources. The aim of this study was to assess the association between nursing cost per intensive care unit bed and patient outcomes (mortality, readmission, and length of stay).
Methodology: This was a retrospective cohort study using data collected from the intensive care units of 17 Belgian hospitals from January 01 to December 31, 2018. Hospitals were dichotomized using median annual nursing cost per bed. A total of 18,235 intensive care unit stays were included in the study with 5,664 stays in the low-cost nursing group and 12,571 in the high-cost nursing group.
Results: The rate of high length of stay outliers in the intensive care unit was significantly lower in the high-cost nursing group (9.2% vs 14.4%) compared to the low-cost nursing group. Intensive care unit readmission was not significantly different in the two groups. Mortality was lower in the high-cost nursing group for intensive care unit (9.9% vs 11.3%) and hospital (13.1% vs 14.6%) mortality. The nursing cost per intensive care bed was different in the two groups, with a median [IQR] cost of 159,387€ [140,307–166,690] for the low-cost nursing group and 214,032€ [198,094–230,058] for the high-cost group.
In multivariate analysis, intensive care unit mortality (OR = 0.80, 95% CI: 0.69–0.92, $p < 0.0001$), in-hospital mortality (OR = 0.82, 95% CI: 0.72–0.93, $p < 0.0001$), and high length of stay outliers (OR = 0.48, 95% CI: 0.42–0.55, $p < 0.0001$) were lower in the high-cost nursing group. However, there was no significant effect on intensive care readmission between the two groups (OR = 1.24, 95% CI: 0.97–1.51, $p > 0.05$).
Conclusions: This study found that higher-cost nursing per bed was associated with significantly lower intensive care unit and in-hospital mortality rates, as well as fewer high length of stay outliers, but had no significant effect on readmission to the intensive care unit.
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Implications for clinical practice

- Patients in hospitals with higher intensive care unit nursing costs per bed have better outcomes: including lower intensive care and in-hospital mortality, and lower length of stay in the intensive care unit.
- Increased investment in the intensive care nursing workforce and education is essential to improving care quality and decreasing patient length of stay.
- For the authorities, the nursing cost per intensive care unit bed could be used as an quality indicator for countries without continuous nursing resources.

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Introduction

The cost of caregivers is the most important cost factor in intensive care units (ICUs) (Bittner et al., 2013; Reis Miranda and Jegers, 2012; Kilic et al., 2019). One study conducted in four European countries estimated the cost of an ICU to be around 20% of total hospital direct costs, of which about half is spent on nurse staffing (Halpern and Pastores, 2010; Moerer et al., 2007). The cost of nursing staff includes the nurse-to-patient (N:P) ratio, and the experience and education level of nurses.

Studies have demonstrated an association between inadequate N:P ratio and quality of care, with reported increases in the incidence of nosocomial infections, adverse events, and ICU mortality (Driscoll et al., 2018; Lasater et al., 2020; Needleman et al., 2020; Rae et al., 2021). In addition, the same associations have been made for increases in the prevalence of burnout among nurses, which also impacts quality of care (Bruyneel et al., 2021; Cimiotti et al., 2012).

Regarding the level of education of nurses, a high level of education is associated with better patient outcomes (Aiken et al., 2014; Haegdorens et al., 2019; Lasater et al., 2021b; Musy et al., 2021; Sloane et al., 2018; Van den Heede et al., 2009). With regard to specialisation, the organisation of specialisations is very different depending on the country but specialised nurses may have a positive impact on quality of care and nurse satisfaction (Adibelli et al., 2017; Dury et al., 2014; Falk and Wallin, 2016; Obeidat et al., 2022). One study from Brazil reported that ICU nurses with greater autonomy have better patient outcomes (Zampieri et al., 2019).

On the other hand, the association between the experience level of nurses and the quality of care is less clear. Some studies have reported an impact of years of experience on mortality and others have not found a significant effect (Fasolino and Snyder, 2012; Lee et al., 2018). In any case, the turnover of nurses in the ICU is more frequent and, therefore, experience levels are lower than for other units and it is important to have expert nurses in the management of a team of ICU-competent level nurses (Adams et al., 2019; Christensen and Hewitt-Taylor, 2006; Milhomme et al., 2018).

