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ICU Capacity and Organization

Reducing night-time discharge from intensive care. A nationwide improvement project with public display of ICU outcomes

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ABSTRACT

Purpose: Discharge from an intensive care unit (ICU) during the night is an independent risk factor for adverse outcomes. A quality improvement project was conducted with the aim of reducing the incidence and the associated mortality after night-time discharge.

Materials and methods: ICUs that submitted data to the Swedish Intensive Care Registry (SIR) agreed to appoint night-time discharge as a national quality indicator with detailed public display on the internet of various discharge proportions and outcomes. The registry was then examined for trends during a 10-year period with use of multilevel mixed-effects models.

Results: We analysed 163,371 patients who were discharged alive from 70 ICUs to a general ward within the same hospital during 2006–2015. The prevalence of night-time discharge fell from 7.0% (95% CI: 5.2 to 8.7%) in 2006 to 4.9% (95% CI: 4.3 to 5.5%) in 2015 ($P = .035$ for trend). The original increased risk of death within 30 days after night-time discharge in 2006–2010, OR 1.20 (95% CI: 1.01 to 1.42), disappeared in 2011–2015, OR 1.06 (95% CI: 0.96 to 1.17).

Conclusions: During the 10-year period of the quality improvement project, the annual prevalence and risk of death within 30-days after night-time discharge were reduced. The public display and feedback of audit data could have helped in achieving this.

1. Introduction

Discharge of patients from intensive care to general wards during the night (night-time discharge) has been widely identified as an independent risk factor for adverse outcomes, including increased mortality [1-3]. In a seminal study, night-time discharge was found to be associated with premature discharge from intensive care, possibly leading to poor quality care and preventable deaths [4]. However, night-time discharge is not always avoidable, particularly when there is need for urgent transfer for specialist care, e.g. discharge to another hospital for neurosurgery. Hence, signs of premature discharge of patients are usually examined by analysing discharges to a less-intensive level of care, most often by looking at discharges to general wards within the same hospital. While night-time discharge to a general ward is not always preventable, it is usually believed that thorough risk assessment on discharge from intensive care and early post-discharge follow-up may individually or in combination reduce early mortality.

During the Swedish Intensive Care Registry's first five years of operation (2001–2005), discharge from intensive care units (ICUs) to general wards was quite infrequent; approximately 5% of discharges occurred between 10 PM and 7 AM the following morning. However, night-time discharge was associated with an increased unadjusted 30-day mortality of 9.9% compared to 8.6% if discharged during the day. Recognizing that time of discharge from the ICU is an important and modifiable risk factor, the Swedish Intensive Care Registry (SIR) initiated a national quality improvement (QI) project and assigned night-time discharge status an intensive care quality indicator, effective from 2005.

Effective approaches to modify night-time discharge and its unwanted outcomes differ, since operating conditions vary across ICUs.

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In the present improvement project, the role of SIR was to collect measures and provide timely feedback to member ICUs using a public web portal, which enabled detailed comparisons between ICUs.

The purpose of the present study is to report the quality improvement activities initiated by SIR and examine to what extent these were followed by changes in night-time discharge and patient survival. We hypothesized that the activities associated with the assignment of night-time discharge as a quality indicator reduced the proportion of night-time discharges and diminished the associated risk when analysed over a 10-year period (2006–2015).

2. Material and methods

2.1. Context and study cohort

This work was undertaken in Swedish general ICUs that voluntarily participated in a multidisciplinary audit and benchmarking managed by SIR. SIR is the only national quality registry for comparative auditing of intensive care in Sweden [5]. Swedish general ICUs have approximately 39,000 intensive care admissions to general ICUs annually.

The study cohort was created from adult patients (≥18 yrs.) discharged alive from the ICU to a general ward within the same hospital during a 10-year period (Jan 1, 2006, to Dec 31, 2015). We excluded all patients discharged to any other location. If patients had multiple admissions in the registry, only the first admission and its following discharge were included for analysis. Patients with missing survival times and without separate co-morbidity scores were also excluded from analysis. A patient flowchart is provided in Fig. 1.

Discharges from a few non-member and specialized ICUs were excluded, leaving data from 70 of 84 Swedish ICUs for analysis (83.3% of Swedish ICUs). There was a gradual increase in participating ICUs over time, with 46 ICUs submitting data for at least 8 yrs.

