Intensive care unit to unit capacity transfers are associated with increased mortality. An observational cohort study on patient transfers in the Swedish Intensive Care Register

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Research

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Abstract

Background

Transfers from one intensive care unit (ICU) to another ICU are associated with increased length of intensive care and hospital stay. We show that non-clinical transfers due to resource constraints in the transferring ICU (capacity transfers) are associated with increased 30- and 180-day mortality compared to repatriations. Inter-hospital ICU Transfers are carried out for three main reasons: clinical transfers, capacity transfers and repatriations. We hypothesised that different ICU transfers differ in risk-adjusted mortality rate with repatriations having the least risk.

Methods

Observational cohort study of adult patients transferred between Swedish ICUs during 3 years (2016–2018) with follow up ending September 2019. Primary and secondary end-points were survival to 30 days and 180 days after discharge from the first ICU. Data from 75 ICUs in the Swedish Intensive Care Register, a nationwide intensive care register, was used for analysis (89 % of all Swedish ICUs). Covering local community hospitals, district general hospitals and tertiary care hospitals. We included adult patients (16 yrs. or older) admitted to ICU and subsequently discharged by transfer to another ICU. Only the first admission was used. Exposure was discharge to any other ICU (ICU to ICU transfer), whether in the same or in another hospital. Transfers were grouped into three predefined categories: clinical transfer, capacity transfer, and repatriation.

Results

We identified 15,588 transfers among 112,860 admissions (14.8 %) and analysed 11,176 after excluding 4,112 repeat transfer of the same individual and 300 with missing risk adjustment. The majority were clinical transfers (62.7 %), followed by repatriations (21.5 %) and capacity transfers (15.8 %). Unadjusted 30-day mortality was 25.0% among capacity transfers compared to 14.5% and 16.2% for clinical transfers and repatriations respectively. Adjusted odds ratio (OR) for 30-day mortality were 1.25 (95% CI: 1.06–1.49 P = .01) for capacity transfers and 1.17 (95% CI: 1.02–1.36 P = .03) for clinical transfers using repatriation as reference. The differences remained 180 days post discharge.

Conclusions

There was a large proportion of ICU to ICU transfers and an increased odds of dying for those transferred due to other reasons than repatriation.

Background

Intensive care beds are expensive and limited. The need for beds varies over time, and sometimes all beds are occupied, particularly on intensive care units (ICUs) where a high proportion of admissions are acute. When a critically ill patient needs admitting to a full ICU, the usual procedure is to either delay admission or create a temporary place for a short period while trying to free an intensive care bed by discharging another patient. This

strategy comes at a cost since premature discharge from the ICU to a general ward is associated with increased mortality [1]. Transfer to another ICU (ICU to ICU transfer) for various reasons appears to be associated with increased total duration of intensive care and hospital stay, but it is not clear whether this is associated with increased mortality rate [2,3].

Studies on ICU to ICU transfer are problematic since transfers are carried out for three main reasons that must be considered separately in the analyses. First, patients are transferred when there is need for specialised care that is not available in the admitting hospital (clinical transfer). Second, ICU patients are transferred to their home ICU after having undergone initial treatment at another unit (repatriation). Third, patients are transferred to make room for patients with more urgent need for intensive care when all ICU beds are occupied (capacity transfer). Furthermore, follow up of transferred patients should preferably be carried out after discharge from ICU or hospital to capture important long-term effects on survival.

The present study is based on data from a large nationwide intensive care register, the Swedish Intensive Care Register (SIR), which registers the three reasons for transfer named above as well as long-term follow-up data. The hypothesis was that the three classes of ICU to ICU transfer differ in risk-adjusted mortality rate with repatriation having the lowest.

Methods

This was an observational cohort study on patients admitted to Swedish intensive care units (ICUs) from Jan 1st, 2016 to Dec 31st, 2018. Follow-up ended Sept 30th, 2019.

Setting and participants

We used the Swedish Intensive Care Register (SIR) to identify eligible patients (see below). SIR is a national quality register which collects data from intensive care admissions in Sweden. Admissions to a few non-affiliated and paediatric ICUs were not included, leaving data from 75 ICUs for analysis (89 % of all Swedish ICUs). The ICUs were located in local community hospitals (25 ICUs), district general hospitals (24 ICUs) and tertiary care hospitals (26 ICUs).

We included patients (16 yrs. or older) admitted to ICU and subsequently discharged by transfer to another ICU. For patients with multiple admissions during the study period we included the first admission only using the Swedish personal identity number for identification [4]. We excluded patients missing to follow-up (i.e. non-Swedes and a few individuals with concealed identity number, n = 714) or missing SAPS3 risk-adjustment data (n = 300 in 4 ICUs).