Optimal nurse staffing in acute care hospitals also reduces costs due to fewer readmissions, lower rates of admission to intensive care, and shorter lengths of stay (Aiken et al., 2021; McHugh et al., 2021; Murphy et al., 2021). Hospitals with better nursing resources (staffing, skill mix, education, work environment) have better patient outcomes and experiences, with no difference in cost (Lasater et al., 2021a; Lake et al., 2022). However, to our knowledge, no study has been conducted on the association between nursing cost and patient outcomes in ICUs only.

The aim of this study was to assess the association between nursing cost per ICU bed and patient outcomes (mortality, readmission, and length of stay) in the ICU.

Methods

Patients and setting

This was a retrospective cohort study using data for the intensive care units of 17 Belgian hospitals from January 01 to December 31, 2018. These 17 hospitals represent 18.84% of hospital stays in Belgium. Hospitals were dichotomized using the median annual nursing cost adjusted per ICU bed. Eight hospitals in the low-cost nursing group and 9 hospitals in the high-cost nursing group were compared. A total of 3,173 patients were excluded from the analysis because their files were not closed by the hospital, including 757 paediatric patients (<15 years), 1,561 that were designated as incomplete stays by hospital coding teams, and 855 patients who were still hospitalized on December 31, 2018. A total of 18,235 ICU stays were included in the study with 5,664 patients in the low-cost nursing group and 12,571 in the high-cost group.

Context of the study in Belgium

In Belgium, the legal nurse to patient ratio in the ICU is 1:3 with wide heterogeneity between hospitals (Bruyneel et al., 2019; Van den Heede et al., 2019). This ratio is one of the highest in Europe and does not correspond to recommendations on this subject (Bray et al., 2010; Chamberlain et al., 2018; Greaves et al., 2018; Reis Miranda et al., 2007). On the other hand, the country's ICU nurses are mainly specialized (around 75%), only 6% are non-bachelor level nurses with an average age of 37 years (±10.3), and an average duration of experience of 13.9 (±10.5) years (Bruyneel et al., 2021). Logistics assistants, physiotherapists, and care assistants are present in a majority of the ICUs, but only during the morning shift, and ICU nurses generally work in three shifts. ICUs in Belgium are mostly closed, mixed units (surgical and medical), non-sectoral, with no differences in care level, and general intermediate care (except stroke units and coronary units) does not exist (Marshall et al., 2017). In the general wards, the nurse to patient ratio is 1:9.4 on average and 63% of the nurses have a bachelor degree (Van den Heede et al., 2019).

Concerning the training level of the nurses in the study, nurses had one of two levels of training (bachelor's degree or no bachelor's degree), as well as a specialisation which takes place after completion of the bachelor's degree with an additional year that includes training in intensive and emergency care.

Hospital funding is mixed. Part of the funding is financed by the budget of financial means (37.3%) which is linked to the activity of the hospital and evaluated by the diagnosis-related group (DRG), and the remainder of the funding comes from medical acts (39.8%), pharmaceutical products (18.4%), and conventions (4.5%) (Durant et al., 2021). The financing of nursing care, including that of intensive care nurses, comes from part of the budget of financial means and is adjusted according to the nursing activity Minimum Hospital Dataset (Pirson et al., 2013). Academic hospitals have additional funding to compensate for research and teaching.

Data collection

All data for the study came from a hospital cost analysis project PACHA conducted by the research centre "Health Economics, Hospital Management and Nursing Research" the School of Public Health at the Université Libre de Bruxelles in Belgium (Pirson and Leclercq, 2014).

The outcome variables from the minimum hospital discharge summary data included mortality, ICU readmission, and length of stay (LOS). Mortality and ICU readmission were binary variables that distinguished the stays of who died in the ICU from those who did not, and from stays discharged alive and readmitted to the ICU during the same hospitalisation. To dichotomize LOS, long stays (high outliers) were used. To calculate high LOS outliers, no consensus has been found in the literature (Cots et al., 2003) (Freitas et al., 2012). We therefore dichotomized LOS, long stays (high outliers) using the formula (75th percentile + 1.5 * inter-quartile range) that was previously used by Pirson et al. (Pirson et al., 2006).