2.2. Intervention

Night-time discharge was chosen by SIR members as one of ten quality indicators effective from March 17, 2005. Data individual to each ICU and identifiable by ICU were published with unrestricted public access (no login needed) for professionals as well as laymen on the SIR open web portal. Night-time discharge proportions per ICU were openly displayed, allowing the user to generate groups, choose appropriate comparators and time periods. Funnel plots and risk-adjusted analyses identifying individual ICUs were published frequently on the web page, and ways to reduce the adverse impact of night-time discharge were regularly discussed at local, regional and national intensive care meetings and seminars. A quality matrix was constructed that displayed the standing of all Swedish ICUs (compare Fig. 2).

All ICUs received the same information by mail and through the SIR official website. We did not examine how the information that was provided by SIR was processed locally or whether it generated any operational changes. Since effective approaches to modify night-time discharge and its unwanted outcomes differed across ICUs, this was left to be decided in local improvement projects.

2.3. Measures and variables

The night-time discharge definition used by SIR was taken from Goldfrad and Rowan and was defined as discharge from the ICU between 10.00 PM and 6.59 AM from the ICU to a general ward in the same hospital [4]. The proportion of night-time discharges per ICU and year was the number of night-time discharges to general wards in the same hospital divided by the total number of discharges to general wards in the same hospital. The primary outcome measure was yearly prevalence of night-time discharge. Mortality within 30 days after discharge (30-day post-discharge mortality) was the secondary outcome.

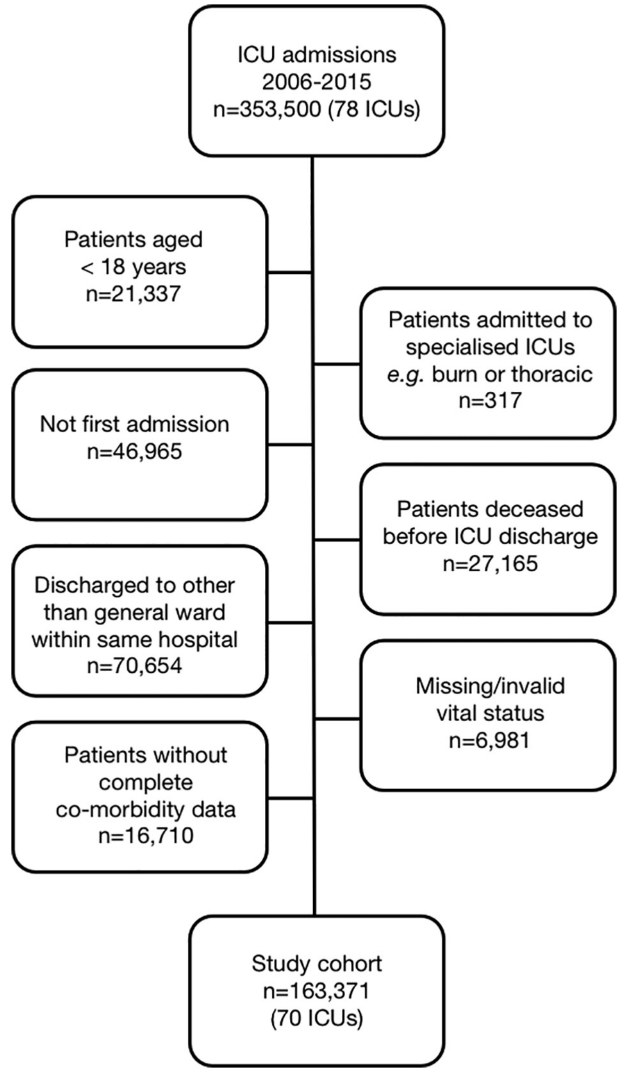

Fig. 1. Patient flow diagram of the study cohort.

SIR collects a comprehensive dataset of patient and admission characteristics, including time stamps and discharge destinations using detailed guidelines. The Acute Physiology and Chronic Health Evaluation II (APACHE II) model was used to characterize the severity of illness from 2006 to 2010; the Simplified Acute Physiology 3 (SAPS3) model was introduced in 2008 and used solely from 2011 to 2015 [6,7]. Vital status was added to the registry from the Swedish Population Register using the unique Swedish personal identity number. We also categorized ICUs depending on which type of hospital they were located in. Local hospitals are community hospitals with a single 2–6-bed medical and surgical general ICU, county hospitals are secondary referral centres with a single 6–12-bed medical and surgical general ICU, and regional hospitals are tertiary referral centres with multiple general and specialized ICUs.

