# Outcomes of patients admitted to tertiary intensive care units after interhospital transfer: comparison with patients admitted from emergency departments

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A significant number of critically ill patients undergo interhospital transfer (IHT). In the United Kingdom, it is estimated that 11 000 patients per year are transferred to another hospital intensive care unit.[1] A significant proportion of IHTs occur solely because of insufficient resources, rather than the need to access a specific service not available at the referring hospital.[2,3] In metropolitan Victoria, 10% of patients referred to a public hospital ICU were unable to be admitted to the ICU of first choice, and 60% of those patients (equivalent to almost two patients per day) underwent acute IHT.[4]

To date, studies of the outcomes of critically ill patients who undergo IHT have been small, single-centre studies, lacked comparable controls, and were confined to a specific cohort of patients or risked significant bias from confounding factors.[3,5-7] Furthermore, regional, geographical and population variability may limit the generalisability of their findings.

Using a large dataset of adult intensive care patients, we conducted a case–control study of patients whose ICU source of admission was another acute hospital, and explored differences in their outcomes compared with those of similar ICU patients admitted from the emergency department (ED). We also explored regional variations among Australian states and territories and New Zealand.


## ABSTRACT

**Objectives:** To compare outcomes of patients admitted to tertiary-level intensive care units after interhospital transfer (IHT) with those of similar patients admitted from the emergency department (ED).

**Design:** Historical case–control study using data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD), a quality-assurance dataset.

**Participants and setting:** 28 882 patients aged 16 years or older admitted to an adult tertiary ICU in Australia or New Zealand between 1 January 1994 and 31 December 2003 with one of the eight most common diagnoses for IHT patients. Patients admitted directly to the ICU from another hospital (DIHT group) ($n = 9203$) were matched by age, sex, APACHE II score and diagnosis with non-IHT patients admitted from the ED (ED group).

**Results:** Hospital mortality was higher in the DIHT group than in the ED group for patients with a diagnosis of multiple trauma (11.0% v 5.1%; odds ratio [OR], 2.3; 95% CI, 1.6–3.34), respiratory infection (28.1% v 19.1%; OR, 1.66; 95% CI, 1.34–2.05), sepsis (38.7% v 28.7%; OR, 1.57; 95% CI, 1.34–1.83), intracranial haemorrhage (49.9% v 42.6%; OR, 1.34; 95% CI, 1.14–1.58), head injury alone (16.9% v 13.7%; OR, 1.28; 95% CI, 1.01–1.62), and cardiac arrest (59.3% v 53.2%; OR, 1.28; 95% CI, 1.06–1.56), but not overdose (3.9% v 3.6%; OR, 1.09; 95% CI, 0.72–1.67) or chronic obstructive pulmonary disease (19.8% v 22.5%; OR, 0.85; 95% CI, 0.63–1.15). Overall, the DIHT group had a higher intubation rate, longer ICU stay and higher rate of discharge to another hospital.

**Conclusions:** Patients admitted to an ICU from another hospital have higher hospital mortality and longer stay than those admitted from the ED, with the differences varying between diagnoses. These differences are important considerations for resource allocation and triage, and as a measure of quality.


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## Methods

The study used data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD),[8] which contains de-identified data on patients admitted to participating ICUs in Australia and New Zealand. Not all ICUs contribute data. In 2003, the participation rate was 60% overall, 78% for Australian ICUs, and 37% for NZ ICUs.[8]

Patients were selected using the criteria: age 16 years or older; admission to a tertiary-level ICU between 1 January 1994 and 31 December 2003; hospital source of admission either "another acute hospital" or "home"; and ICU source of admission either an "ED" or "another acute hospital".

The data sought were patient age, sex, hospital and ICU source of admission, APACHE II score, APACHE II-derived risk of death (ROD), APACHE II diagnostic category, intubation (endotracheal intubation within the first 24 hours of ICU admission), date of hospital and ICU admission, ICU and hospital outcomes, and ICU location (Australian states and