The main diagnostic and sociodemographic data (e.g., age, sex, mortality) were obtained via minimum hospital discharge summaries. The Charlson score was also calculated through the minimum hospital discharge summary data system with International Classification of Diseases-10. With advances in the effectiveness of treatment and disease management, the contribution of chronic comorbid diseases (e.g., diabetes or cancer) as well as sex and age found within the Charlson comorbidity index to mortality is likely to have changed since development of the index in 1984 (Charlson et al., 1987). The authors revaluated the Charlson index and reassigned weights to each condition by identifying and following patients to observe mortality within one year after hospital discharge. The updated index and weights to hospital discharge data from six countries were applied and tested for their ability to predict in-hospital mortality (Quan et al., 2011). This score showed good agreement and predicted 30-day and one-year mortality in ICU patients (Christensen et al., 2011; Stavem et al., 2017). Medical procedures (e.g., mechanical ventilation and duration, extra-corporeal membrane oxygenation (ECMO), continuous hemofiltration) were obtained through invoicing. The occupancy rate was obtained via the number of stays and LOS in minutes adapted to the number of ICU beds for a year. The number of full-time equivalents (FTEs) was obtained from the accounting data of the hospitals. The nursing costs for the hospital were obtained via the cost accounting of the hospital.

Statistical analysis

Statistical analyses were performed using the statistical software STATA® version 14. A p-value <0.05 was considered statistically significant. Means and standard deviations (SD) are used to describe symmetric variables and medians and interquartile ranges (IQR) are used to describe asymmetric variables. To describe the difference between the low-cost nursing group and the high-cost nursing group, we used the Mann-Whitney (U) and Kruskal-Wallis (H) tests for comparisons of asymmetric variables. For symmetric variables, Student's T (t) test and the Chi-square test (χ^2) were used for proportion comparisons.

Univariate and multivariate logistic linear regression models were performed in order to test the association between the different independent variables and each of the stay outcomes. Odds ratios (OR) or odds ratio adjusted (ORa) and 95% confidence intervals (95% CI) are used to describe the results. To correct for important clinical differences between the nursing cost groups that may confound the association between the cohort and stay outcomes, the logistic regression model was expanded with adjustment for important patient characteristics and selected in the univariate analysis (e.g., Charlson score, geriatric cases (>75 years), age, sex, academic hospital, ventilated patients, mechanical ventilation time, patients with continuous hemofiltration, patients with ECMO, patients with intracranial pressure measurement, and main diagnosis). For mortality, an adjustment for readmission and length of stay was made. The analysis of the variables influencing the stay outcomes was conducted step-by-step to determine which variables had independent effects.

Ethical considerations

The inpatient records used in the retrospective study were fully anonymised by the hospitals and the research team did not have any access to medical files. In addition, the hospitals were also anonymised before analysis.

Results

Descriptions of hospitals

Seventeen hospitals were included in the study, 8 in the low-cost nursing group and 9 in the high-cost nursing group. All academic hospitals were in the high-cost nursing group but the number of beds per ICU (16 [14–24]) and the occupancy rate (76% [69–86]) were very similar between the groups. Conversely, the nursing cost per ICU bed was different in the two groups, with a median cost of 159,387€ [140,307 – 166,690] for the low nursing cost group and 214,032€ [198,094 – 230,058] for the high-cost nursing group (p = 0.0005) and 179,838€ [161,605–214,032] for both groups. The nursing cost per ICU day was not significantly different between the two groups at €748 [685–911]. The annual cost of an FTE nurse also varied significantly between the two groups, with a lower cost for the low-cost group (€72,507 [68,993–75,111] vs. €77,352 [76,113–81,172], p = 0.009) and a lower number of FTEs per ICU bed (2.17 [1.98–2.33] vs. 2.80 [2.6–2.9], p = 0.0011) (Table 1).

Table 1
Description of hospitals and nursing costs for a year.

Characteristics	Low nursing cost hospitals (n = 5664)	High nursing cost hospitals (n = 12571)	Test value	p-value	Total (n = 18235)
Number of hospitals, n	8	9			17
Academic hospital, n	0	3			3
Number of beds, n	124	208			379
Number of beds by hospital, median [IQR]	15.5 [11–19]	20 [15–31]			16 [14–24]
Occupancy rate, median [IQR]	74 [69–82]	82 [76–86]	U = 0.04	0.8276	76 [69–83]
Cost of nursing by bed ICU €, median [IQR]	159 387 [140 307–166 690]	214 032 [198 094–230 058]	U = 12.00	0.0005	179 838 [161 605–214 032]
Nursing cost per stay €, median [IQR]	3 561 [2 854–3 741]	3 413 [3 204–3 679]	U = 0.03	0.8474	3 440 [3 240–3 740]
Nursing cost per day €, median [IQR]	671 [637–739]	838 [784–1073]	U = 2.80	0.0053	748 [685–911]
Cost FTE nurse €, median [IQR]	72 507 [68 993–75 111]	77 352 [76 113–81 172]	U = 6.75	0.009	75 593 [70 641–77 352]
FTE nurse per ICU bed	2.17 [1.98–2.33]	2.80 [2.60–2.90]	U = 10.70	0.0011	2.50 [2.10–2.80]