2.4. Analysis

Normally distributed data are reported as the means with standard deviations (SD). Non-normally distributed data are reported as medians with inter-quartile ranges (IQRs). Categorical values are listed as numbers and percentages. Changes in patient characteristics during the study period were examined with linear regression, and changes over time in the proportion per ICU of night-time discharges and mortality were analysed using the non-parametric trend test. Changes over time in the incidence risk ratio was analysed with a multilevel mixed-effects

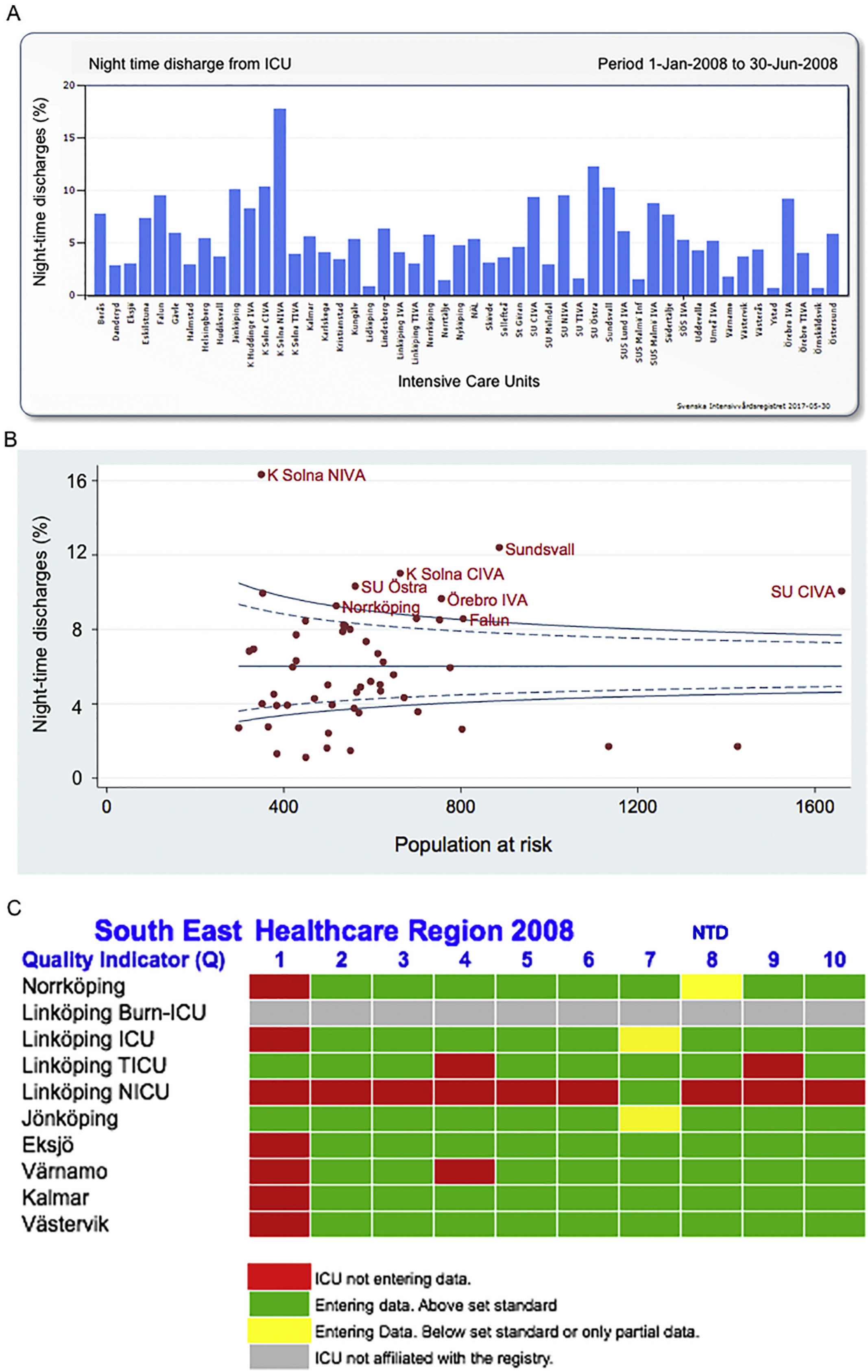

Fig. 2. Three examples of publicly accessible data produced online at the Swedish Intensive Care registry (SIR) webpage (showing data from 2008). **a**: Comparison between the different intensive care units (ICUs) regarding proportions of night-time discharge to the general ward. **b**: Funnel diagram where the individual ICUs are identified in relation to the national mean with alert and alarm limits. All ICUs could be identified by name without any restrictions. **c**: Diagram showing separate ICU (this taken from the southeast region) statuses in relation to national quality indicators (1—10), number 8 being night-time discharge (NTD). Green indicates fulfilment of the national standard, yellow is inferior to the national standard, red is a member ICU not submitting data to SIR, and grey shows non-member ICUs. National standards were decided by the SIR board and were usually based on data available in the registry. The standard for night-time discharge was during the first years set at the 3rd quartile of the previous year.

Poisson regression. We used two-level logistic regression models (patients nested within ICUs and ICUs treated as a random factor) adjusted for age, comorbidities, circumstances on admission, ICU category and calendar year to examine the influence of night-time discharge on mortality. Comorbidities and circumstances on admission were derived from the APACHE II model for admissions during 2006–2010 and from SAPS3 for admissions during 2011–2015. Comorbidities were scored as originally described [6,7]. Circumstances on admission included acute physiology scores in the APACHE II model and in SAPS3 the residual score after removing scores for age and comorbidities. Finally, we performed sensitivity analyses with data from units reporting to SIR during at least 8 years of the study period.

The results are reported as regression coefficients, incidence risk ratios (IRRs) and odds ratios (ORs), all with 95% confidence intervals (CIs). The data were analysed using STATA/SE 14.2 (StataCorp, College Station, TX, USA). A p-value of <0.05 was considered significant.

The manuscript was composed in accordance with guidelines from SQUIRE (Standards for QUality Improvement Reporting Excellence) [8].