**Figure 1. Derivation of the study population**

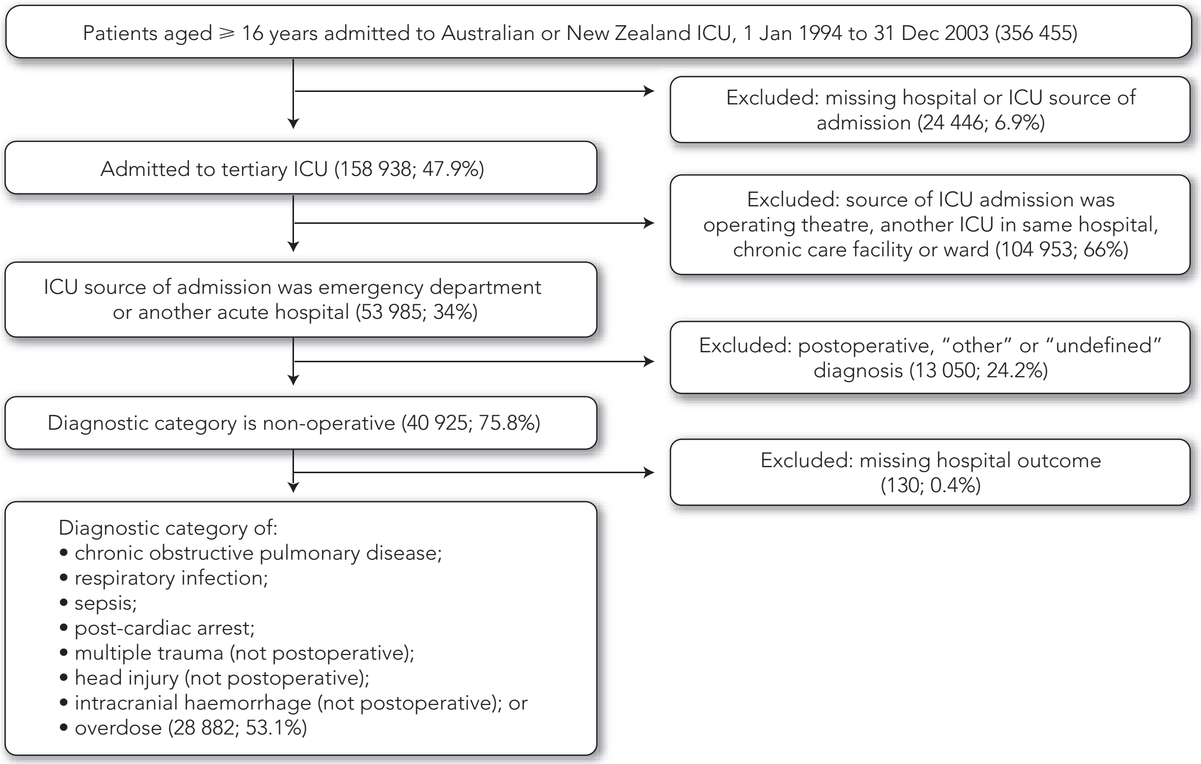



**Table 1. Patient demographics, severity of illness and outcome measures, by ICU source of admission**

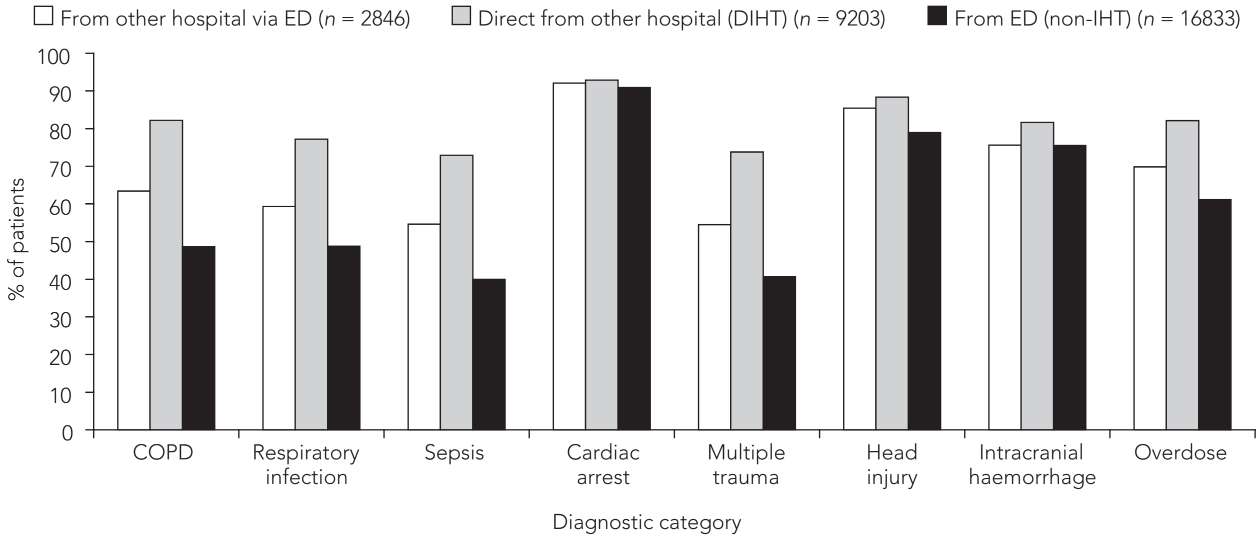
| | Direct from other hospital (DIHT) | From emergency department (ED) | From other hospital via ED |
|---|---|---|---|
| Number | 9203 | 16 833 | 2846 |
| Male sex | 59.8% | 60.8% | 62.1% |
| Age in years (95% CI) | 51.1 (50.7–51.5) | 49.8 (49.5–50.1) | 49.2 (48.5–50) |
| APACHE II score (95% CI) | 18.8 (18.6–18.9) | 16.7 (16.6–16.8) | 16.7 (16.3–17) |
| Predicted risk of death (95% CI) | 0.33 (0.32–0.33) | 0.26 (0.26–0.26) | 0.27 (0.26–0.28) |
| ICU stay in days* (IQR) | 3 (1–8) | 2 (1–4) | 3 (1–7) |
| Hospital stay in days* (IQR) | 9 (3–23) | 7 (2–16) | 10 (3–23) |
| Intubated* | 81% | 64% | 70.6% |
| Hospital mortality* | 27.9% | 23.8% | 24.4% |
| Discharge to other hospital* | 25.3% | 8.7% | 14% |