Legend: ICU = Intensive care Unit; IQR: Interquartile range; FTE: Full time equivalent.
* pvalue: The Wilcoxon Ranksum test for non-parametric test (U).

Sociodemographic characteristics

Sociodemographic characteristics for the ICU patient stays included in the study are shown in Table 2. Mean (±SD) age (64.7 ± 16.4 vs 62.4 ± 17.4, p < 0.0001) and proportion of geriatric patients (27.9% vs 23.5%, p < 0.0001) were higher for the low-cost nursing group. The proportion of men was not significantly different between the two groups with a proportion of 58.5% for both groups. The median [IQR] Charlson score of 4.4 [2.3–7.4] was identical in the two groups. The proportion of ventilated patients was higher in the high-cost nursing group (33.9% vs 22.6%, p < 0.0001 and 30.4% for both groups) and, on the other hand, the duration of mechanical ventilation was significantly lower in this group (3 [2–7] vs 5 [2–10] days, p = 0.0001). The most important main diagnosis was cardiogenic shock/cardiac decompensation (20.5%) for the low-cost nursing group and coma/convulsion (18.2%) for the high-cost nursing group.

LOS in the ICU was significantly higher in the low-cost nursing group as were high outliers (14.4% vs 9.2%, p = <0.0001 and 10.8% for two groups) and only 262 stays (1.4%) had an LOS of more than 30 days. In contrast, the proportion of ICU readmissions was higher in the high-cost nursing group (4.9% vs 6.8%, p < 0.0001). Mortality was lower in the high-cost nursing group compared to the low-cost group in terms of ICU mortality (9.9% vs 11.3%, p = 0.004) and in-hospital mortality (13.1% vs 14.6%, p = 0.007) (Table 2).

Risk factors by stay outcomes

In the univariate analysis, all factors studied (ventilated patients,

Table 2
Sociodemographic and medical characteristics of the included ICU stays.

Characteristics	Low nursing cost hospitals per ICU bed (n = 5664)	High nursing cost hospitals per ICU bed (n = 12571)	Test value	p value*	Total (n = 18235)
Age, years, mean (±SD)	64.7 ± 16.4	62.4 ± 17.4	t = 8.22	< 0.0001	63.1 ± 16.8
Geriatrics cases (>75 years), n (%)	1486 (27.9)	2900 (23.5)	χ^2 = 38.32	< 0.0001	4386 (24.8)
Men, n (%)	3154 (55.7)	7509 (59.7)	χ^2 = 26.34	< 0.0001	10,663 (58.5)
Charlson score, median (IQR)	4.5 [2.3–7.4]	4.4 [2.2–7.3]	U = 0.29	0.588	4.4 [2.3–7.4]
Ventilated patients, n (%)	1280 (22.6)	4272 (33.9)	χ^2 = 254.28	< 0.0001	5552 (30.4)
Mechanical ventilation time in days, median (IQR)	5 [2–10]	3 [2–7]	U = 27.13	0.0001	4 [2–8]
Measurement of intracranial pressure, n (%)	37 (0.6)	160 (1.2)	χ^2 = 14.02	< 0.0001	197 (1.0)
ECMO, n (%)	16 (0.3)	77 (0.6)	χ^2 = 8.38	0.004	93 (0.5)
Continuous hemofiltration, n (%)	222 (3.9)	531 (4.2)	χ^2 = 0.91	0.339	753 (4.1)
ICU LOS in days, median (IQR)	2.5 [1.1–4.9]	1.7 [0.8–3.7]	U = 426.62	0.0001	1.8 [0.8–3.7]
High outliers LOS ICU, n (%)	818 (14.4)	1155 (9.2)	χ^2 = 111.71	< 0.0001	1973 (10.8)
Hospital LOS in days, median (IQR)	9.5 [4.6–18.2]	9.3 [4.8–17.0]	U = 0.72	0.3950	9.3 [4.8–17.6]
Readmission ICU, n (%)	279 (4.9)	857 (6.8)	χ^2 = 23.91	< 0.0001	1136 (6.2)
ICU mortality, n (%)	640 (11.3)	1242 (9.9)	χ^2 = 8.50	0.004	1882 (10.3)
Hospital mortality, n (%)	830 (14.6)	1655 (13.1)	χ^2 = 7.35	0.007	2432 (13.3)
Main diagnosis, n (%)			χ^2 = 230.92	< 0.0001	
Sepsis/sepsis shock	410 (7.2)	913 (7.2)			1323 (7.3)
Cardiogenic shock/ cardiac decompensation	1161 (20.5)	1877 (14.9)			3038 (16.7)
Decompensation of chronic respiratory failure	366 (6.4)	625 (5.0)			991 (5.4)
Coma/convulsion	805 (14.2)	2283 (18.2)			3088 (16.9)
Intoxication	183 (3.2)	291 (2.3)			474 (2.6)
Heart surgery	524 (9.3)	1784 (16.9)			2651 (14.6)
Digestive surgery	929 (16.4)	1987 (15.7)			2916 (16.0)
Post-operative monitoring	1061 (18.8)	2049 (16.3)			3110 (17.0)
Other	225 (4.0)	419 (3.5)			644 (3.5)