Variables and definitions

The primary end-point, survival 30 days after discharge from the first ICU, and the secondary end-point, survival 180 days after discharge from the first ICU, were both determined by linking SIR to the Swedish Population Register.

Exposure was discharge to any other ICU (ICU to ICU transfer), whether in the same or in another hospital. Transfers in the SIR are grouped into three categories by the referring intensivist: clinical transfer, capacity transfer, and repatriation. Clinical transfer is where the patient is transferred for specialised treatment or investigations not provided at the first ICU. Capacity transfer is where a patient is transferred to make room for another patient with

more urgent need for intensive care when all ICU beds are occupied. Repatriation is where a patient is transferred from the first ICU to another ICU nearer the patient's home address.

Patient age, gender and admission and discharge times were retrieved from SIR which was the principle data source. The duration of ICU stay was calculated, as well as identification of discharges at night and during weekends. Night time was defined as 10.00 PM to 6.59 AM and weekend as Saturday 0.00 AM to Sunday 23.59 PM [5]. We used the Simplified Acute Physiology Score (SAPS) 3 model to score chronic comorbidities and circumstances prior to admission, and reasons for admission and physiologic derangements on admission to ICU [6]. The score was subdivided into the original three boxes where Box 1 included comorbidities and time in hospital before ICU (age was deducted from Box1), Box 2 included circumstances on admission, and Box 3 included reasons for admission and physiological derangements on admission. Organ failure at discharge was calculated according to the Sequential Organ Failure Assessment (SOFA) score [7]. The score was based on clinical examination before discharge and blood samples obtained on the day of discharge. Missing individual organ scores were presumed normal (0 points). Primary and secondary diagnoses were recorded by the attending intensivist at discharge from ICU according to SIR guidelines. We used the primary International Classification of Diseases version 10 (ICD-10) diagnosis code to group patients into six principal disease groups (See Supplementary Table 1, Additional File 1).

Data were recorded in raw format by each ICU and after local validation transferred to SIR for central validation (required data were present, entries were within prespecified limits, and inconsistencies and illogical entries were identified). If necessary, data were returned for correction and revalidation before being accepted and entered into the master database. In addition to a required comprehensive data set, SIR has a number of optional data sets, including SAPS3 and SOFA, which were used in the present study. While the SAPS3 set was used in all but a few ICUs (300 admissions in 4 ICUs had missing SAPS3 data), SOFA was used in 22 ICUs only. We used admissions from 75 ICUs with SAPS3 data and 22 ICUs with SAPS3 data and SOFA scores at discharge in our risk-adjusted analyses.

Calculations and statistical methods

Descriptive data are presented as mean (95 % confidence intervals, CI) or median (interquartile range, IQR) values and proportions (95 % CI) as appropriate. Differences in crude survival were examined using the Kaplan-Meier estimate and the log-rank test.

The association between category of transfer and survival was analysed using univariable and two-level multivariable logistic regression models (patients nested within ICUs and ICUs treated as a random factor). The primary multivariable model was adjusted for age, gender, comorbidity, reasons for admission, circumstances and physiological derangements on admission as recorded in the SAPS3 model, duration of ICU stay and whether ICU discharge was during the night or weekend. All variables determined by expert opinion and previous experience as relevant predictors of mortality. Additional candidate variables for adjustment were a completely broken down SAPS3 score (instead of the partially broken down score in this study), hospital category, admission time and day of the week.

In a secondary model, in addition to the other variables, the SOFA score was used at discharge using observations from the 22 ICUs using SOFA scores. We performed a sensitivity analysis including admissions with the six principal diagnoses only.

The regression results are reported as odds ratios (ORs) with 95% CI. We used STATA/SE 16 (StataCorp, College Station, TX, USA) for data analysis. A p-value < 0.05 was considered significant. This manuscript is conducted in accordance with the Equator network STROBE-statement [8].

Results

From 1st Jan, 2016 to 31st Dec, 2018 there were 112,860 adult admissions to Swedish ICUs, 15,588 (14.8%) of which ended with discharge by transfer to another ICU (see patient flow diagram Fig. 1). The majority were transferred for specialised care that was not available at the admitting hospital or ICU (clinical transfers, 62.8% of the study cohort). Capacity transfers were 15.8% of all transfers accounting for roughly 1.7% of ICU survivors.

Figure 1. Patient flow diagram

The primary analysis included 11,176 transfers from 75 ICUs (bold boxes). A secondary analysis was based on 1,777 transfers from 22 referring ICUs (grey boxes) where patients had a SOFA score recorded at discharge from the referring ICU.