2.5. Ethical considerations

SIR has operated since 2001 within the legal framework of the Swedish national quality registries [9]. Written informed consent was not sought, in accordance with the legal framework. The present study complies with the declaration of Helsinki and was approved by the Regional Ethics Review Board as well as by the research committee of the SIR.

3. Results

We identified 163,371 patients who were discharged alive from an ICU to a general ward within the same hospital during the 10-year study period (2006–2015); 9675 (5.9%) were discharged between 10.00 PM and 6.59 AM (night-time discharges). The mean age of all patients was 61.1 years, and 43.9% were women. The mean APACHE II score was 16.3, and the mean SAPS3 score was 48.8. The night-time discharge rate was 5.5% during weeknights and 7.3% during weekends. Characteristics are shown in Table 1.

The linear regression model indicated that the patients became older during the study period. Illness severity scores (without age points) and the predicted mortality calculated from the complete illness severity scores increased during the last five years. No significant changes were found over time for night-time discharges regarding co-morbidity scores. See Table 2.

We noticed a decrease in the mean annual proportion of night-time discharge per ICU from 7.0% (95% CI: 5.2 to 8.7%) in 2006 to 4.9% (95% CI: 4.3 to 5.5%) in 2015 ($P = .035$ for trend, Fig. 3, left panel). The decrease was mirrored by an incidence risk ratio (IRR) per year of 0.97 (95% CI: 0.96 to 0.98, $P < .001$). Because many ICUs joined the national registry during the study period, we analysed separately ICUs that participated in the audit and had entered data for at least 8 years of the 10-year study period ($n = 46$). The findings were similar; the mean annual proportion of night-time discharge was 7.4% (95% CI: 5.6 to 9.1%) in 2006 and 5.0% (95% CI: 4.4 to 5.5%) in 2015 ($P = .026$ for trend), with an IRR of 0.97 (95% CI: 0.96 to 0.98, $P < .001$).

Crude mortality 30 days after night-time discharge was lower than after day-time discharge during both study periods (Table 1). However, after adjusting for age, comorbidities, circumstances on admission, type of hospital and admission year, night-time discharge was associated with increased 30-day mortality during the first 5 years (2006–2010) of the improvement project (Table 3). Calendar year appeared to be associated with reduced post-discharge mortality during the first 5 years, indicating that mortality decreased with time; the association disappeared during the second 5-year period. This agrees with crude annual mortality rates (Fig. 3, right panel), which showed a decline during 2006–2010. The results were similar when we restricted the analysis to ICUs that participated during at least 8 years of the 10-year study period.