Legend: SD = standard deviation; ICU = Intensive care Unit; LOS: Length of stay; ECMO = Extracorporeal membrane oxygenation; IQR: Interquartile range; high outliers = with formula: 75th percentile + 1.5 * inter-quartile range.
* p-value: T test for parametric variable (t), the Wilcoxon Ranksum test for non-parametric test (U) and chi-square for categorical variables (χ^2).

Table 3
Univariate analysis of risk factors by patient outcomes - OR (95%CI).

Variables	ICU mortality	ICU Readmission	High LOS outliers	Hospital mortality
Age	1.03 (1.02–1.03)***	1.00 (1.00–1.01)***	1.01 (1.00–1.01)***	1.04 (1.03–1.04)***
Geriatrics cases (>75 years)	1.97 (1.78–2.18)***	1.07 (1.04–1.10)*	1.19 (1.07–1.35)*	2.51 (2.30–2.74)***
Sex, men = reference	0.98 (0.89–1.08)	0.86 (0.76–0.98)*	0.76 (0.69–0.84)***	1.00 (0.92–1.09)
High LOS outliers	3.49 (3.10–3.92)***	6.14 (5.38–6.99)***	–	3.85 (3.45–4.28)***
Charlson score	1.07 (1.06–1.08)***	1.07 (1.06–1.08)***	1.04 (1.03–1.05)***	1.10 (1.09–1.10)***
ICU readmission	2.13 (1.82–2.49)***	–	6.14 (5.38–6.99)***	2.57 (2.24–2.95)***
Academic hospital	0.91 (0.82–1.01)	1.64 (1.45–1.85)***	0.62 (0.55–0.69)***	0.93 (0.85–1.02)
Ventilated patients	9.35 (8.37–10.46)***	3.08 (2.72–3.47)***	8.41 (7.56–9.36)***	6.62 (5.72–6.86)***
Mechanical ventilation time	1.02 (1.01–1.03)***	1.02 (1.01–1.03)***	1.50 (1.41–1.54)***	1.03 (1.02–1.04)***
Patients with intracranial pressure measurement	4.05 (3.33–6.07)***	2.53 (1.69–3.79)***	10.74 (8.08–14.29)***	4.39 (3.26–5.80)***
Patients with ECMO	13.52 (8.90–20.54)***	1.82 (0.94–3.51)	8.60 (5.71–12.95)***	11.78 (7.69–18.06)***
Patients with continuous hemofiltration	10.02 (8.60–11.67)***	4.56 (3.79–5.49)***	8.85 (7.60–10.30)***	8.31 (7.15–9.68)***
ICU mortality	–	2.13 (1.82–2.49)***	3.49 (3.10–3.92)***	–
Hospital mortality	–	2.57 (2.24–2.95)***	3.85 (3.45–4.28)***	–
Main diagnosis				
Coma/convulsion	Ref	Ref	Ref	Ref
Cardiogenic shock/ cardiac decompensation	1.06 (0.89–1.26)	0.71 (0.55–0.91)**	0.62 (0.50–0.75)***	1.01 (0.87–1.18)
Post-operative monitoring	1.13 (0.95–1.31)	1.55 (1.25–1.92)***	1.57 (0.78–2.01)	0.89 (0.68–1.42)
Decompensation of chronic respiratory failure	2.34 (1.91–2.86)***	1.06 (0.76–1.41)	2.79 (2.28–3.41)***	2.50 (2.09–2.99)***
Digestive surgery	1.05 (0.88–1.25)	1.62 (1.31–2.01)***	1.10 (0.92–1.32)	1.06 (0.90–1.23)
Heart surgery	0.75 (0.62–0.92)**	1.89 (1.53–2.34)***	1.94 (1.64–2.29)***	0.71 (0.60–0.85)**
Intoxication	0.35 (0.21–0.59)***	0.33 (0.16–0.68)**	0.55 (0.35–0.86)***	0.32 (0.20–0.52)***
Sepsis/sepsis shock	2.89 (2.42–3.46)***	1.68 (1.25–2.18)***	2.21 (1.82–2.68)***	2.91 (2.48–3.43)***
Other	0.85 (0.62–1.16)	0.92 (0.61–1.37)	0.78 (0.55–1.09)	0.89 (0.68–1.15)