Table 1 provides an overview of baseline patient data and characteristics of the referring ICUs. Repatriation and capacity transfers were usually from tertiary care hospital ICUs where the median stay on the referring ICU was about 48 hours before transfer. Most repatriations occurred during the day while almost one in five capacity transfers were at night. Capacity transfers hade greater SOFA scores on discharge from the referring ICU, mainly due to cardiovascular and/or respiratory failure (See Supplementary Table 2, Additional File 1).

Table 1
Baseline patient data and characteristics of the referring ICU. Numbers are means or proportions within transfer group and 95 % CI, unless otherwise specified

	Repatriation n = 2401	Clinical transfers n = 7014	Capacity transfers n = 1761
Age, years	60.3 (59.6–61.1)	55.5 (55.0–55.9)	63.1 (62.3–63.8)
Male	64.0 (62.0–65.9)	58.7 (57.6–59.9)	62.2 (60.0–64.6)
Year of admission			
2016	31.1 (29.3–33.0)	34.8 (33.7–36.0)	32.1 (29.9–34.3)
2017	33.8 (31.9–35.7)	32.5 (31.4–33.6)	32.0 (29.8–34.2)
2018	35.1 (33.2–37.1)	32.6 (31.5–33.7)	36.0 (33.7–38.2)
Hospital category of referring ICU			
Local hospital	15.3 (13.9–16.8)	40.2 (39.0–41.3))	9.4 (8.0–10.8)
District general hospital	26.0 (24.2–27.8)	41.4 (40.3–42.6)	27.0 (24.9–29.1)
Tertiary care hospital	58.7 (56.7–60.7)	18.4 (17.5–19.3)	63.7 (61.4–65.9)
Days in hospital before ICU admission	2.7 (2.4–3.1)	1.6 (1.2–2.1)	3.0 (2.6–3.4)
Days in hospital before ICU admission; medians (IQR)	0 (0–2)	0 (0–1)	0 (0–2)
Source of admission to referring ICU			
Emergency room	32.1 (30.2–34.0)	64.8 (63.7–66.0)	39.7 (37.4–42.0)
theatre or PACU	17.7 (16.2–19.3)	6.5 (5.9–7.1)	13.4 (11.8–15.1)
Ward	18.4 (16.8–20.0)	23.6 (22.6–24.6)	39.5 (37.2–41.9)
Other hospital or ICU	30.0 (28.2–31.9)	3.9 (3.4–4.3)	6.8 (5.6–8.0)
Other source	1.8 (1.3–2.4)	1.2 (1.0–1.5)	0.6 (0.3–1.1)
Surgical status on referring ICU			

[a] See methods for SAPS3 boxes. [b] The number of admissions with SOFA scores were for repatriation 622, clinical transfers 659 and capacity transfers 531, PACU = Post-anaesthesia care unit, SAPS3 = Simplified acute physiology score version 3, SOFA = Sequential organ failure assessment, ICH = Intracranial haemorrhage, COPD = Chronic obstructive pulmonary disease

	Repatriation n = 2401	Clinical transfers n = 7014	Capacity transfers n = 1761
Elective surgery	8.0 (7.0–9.2)	2.3 (2.0–2.7)	6.1 (5.0–7.3)
Emergency surgery	18.3 (16.8–19.9)	6.8 (6.2–7.4)	12.7 (11.1–14.3)
Without surgery	73.6 (71.8–75.4)	90.9 (90.2–91.6)	81.3 (79.4–83.1)
Illness severity (SAPS3) on admission to referring ICU [a]			
SAPS3 score Box 1 with age deducted	7.9 (7.7–8.0)	7.0 (6.9–7.1)	8.3 (8.1–8.5)
SAPS3 score Box 2	27.7 (27.4–27.9)	27.7 (27.6–27.8)	28.5 (28.3–28.8)
SAPS3 score Box 3	12.4 (12.0–12.8)	10.8 (10.6–11.1)	16.9 (16.4–17.3)
SAPS3 probability	0.21 (0.20–0.21)	0.16 (0.16–0.17)	0.29 (0.28–0.30)
Total SOFA score at ICU discharge [b]	4.9 (4.6–5.2)	6.0 (5.7–6.4)	6.5 (6.2–6.8)
Total SOFA score at ICU discharge; median (IQR)[b]	4 (2–7)	6 (3–9)	7 (4–9)
Length of stay on referring ICU, hours	95.8 (90.5–101)	40.0 (37.6–42.4)	103 (96.1–110)
Length of stay on referring ICU, hours; median (IQR)	47.6 (21.8-107.9)	11.8 (3.1–32.0)	48.2 (16.1-125.8)
Time and day of discharge			
Night-time discharge	4.7 (3.9–5.6)	18.4 (17.5–19.3)	18.9 (17.1–20.8)
Weekend discharge	19.5 (17.9–21.1)	25.3 (24.3–26.4)	22.4 (20.4–24.4)
Principal disease group			
Central nervous system injury	19.5 (17.9–21.1)	19.5 (18.6–20.5)	7.4 (6.2–8.7)
COPD	1.6 (1.2–2.2)	0.3 (0.2–0.5)	1.5 (1.0–2.2)
Cardiac arrest	4.7 (3.9–5.6)	2.5 (2.1–2.9)	5.5 (4.5–6.7)
Acute lung injury	17.8 (16.3–19.4)	8.8 (8.2–9.5)	32.7 (30.5–35.0)
Sepsis	7.0 (6.0–8.1)	7.2 (6.6–7.8)	12.8 (11.3–14.4)