4. Discussion

There were two principal findings in this 10-year study of an intensive care quality-improvement project. First, we observed a reduction in the annual proportion of night-time discharges from ICUs to general wards. Second, we noted dissociation between night-time discharge and adjusted 30-days post-discharge mortality, indicating that patient selection, post-discharge care, or both had improved by the end of the study period. These important changes followed in time after a campaign was started within the Swedish Intensive Care Registry to reduce night-time discharges and improve outcome.

Before discussing these results, we need to address some methodological issues. We defined night-time discharge as the transition from the ICU to the general ward between 10 PM and 6.59 AM. While recent studies apply more liberal limits, our definition corresponds well with

Table 1
Baseline characteristics of the study cohort stratified by time of ICU discharge and time period. (2006-2010 vs. 2011-2015).

Characteristics	All patients $n = 163{,}371$	Day time discharge 2006-2010 $n = 57{,}984$	Night-time discharge 2006–2010 $n = 3726$	Day time discharge 2011–2015 $n = 95{,}712$	Night-time discharge 2011–2015 $n = 5949$
Female sex, n (%)	71,735 (43.9)	25,375(43.8)	1660 (44.6)	42,047(43.9)	2653(44.6)
Age, years (mean [SD])	65 [19]	60.8 [19.0]	56.4 [20.8]	61.7[18.9]	58.0[20.6]
Probability of in-hospital death (mean [SD]) [a]	25.3 [22.0]	25.3 [22.2]	19.3 [20.1]	25.7[22.0]	20.3[19.9]
Crude 30-day mortality, n (%)	18,252 (11.2)	6475(11.2)	339 (9.1)	10,877(11.36)	561(9.43)
Comorbid illness, n (%)					
None	132,583(81.2)	27,595(80.7)	1695(85.9)	74,644(79.9)	4919(84.9)
One or more	30,788 (18.9)	6584(19.3)	278(14.1)	18,743(20.1)	873(15.1)
Source of admission, n (%)					
Emergency department	73,127 (44.8)	25,199 (43.5)	2090 (56.6)	42,453(44.4)	3385(56.9)
Theatre / Operating Room	23,646 (14.5)	8771 (15.1)	426 (11.4)	13,781(14.4)	668(11.2)
Ward or other hospital	66,598 (40.8)	24,014 (41.4)	1210 (32.5)	39,478(41.3)	1896(31.9)
Surgery on admission, n (%)	33,684 (20.2)	12,574 (21.7)	573 (15.4)	19,048(19.9)	880(14.8)
ICU LOS, hours (median [IQR])	25[14–61]	25[15–62]	8[4–24]	27[16–64]	9[4–25]
Weekend discharges	39,202 (24.0)	13,818 (23.8)	1123(30.1)	22,541(23.6)	1720(28.9)
Hospital type, n (% of total)					
Tertiary Hospital	49,025 (30.0)	16,882(29.1)	1409(37.8)	28,516(29.8)	2218(37.3)
County Hospital	73,499 (45.0)	26,729(46.1)	1718 (46.1)	42,370(44.3)	2682(45.1)
Local Hospital	40,847 (25.0)	14,373(24.8)	599(16.1)	24,826(25.9)	1049(17.6)

SD Standard deviation. LOS length of stay. IQR Inter Quartile Range.
[a] In percent on admission, calculated from APACHEII 2006-2010 and SAPS3 2011-2015 [6,7].

Table 2
Changes over time in selected patient characteristics.

Changes over time	Daytime	95% CI	P-value	Night-time	95%CI	P-Value
Age	0.26	0.22–0.30	0.000	0.37	0.19–0.54	0.000
APACHEII[a]	0.09	−0.20–0.03	0.138	−0.28	−0.75–0.19	0.202
SAPS3[b]	0.27	0.20–0.34	0.000	0.30	0.05–0.56	0.020
Co-morbidities[b]	−0.001	−0.002–0.000	0.077	−0.002	−0.007–0.003	0.476
LOS (hours)	0.37	0.13–0.61	0.002	−0.32	−0.83–0.19	0.223

[a]2006–2010 [b]2011–2015 LOS (Length of Stay). Numbers are regression coefficients, CI confidence interval. Comorbidities as declared in SAPS3 [7].

the typical night-time nursing shift in Swedish hospitals and agrees with the landmark UK study by Goldfrad and Rowan [4,10,11]. Like the UK study and a recent study from a large Canadian integrated health region, we limited our analysis to discharges from the ICU to general wards in the same hospital [11]. We used the raw scores of two commonly applied admission illness severity models to adjust our analyses because a shift from one (APACHE II) to the other (SAPS3) was completed halfway through the study. Because admission status may not correlate with discharge status, we decomposed scores into constant (age and comorbidities) and acute (physiological alterations on admission) components.