Legend: * p-value <0.05. ** p-value <0.01. *** p-value <0.001; ref = reference; ICU = Intensive care Unit; LOS: Length of stay; ECMO = Extracorporeal membrane oxygenation; outliers = reference with the median; high outliers LOS = with formula: 75th percentile + 1.5 * inter-quartile range.

patients with ECMO and continuous hemofiltration) were associated with increased ICU risk, hospital mortality, and high LOS outlier. All factors, such as high LOS outliers (OR = 6.14, 95% CI: 5.38–6.99, $p < 0.0001$) also influenced ICU readmission, with the exception of sex. For high outliers of LOS, all factors also influenced this outcome except female sex (OR = 0.76, 95% CI: 0.69–0.84, $p < 0.0001$) and academic hospital (OR = 0.62, 95% CI: 0.55–0.69, $p < 0.0001$). For the main diagnoses, decompensation of chronic respiratory failure and sepsis were associated with mortality in the ICU and in the hospital. Sepsis and cardiac surgery were associated with higher ICU readmission (Table 3).

In multivariate analysis (Fig. 1), the risks of ICU mortality (ORa = 0.80, 95% CI: 0.69–0.92, $p < 0.0001$) and hospital mortality (ORa = 0.82, 95% CI: 0.72–0.93, $p < 0.0001$) were lower in the high nursing cost group. Similarly, the risk of high outlier of LOS (ORa = 0.48, 95% CI: 0.42–0.55, $p < 0.0001$) was lower in the high nursing cost group. However, no significant effect was observed for ICU readmission (ORa = 1.24, 95% CI: 0.97–1.51, $p > 0.005$) (Fig. 1).

Discussion

In this study, the demographics, with age of 63.1 ± 16.8, LOS (2 days [1–4]), and a mortality rate of 10.3% in the ICU are similar to previous studies in Belgium (Bruyneel et al., 2019; Mertens et al., 2013). The rates of mortality and LOS are also very comparable to other European studies (Vincent et al., 2018). The overall ICU readmission rate (6.2%) is lower than that previously reported in the literature of approximately 10% in the same hospitalisation (Azevedo et al., 2021; Rojas et al., 2018). However, there is significant variability in our study (4.1–9.6%), with some hospitals certainly being more cautious in ICU discharges and having case mixes with a lower risk of readmission.

It is not easy to compare the costs of FTE nurses (€75,593 [70,641–77,352]) in ICUs in other countries because many factors influence this number. For example, the salary of nurses varies greatly from country to country, as do the presence and value of specialisations, and the experience and turnover of nurses (Mastrogianni et al., 2021; Stafseth et al., 2018; Tan et al., 2012). Belgian nursing pay is right in the middle according to a 2019 OECD report (OECD, 2019). On the other hand, the nurse to patient ratio is one of the highest in Europe (Depasse et al., 1998; Reis Miranda et al., 2007). The overall annual cost of intensive care nurses thus appears to be very similar to some European countries (e.g., France, Italy, Germany) but lower than others (e.g., Switzerland, Netherlands, Norway) and the United States (Khandelwal et al., 2016); Mastrogianni et al., 2021; Ricci de Araújo et al., 2021). The significant difference in the cost of FTE nurses between the two groups means that the nurses in the high-cost nurse group are either more experienced or/and have more specialisations.