[a] See methods for SAPS3 boxes. [b] The number of admissions with SOFA scores were for repatriation 622, clinical transfers 659 and capacity transfers 531, PACU = Post-anaesthesia care unit, SAPS3 = Simplified acute physiology score version 3, SOFA = Sequential organ failure assessment, ICH = Intracranial haemorrhage, COPD = Chronic obstructive pulmonary disease

	Repatriation n = 2401	Clinical transfers n = 7014	Capacity transfers n = 1761
Multi-trauma	7.2 (6.2–8.3)	5.4 (4.9–6.0)	2.7 (2.0–3.5)
Other diagnoses	42.2 (40.2–44.2)	56.3 (55.1–57.5)	37.5 (35.2–39.8)
Mortality			
30 days after ICU discharge	16.2 (14.8–17.8)	14.6 (13.8–15.5)	25.0 (23.0-27.1)
180 days after ICU discharge	23.4 (21.7–25.1)	20.9 (20.0–21.9)	33.2 (31.0-35.4)

[a] See methods for SAPS3 boxes. [b] The number of admissions with SOFA scores were for repatriation 622, clinical transfers 659 and capacity transfers 531, PACU = Post-anaesthesia care unit, SAPS3 = Simplified acute physiology score version 3, SOFA = Sequential organ failure assessment, ICH = Intracranial haemorrhage, COPD = Chronic obstructive pulmonary disease

Unadjusted mortality within 30 days after discharge from the referring ICU was greater among capacity transfers where 25.0 % died within one month of discharge (Table 1). Mortality in the capacity transfer group remained significantly higher for at least 180 days after discharge from the referring ICU, as seen in the unadjusted Kaplan-Meier diagram (Fig. 2).

Figure 2. Kaplan-Meier diagram showing survival after ICU to ICU transfer.

Shaded area showing 95% CI. Log-rank test $p < 0.001$

Table 2 displays the uni- and multivariable associations between category of transfer and the primary end-point. In the primary multivariable analysis, an increased risk of death within 30 days of discharge was seen if the transfer was due to any other reason than repatriation. Results were similar when the association with 180-day survival was analysed (See Supplementary Table 3, Additional File 1).

Table 2
Association between covariates and 30-day mortality

	Single explanatory variable **n = 11176**			**Multivariable, all variables below** **included in analysis. n = 11176**			**Multivariable, excluding Other diagnoses** **all variables below included in analysis. n = 5554**		
	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Type of transfer									
Repatriation	Reference			Reference			Reference		
Clinical transfer	0.88	0.78-1.00	.058	1.17	1.02–1.36	.029	1.15	0.95–1.38	.153
Capacity transfer	1.72	1.48-2.00	< .001	1.25	1.06–1.49	.009	1.35	1.10–1.67	.005
Variables adjusted for									
Age (per year)	1.04	1.04–1.05	< .001	1.04	1.04–1.05	< .001	1.04	1.03–1.05	< .001
Gender									
Female	Reference			Reference			Reference		
Male	1.12	1.01–1.24	.035	0.97	0.87–1.09	.627	0.96	0.82–1.05	.554
SAPS3 score									
Box 1 (per point) [a]	1.09	1.08–1.10	< .001	1.06	1.05–1.07	< .001	1.06	1.05–1.08	< .001
Box 2 (per point)	1.05	1.04–1.06	< .001	1.03	1.02–1.04	< .001	1.02	1.00-1.03	.018
Box 3 (per point)	1.07	1.06–1.07	< .001	1.06	1.06–1.07	< .001	1.06	1.05–1.07	< .001
Time and day of discharge									
Daytime	Reference			Reference			Reference		
Night-time	1.21	1.06–1.38	.004	1.20	1.04–1.40	.014	1.13	0.93–1.38	.227
Weekday	Reference			Reference			Reference		
Weekend	0.92	0.82–1.04	.197	0.98	0.86–1.11	.730	0.98	0.82–1.16	.807