The impetus for this improvement project was early observations within the registry of increased risk-adjusted mortality after night-time discharge, as seen in other countries and health care systems. By emphasizing night-time discharge, SIR and its members sought to decrease the incidence and avoid preventable deaths on general wards. SIR chose to release frequently updated performance data on a public dynamic web page in addition to supporting member ICUs in their efforts to improve care quality. Public display of quality measures and outcomes, though sometimes contested, appears to generate activities to improve quality of care. The feedback inherent in public reporting seems to be sufficient to stimulate efforts to improve quality [12-16].

The incidence of night-time discharge was already low at the start of the campaign compared to international data [2,4]. It is likely that varying definitions were at least partly responsible for that difference. Obviously, liberal time limits and inclusion of discharges to destinations other than a general ward in the same hospital must increase incidence. Crude mortality was lower for night-time than for day-time discharges from the start, suggesting that patients having a high probability of dying were not transitioned to general wards during the night. This notion is supported by our findings of higher risk scores in the day-time discharge group. However, the risk-adjusted analysis of the first study years indicated that avoidable deaths occurred following night-time discharge. This was in contrast to the second time period of the study which showed no significant differences in survival between day- and night-time discharges. We used time-fixed mortality end-points to avoid bias due to different discharge practices, although this hampers comparison with other studies.

While most prior studies have identified night-time discharges from the ICU as a major safety issue, few describe changes that occur in the context of a quality improvement effort. A notable exception is the study by Gantner et al., who analysed discharges from ICUs in Australia and New Zealand in a situation where the proportion of after-hours discharges was established as a national quality of clinical care indicator [10]. Their findings, using the large Australian and New Zealand Intensive Care Society adult patient database over a similar time period (2005–2012), differ from ours in the way that they did not observe a decreased proportion nor a reduction of the associated risk of after-hours discharges.

4.1. Strengths and limitations

This study has a number of strengths. First, it is a large multi-centre study with an extensive national coverage of ICU admission and discharges. It is current, yet it covers a 10-year long time-span. Second, the member ICUs were active in the decision to start and design the campaign to reduce the adverse effects of untimely discharges. The bottom-up approach where stakeholders were influential from the start and had the possibility to receive timely feedback from the open web portal was of importance for maintaining momentum over the years. Third, the study is based on a prospectively collected high-quality clinical database with raw data collection, detailed data validation routines and an updated illness severity model in place [17]. Fourth, we used time-fixed endpoints to avoid bias due to regional differences and longitudinal changes in discharge practices.

However, the before-and-after approach limits our ability to infer that our campaign with publicly displayed outcomes generated the improvement [18]. The pragmatic approach was decided early on by the SIR board because of the perceived urgency to generate improvement. Strategies were left to be decided and established locally, with no