Concerning univariate risk factors for ICU and hospital mortality, the clinical factors observed in the study (e.g., geriatric patients, high Charlson score, readmitted patients, ventilated patients, ECMO, and continuous hemofiltration) are very similar to other studies (Fernandez et al., 2010; Gayat et al., 2018; Peigh et al., 2015; Stavem et al., 2017). On the other hand, high LOS outliers had lower mortality, so patient discharge policy is important (Lin et al., 2017). In Belgium, there are no criteria for ICU discharge and the decision is often taken by the medical team alone. This result was certainly also influenced by the rather high occupancy rate in the study despite the high number of ICU beds in Belgium (Chrusch et al., 2009; Fergusson et al., 2020; Rhodes et al., 2012). In addition, patients who died quickly could also have influenced this result. For pathologies, we observed higher mortality in patients with sepsis and chronic respiratory failure (Akkutuk et al., 2014; Kaukonen et al., 2014; Molinari et al., 2015). For readmissions and LOS, the same was observed and is consistent with the literature on the subject (Azevedo et al., 2021; Rojas et al., 2018). In addition, given the association with geriatric patients, ethical factors may have had an impact on this result (Curtis and Vincent, 2010; Flaatten et al., 2017). In our study, in academic hospitals, there were significantly fewer LOS outliers, with higher risk of ICU readmission. Patients may be discharged faster from the ICU in this type of hospital because of the higher pressure, which increases the risk of ICU readmission (Brown et al., 2012).

Regarding the comparison of the two groups and the outcomes, adjusted ICU and hospital mortality were lower in the high-cost nursing group despite a similar occupancy rate in both groups. A study comparing better and worse nursing resources found the same type of result in acute care hospitals (Lasater et al., 2021a). This result can be explained either by an increase in missing care in low-cost hospitals, which certainly have a less adequate nurse to patient ratio, or by a lower proportion of bachelor/specialist nurses in the same group (Ball et al., 2018; Lasater et al., 2021b). Given recent studies conducted in Belgium, it is more likely that it is the high nurse to patient ratio in the country and heterogeneity between hospitals that is influenced by a lower adjusted mortality in the high-cost nursing group (Bruyneel et al., 2019). This is most likely based on the lower median nurse FTE per ICU bed in the low-cost nursing group (2.17 [1.98–2.33] vs 2.80 [2.6–2.9]). Given the median FTE and occupancy rate results, one can extrapolate a ratio of about 1:2 for the high-cost group and more like 1:3 for the low-cost group. In addition, the significant difference in the cost of FTE nurses between the two groups means that the nurses in the high-cost nursing group are more experienced and/or are more specialised nurses. Finally,