	Single explanatory variable n = 11176			Multivariable, all variables below included in analysis. n = 11176			Multivariable, excluding Other diagnoses all variables below included in analysis. n = 5554		
ICU length of stay (per hour)	1.00	1.00–1.00	.002	1.00	1.00–1.00	.051	1.00	1.00–1.00	.049
Principal disease group [b]									
Central nervous system injury	Reference			Reference			Reference		
COPD [c]	1.42	0.85–2.38	.178	1.09	0.65–1.85	.727	0.74	1.19–3.28	.276
Cardiac arrest	2.77	2.18–3.51	< .001	1.56	1.20–2.01	.001	1.07	0.80–1.44	.659
Acute lung injury	1.43	1.21–1.69	< .001	1.15	0.98–1.35	.072	0.79	0.64–0.97	.023
Sepsis	1.27	1.04–1.55	.017	0.90	0.74–1.09	.292	0.63	0.50–0.79	.001
Multi-trauma	0.34	0.24–0.47	< .001	0.72	0.51–1.02	.066	0.48	0.34–0.70	.001
Other diagnoses	0.71	0.62–0.82	< .001	0.70	0.60–0.83	< .001		Not included	

[a] Age deducted from score (see methods), [b] See supplementary material table 1 for details of groups, [c] Chronic obstructive pulmonary disease.

The results remained when adjusting for persistent organ failure at ICU discharge using SOFA scores. The

30-day mortality rate after ICU discharge was roughly 50 % greater among those transferred for clinical or capacity reasons compared to repatriation (see Table 3). The increased mortality rate was still present but less pronounced when 180-day survival was analysed (See Supplementary Table 4, Additional File 1).

Table 3
Association between covariates and 30-day mortality. 1812 patients with complete SOFA-score on day of transfer.

	Single explanatory variable n = 1812			**Multivariable, all variables below n = 1812**			**Multivariable, including SOFA-score n = 1812**		
	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Type of transfer									
Repatriation	Reference			Reference			Reference		
Clinical transfer	1.37	1.02–1.84	.035	1.77	1.27–2.48	.001	1.52	1.01–2.12	.014
Capacity transfer	2.21	1.66–2.97	< .001	1.71	1.22–2.39	.002	1.62	1.16–2.26	.005
Variables adjusted for									
Age (per year)	1.04	1.04–1.05	< .001	1.04	1.03–1.05	< .001	1.04	1.03–1.05	< .001
Gender									
Female	Reference			Reference			Reference		
Male	1.31	1.03–1.67	.027	1.19	0.92–1.55	.190	1.19	0.91–1.56	.200
SAPS3 score									
Box 1 (per point) [a]	1.06	1.04–1.09	< .001	1.05	1.02–1.07	.001	1.04	1.01–1.07	.006
Box 2 (per point)	1.04	1.02–1.06	< .001	1.04	1.02–1.07	.002	1.03	1.00-1.06	.032
Box 3 (per point)	1.05	1.04–1.06	< .001	1.04	1.03–1.06	< .001	1.03	1.02–1.04	< .001
Time and day of discharge									
Daytime	Reference			Reference			Reference		
Night-time	1.40	1.00-1.96	.050	1.19	0.82–1.73	.361	1.13	0.78–1.65	.515
Weekday	Reference			Reference			Reference		
Weekend	0.98	0.74–1.31	.913	0.93	0.68–1.26	.632	0.94	0.68–1.28	.682

	Single explanatory variable n = 1812			Multivariable, all variables below n = 1812			Multivariable, including SOFA-score n = 1812		
ICU length of stay (per hour)	1.00	1.00–1.00	.519	1.00	1.00–1.00	.992	1.00	1.00–1.00	.469
Principal disease group [b]									
Central nervous system injury	Reference			Reference			Reference		
COPD [c]	0.76	0.22–2.70	.178	0.68	0.18–2.52	.566	0.65	0.17–2.47	.527
Cardiac arrest	2.41	1.44–4.04	< .001	1.08	0.57–2.03	.817	0.97	0.51–1.83	.923
Acute lung injury	1.27	0.89–1.82	< .001	0.79	0.52–1.21	.281	0.71	0.46–1.09	.116
Sepsis	1.80	1.16–1.55	.017	0.92	0.56–1.50	.735	0.71	0.43–1.17	.174
Multi-trauma	0.41	0.24–2.77	< .001	0.59	0.28–1.24	.167	0.59	0.28–1.23	.160
Other diagnoses	0.79	0.21–1.12	.186	0.71	0.48–1.05	.087	0.67	0.45-1.00	.050
SOFA-score on discharge									
Total score (per point)	1.20	1.17–1.24	< .001		Not included		1.15	1.11–1.19	< .001

[a] Age deducted from score (see methods), [b] See supplementary material table 1 for details of groups, [c] Chronic obstructive pulmonary disease.