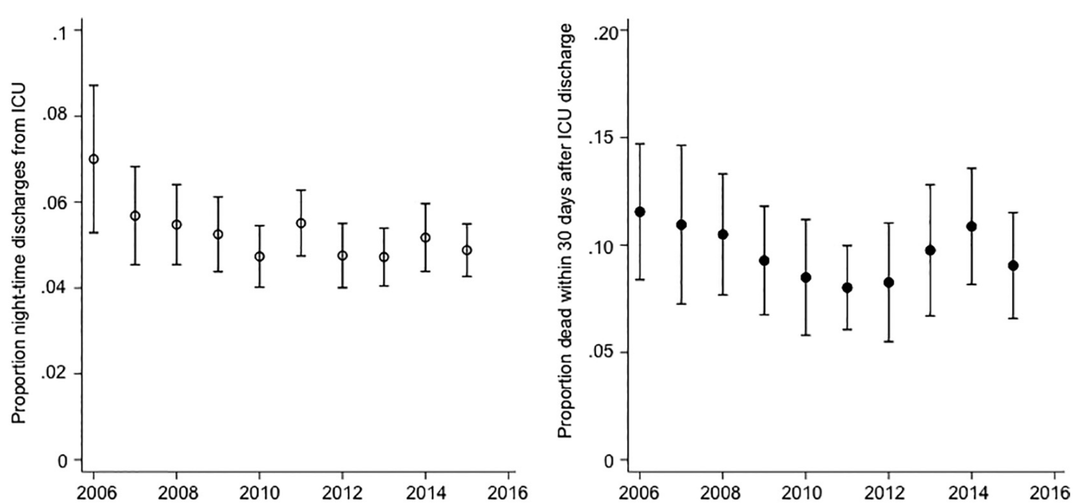

Fig. 3. Annual prevalence of night-time discharge (left panel) and mortality rates (right panel) during 2006–2015. Values are means (95% confidence intervals).

Table 3
Odds-ratios of risk of dying within 30 days of ICU discharge using nested two-level models with single and multiple explanatory variables. Results reported as Odds Ratio with (95% Confidence Interval).

Model characteristic	Single explanatory variable	Multiple explanatory 2006-2010[a]	Multiple explanatory 2011–2015[b]
Number of patients (ICUs)	163,371 (70 ICUs)	28,738 (33 ICUs)	99,170 (68 ICUS)
Time of discharge			
Daytime	Reference	Reference	Reference
Night time	0.82 (0.77–0.88)	1.20 (1.01–1.42) $p = .041$	1.06 (0.96–1.17) $p = .246$
Age, per year	1.06 (1.06–1.07)	1.07 (1.06–1.07)	1.06 (1.06–1.07)
Comorbidities, per point			
APACHE II model	1.23 (1.21–1.25)	1.12 (1.10–1.14)	Not applicable
SAPS3 model	1.10 (1.09–1.11)	Not applicable	1.08 (1.07–1.08)
Circumstances on admission, per point[c]			
APACHE II model	1.10 (1.09–1.10)	1.09 (1.08–1.10)	Not applicable
SAPS3 model	1.07 (1.06–1.07)	Not applicable	1.07 (1.07–1.07)
Hospital type			
Local hospital	Reference	Reference	Reference
District general hospital	0.97 (0.84–1.11)	1.24 (0.97–1.59)	1.00 (0.87–1.14)
Regional hospital	0.74 (0.64–0.87)	1.14 (0.88–1.49)	0.94 (0.82–1.09)
Calendar year, per year	1.01 (1.00–1.02)	0.94 (0.89–0.98) $p = .007$	0.99 (0.99–1.00) $p = .086$

[a] APACHE II variables.
[b] SAPS3 variables.
[c] See methods for details.

involvement from SIR, and included education and increasing awareness and starting post-discharge outreach services [19]. We excluded 16,710 patients chiefly during 2006 and 2007 because they lacked separate APACHE II comorbidity scores. As 7% of these admissions were discharged during the night, the principal finding of a gradual reduction in night-time discharges were most likely not affected. When we included these admissions in an adjusted analysis using total APACHE II scores instead of the decomposed score the association between night-time discharge and mortality decreased with time during 2006–2010 as in the original analysis. We lack information on organ dysfunction at ICU discharge since only a few ICUs submitted organ failure scores daily. Residual organ dysfunction is a potential mechanism by which night-time discharge may affect outcome as suggested by Santamaria et al. [20]. We also lack information on the presence of treatment limitations among the discharged patients. In theory, if treatment limitations were more frequent among patients discharged during the night, this could explain some of the results. We find no reason to think that the proportion of patients with treatment limitations varied with time of discharge, and there is no evidence that this should have changed during the 10-year study period. Further analysis may be warranted given the study from Finland by Uusaro et al., who, while taking account of whether restrictions for care were applied, were unable to find an association between the time of discharge from the ICU and hospital mortality [21]. However, in that study, the night-time (i.e., out-of-office) window was wider than in our study (from 16 PM to 08 AM).

5. Conclusion

The present improvement project focused on regular public presentation of outcomes related to night-time discharges from the ICU to general wards in addition to a public webpage that provided a large number of dynamic reports and appropriate comparisons to inform and guide ICUs in their efforts to improve outcome. Interventions were tailored locally to address patient-specific and health-system factors that were thought to contribute to the adverse effects of untimely discharges. We found that the incidence of night-time discharges was reduced and that the associated risk of early death after night-time discharge disappeared over a 10-year period, while the present quality improvement project was started and maintained.

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