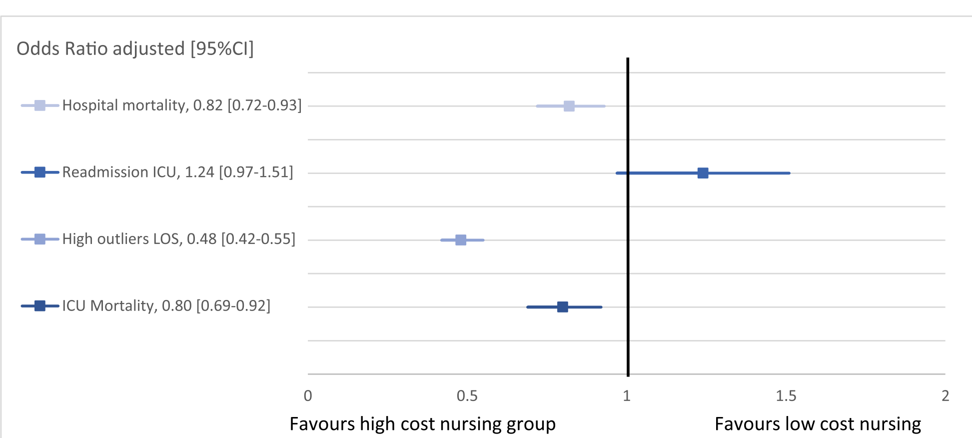

Fig. 1. Adjusted odds ratio (OR) and 95% CI from logistic regression models for each of the outcomes of interest according to the two different nursing cost groups. Intensive care unit (ICU) mortality model: academic hospital, age, sex, ventilated patients, mechanical ventilation time, Charlson score, patients with continuous hemofiltration, extracorporeal membrane oxygenation (ECMO), and main diagnosis, patients with intracranial pressure measurement, ICU readmission and ICU length of stay (LOS). ICU readmission and high LOS outliers models: academic hospital, age, sex, ventilated patients, mechanical ventilation time, Charlson score, patients with continuous hemofiltration, patients with ECMO, main diagnosis, patients with intracranial pressure measurement, and ICU LOS. Hospital mortality model: academic hospital, age, sex, ventilated patients, mechanical ventilation time, Charlson score, patients with continuous hemofiltration, patients with ECMO, main diagnosis, patients with intracranial pressure measurement, ICU readmission and hospital LOS.

there was also a lower rate of high LOS outliers in the multivariate analysis in the high-cost nursing group in the ICU. This is probably due to a lower rate of complications and adverse events in this group, such as sepsis or hospital-acquired infections (Cimiotti et al., 2012; Lasater et al., 2020; Yakusheva et al., 2019).

Adjusted ICU readmission was not significantly different between groups in this study. Readmission to the ICU has been associated with worse patient outcomes, such as increased hospital stays and mortality, and increased costs (Ponzoni et al., 2017; Wong et al., 2016). The use of readmission rate as an indicator of quality of care is highly dependent on ICU discharge policy, the quality of post-ICU care, the occupancy rate, and adherence to evidence-based recommendations for reducing readmissions (Lucchini et al., 2021; Maharaj et al., 2018; Seys et al., 2018). In addition, the median occupancy rate was not very high (76% [69–83]), which may explain the low readmission rate. This information is missing from this study and would help to explain exactly why there is no difference between the two groups.

The results of this study confirm the findings of other recently published papers in acute hospitals (Lasater et al., 2021c; Lasater et al., 2021a; Murphy et al., 2021; Sloane et al., 2018). Furthermore, these results should encourage policy makers and hospital managers to urgently invest in ICU nurses for better patient outcomes. Economics is often an excuse to limit nursing resources, but with the reduction of high LOS outliers, medium-term savings are likely in ICUs (Mastrogianni et al., 2021). Moreover, given the association between nursing cost and quality of care, monitoring this more easily collected indicator could be an interesting alternative for countries without continuous nursing resources (e.g., staffing, skill mix, education, work environment).

Limitations and strengths

This study has certain limitations. First, the cost of nursing per ICU bed includes several indicators (e.g., nurse to patient ratio, experience, and the proportion of bachelor degrees). This information is not present in the study and it is not known which indicator influenced these results. However, previous Belgian studies have shown that the nurse to patient ratio is rather high but that there is a high proportion of specialist nurses. Furthermore, the difference in FTE nurses and cost per FTE between the two groups supports this hypothesis. Second, we built our multivariate model from Minimum Hospital Dataset and billing data, and, therefore, our results are potentially confounded without measurement. Nevertheless, we already have several important factors (e.g., mechanical ventilation, duration of ventilation, continuous dialysis, age) and especially the Charlson score in our adjustment model which are associated with mortality and ICU readmission (Christensen et al., 2011; Stavem et al., 2017). Third, the two groups were created based on nursing costs per ICU bed and not cost per stay. This choice was made because the Belgian legislation on the nurse to patient ratio is based on the number of beds. Moreover, the annual occupancy rate is similar in both groups (Chrusch et al., 2009; Fergusson et al., 2020). Finally, the nursing cost is cross-sectional over one year, which limits our ability to make causal inferences.

This study also has a number of strengths. First, the sample size was large which allowed for statistical precision and external validity for Belgium. Second, the long study period of one year allowed for the construction of robust multivariate models. Finally, there was a significant difference in the FTE nurses between the two groups, supporting the use of nursing cost to define the groups.

Conclusion

This study found that ICU and in-hospital mortality risk and the proportion of high LOS outliers were lower in the high-cost ICU nursing group. These results demonstrate the importance of investing in nurses to improve the quality of care and decrease the proportion of long ICU stays and mortality.

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Ethical approval

None.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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