We repeated our analyses in a subset of the study cohort where we included six principal disease groups only and added them to the multivariable mixed effects models. The results were comparable to the analyses of the main study cohort as shown in Tables 2.

Discussion

There were two principal findings in this study. First, non-clinical transfers due to resource constraints in the transferring ICU (capacity transfer) were associated with increased 30-day mortality compared to other non-clinical transfers (repatriation). Second, the proportion of ICU to ICU transfers in Sweden was greater than generally reported from comparable healthcare systems abroad. Before considering the implications of these findings we need to discuss some methodological issues.

Analysing the impact of category of ICU to ICU transfer on patient outcome is challenging. The analysis is usually made from two viewpoints: that of the referring ICU and that of the accepting ICU. Studies from the referral perspective usually compare outcome of transferred patients with those remaining [3,9]. On the other hand, studies from the receiver's point of view usually compare outcomes of transfers with those of admission from the hospital's own ward or emergency department [2,10,11]. Both perspectives employ various techniques to adjust for confounding, since transferred patients differ substantially from their counterparts.

However, some important differences may be impossible to adjust for in the analyses. Clinical transfers occur when there is need for specialised care not available at the referring hospital. These are usually associated with specific disease requirements such as acute neurosurgical or cardiac interventions. Since these transferrals are for specific and essential treatment, it is difficult to find suitable non-transferred control patients. The first step must therefore be to examine clinical and non-clinical transfers separately. However, analysis of non-clinical transfers (repatriation and capacity transfers) is associated with another difficulty *i.e.* patients are rarely transferred when death is believed to be imminent. Thus, comparing outcomes of patients transferred for non-clinical reasons with non-transferred patients may lead to underestimation of the mortality risk associated with transfer. While life-sustaining treatment limitation can be useful in identifying such patients, these are often poorly documented.

In the present study transfers were examined from the perspective of the referring hospital, and we sought to circumvent the problem of identifying a control population by comparing outcomes within the cohort of transferred patients. Within the group of transferred patients, we assumed that repatriations were associated with the least risk compared to patients that remained. Ideally, capacity transfers should also be associated with a small risk, while it is reasonable to assume that clinical transfers. *i.e.* patients in need of urgent specialised care should be associated with a higher mortality risk. While misclassification of transfers may have caused bias in the analyses, we believe that allocation of transfers to the three categories registered in the SIR was correct. This conclusion is based on demographic distribution. For example, clinical transfers have a shorter length of stay and a higher SOFA-score, and furthermore, most clinical transfers are from smaller to larger hospitals.

Somewhat surprisingly, it was found that 30-day mortality after capacity transfer was greater than after clinical transfer and repatriation in the unadjusted analyses. The difference in outcome between clinical and capacity transfers disappeared in the adjusted analyses but remained for repatriation. The adjusted risk relationships also remained after the inclusion of organ failure (SOFA-score) at discharge in the multivariable analyses. While SOFA-score at discharge from the referring ICU was independently associated with poor outcome, it only partly explained the increase in risk associated with clinical and capacity transfers compared to repatriation. Hence, other explanations not apparent from the results of the present study, must be considered. It has been well established that transfer of critically ill patients is associated with increased risk for adverse outcomes partly due to transportation and poor communication of vital information [12–15]. In up to 50% of adverse events *en route*, pretransport recommendations provided by the referring intensivist were ignored [16]. Several studies have addressed the need for structured informative handover of the critically ill patient [17,18]. However, further studies are needed to see if inadequacy of communication has less impact on the outcome of repatriation cases compared to clinical and capacity transfers. A more obvious explanation is that patients transferred for clinical and capacity reasons are more likely to endure an extra transfer compared to repatriations. A complete understanding of the care trajectory of patients undergoing ICU to ICU transfer is of great importance if we are to improve the chance of survival, particularly since such transports are likely to increase in the future [19].

The second notable result was that almost 15 % of discharges were transferred to another ICU. Moreover, roughly 2% of all discharges were referred to another ICU due to lack of resources (capacity transfers). These numbers appear to be high compared to the literature [3,20,21], although most studies typically report transfers as a proportion of admissions to rather than discharges from ICU. The overall high numbers of transfers may partly be explained by centralisation of specialised care to the few highly populated centres in our otherwise sparsely populated country. However, we believe that the large numbers of ICU to ICU capacity transfers also reflects the low overall number of available ICU beds in Sweden; unfortunately one of the lowest in Europe [22,23].

Conclusion

This study identified an increased mortality rate associated with ICU to ICU transfers during periods of demand-supply mismatch. While prior studies have suggested that the only disadvantage of capacity transfers is longer intensive care periods [2,3] this study shows that such transfers are also associated with greater mortality compared to repatriation. Avoiding the need for capacity transfers by increasing the number of ICU beds and staff is an obvious remedy. However, transfers due to demand-supply mismatch will continue to be necessary since it is impossible to meet all peaks in intensive care requirements. Future studies are needed to examine whether it is possible to minimise risk by careful patient selection and proper organisation of handover and transport.

Declarations

Ethics approval and consent to participate: The Swedish Intensive Care Register operates within the legal framework of the Swedish National Quality Registers. This framework does not require written informed consent from the patients, but patients may withdraw their data from the register. The study was approved by the Regional Ethics Review Board of Linköping University (2016/312-31) as well as by the Board of the Swedish Intensive Care Register

Consent for publication: Not applicable

Availability of data and materials: All data underlying this article was, after ethical approval, extracted and used unmodified from the Swedish Intensive Care Registry (SIR). The database cannot be shared publicly due to regulations under the Swedish law. Requests regarding the data may be made to the corresponding author.

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: Both authors contributed equally to the manuscript including design, acquisition and analysis/interpretation of the data as well as drafting of the final paper. Both authors have approved the submitted version. Part of this study was presented by FP at the “hot topic session” at ESICM Lives Berlin 2019.

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Figures

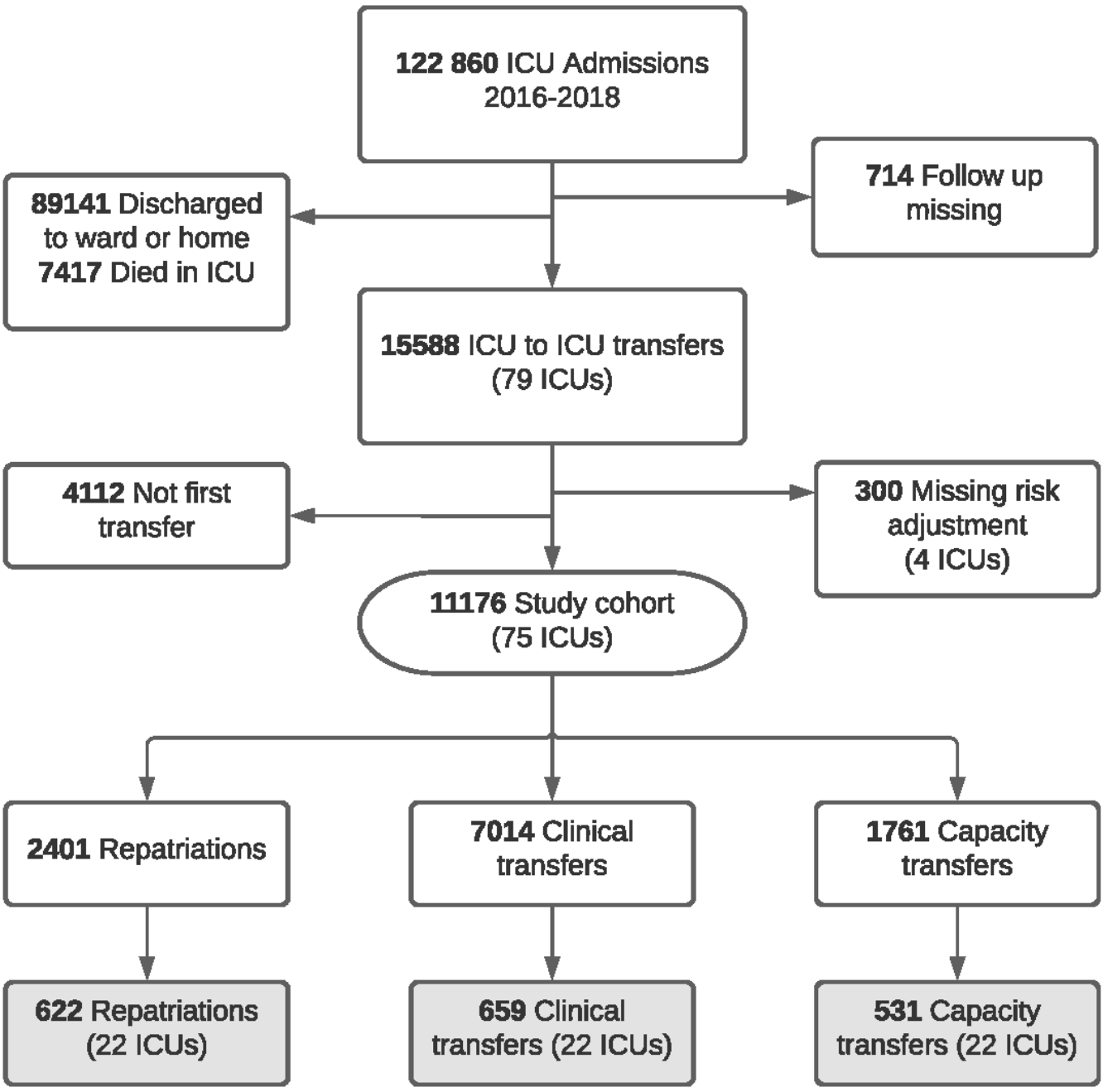

Figure 1

Patient flow diagram The primary analysis included 11,176 transfers from 75 ICUs (bold boxes). A secondary analysis was based on 1,777 transfers from 22 referring ICUs (grey boxes) where patients had a SOFA score recorded at discharge from the referring ICU.

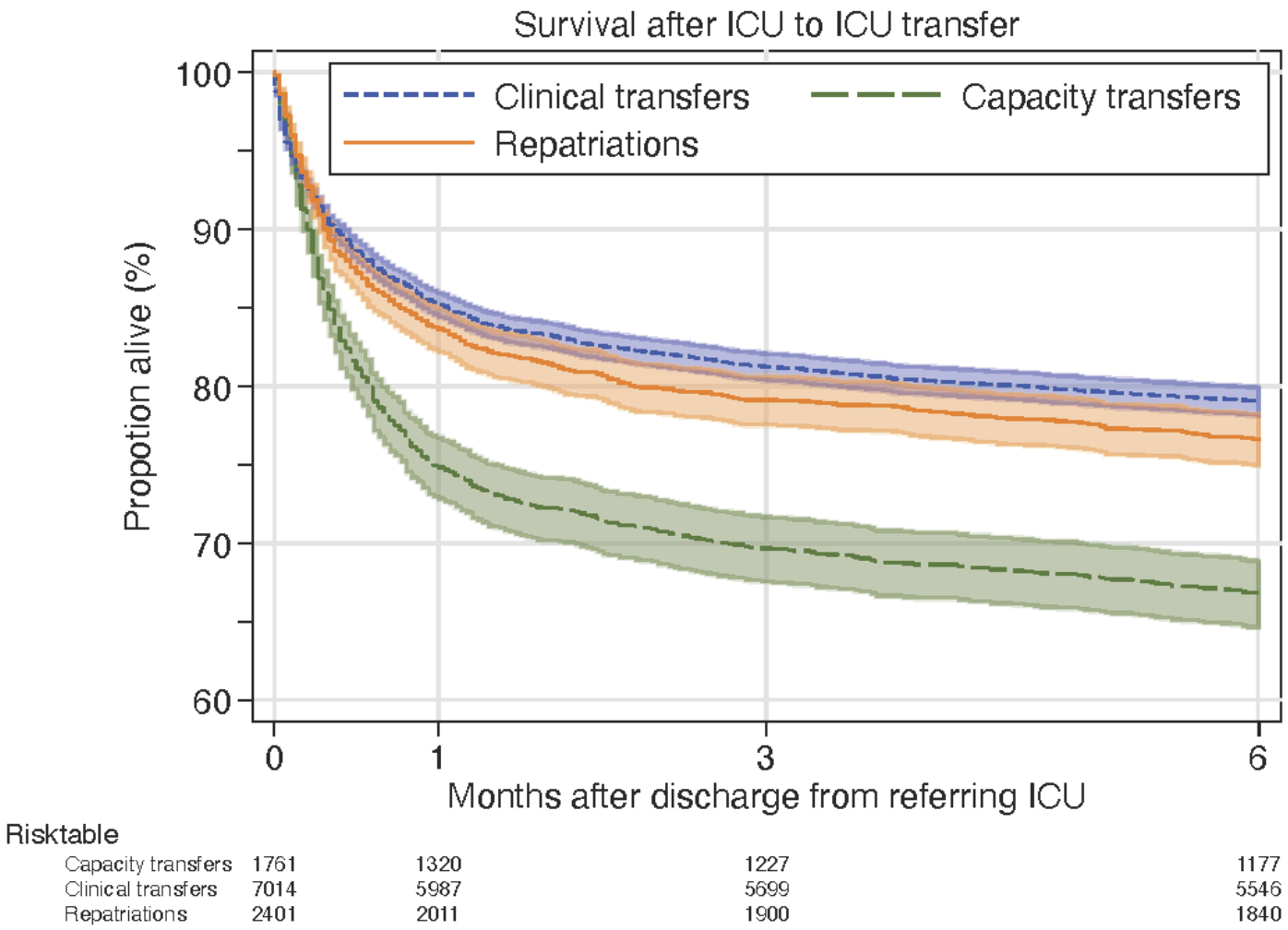

Figure 2

Kaplan-Meier diagram showing survival after ICU to ICU transfer. Shaded area showing 95% CI. Log-rank test p<0.001

Supplementary Files

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