IQR = interquartile range. * $P < 0.001$ for comparisons across the DIHT, ED and other hospital via ED groups.

territories and New Zealand). Patients whose hospital or ICU source of admission was another hospital (referring) ICU were included in the category "another acute hospital". The dataset did not record the type of other acute hospital (referring), the location within that hospital from which the patient was transferred (eg, ward, emergency department or operating theatre) or treatment at that hospital. The Northern Territory was excluded as there was no participating ICU.

Patients were selected from the eight most common non-operative diagnostic categories for patients admitted to a tertiary ICU directly from another acute hospital: chronic obstructive pulmonary disease (COPD), respiratory infection, sepsis, post-cardiac arrest, multiple trauma with or without head injury ("multiple trauma"), head injury alone, non-traumatic intracranial haemorrhage (ICH) and overdose. These categories were chosen as collectively they constituted

**Figure 2. Intubation rates for patients admitted to the ICU, by diagnostic category and admission source***




*Intubation rates varied significantly for all categories ($P < 0.001$), except cardiac arrest ($P = 0.17$).

just over 50% of all diagnoses after excluding postoperative, "undefined" and "other" diagnostic categories.

Patients were classified as "direct IHT" (DIHT; transferred from another hospital and admitted directly to the ICU) or "ED" (not transferred from another hospital and admitted to the ICU directly from the ED). Patients from the DIHT group were matched with patients from the ED group based on age, sex, APACHE II score and diagnosis. The latter variables were combined into a unique string code for matching. The DIHT group was then compared with matched patients from the ED group.

Outcome measures were ICU and hospital length of stay (LOS), hospital outcome, and standardised mortality ratio (SMR; the ratio of observed to predicted death by APACHE II).

Descriptive statistical methods were used for patient and illness demographics. Results were presented as mean and 95% confidence interval or median and interquartile range (IQR; 25th to 75th centile). Statistical significance was set for the outcome measures (hospital outcome and stay) at $P < 0.01$, and for patient demographics to ascertain strength of matching (age, APACHE II score, ROD and intubation) and diagnostic group comparisons (day of week, month, year and region) at $P < 0.05$. Comparisons between groups were examined using the *t* test and ANOVA for normally distributed data, Kruskal–Wallis test for non-parametric data, $\chi^2$ test for categorical data, and a linear regression model for temporal trends over the study period. Length of stay was analysed using the Kaplan–Meier technique, and comparisons with a log rank test. Analyses were performed using SPSS version 11.0.4 statistical software (SPSS, Chicago, Ill, USA).

## Results

For the period 1994–2003, the ANZICS APD recorded 356 455 patients aged 16 years or older, from 125 ICUs. Figure 1 shows the derivation of the study population. A total of 28 882 patients were from one of the eight selected diagnostic categories: 9203 (31.9%) were admitted directly from another hospital (DIHT group), including 863 (9.4% of the DIHT group) transferred from another hospital ICU; and 19 679 (68.1%) were admitted from the ED. These patients formed the basis for all further analyses.

New South Wales contributed 32.2% of all patients analysed, South Australia 18.1%, Victoria 17.4%, Queensland 14.8%, Australian Capital Territory 5.6%, New Zealand 4.5%, Tasmania 4.1% and Western Australia 3.1%.

Among the ICU patients admitted from the ED, 2846 (14.5%) arrived in the ED after IHT. These patients had similar age, severity of illness, and predicted and observed hospital mortality, but significantly longer ICU and hospital stay, and rates of intubation and discharge to another hospital compared with non-IHT patients admitted to the ICU from the ED (Table 1). Patients admitted to the ICU from the ED with head injury alone were the most likely to have arrived in the ED after IHT (26.9%), followed by patients with multiple trauma (23.1%), ICH (17.3%), sepsis (15.4%), respiratory infection (12.6%), COPD (12.4%), post-cardiac arrest (13.6%) and overdose (6.4%).

Patients from the DIHT group and IHT patients admitted to the ICU via the ED had significantly higher rates of intubation overall (Table 1), and for all diagnostic categories ($P < 0.001$) except post-cardiac arrest in comparison with non-IHT ICU admissions from the ED. Post-cardiac

**Table 2. Demographics of patients in the direct interhospital transfer (DIHT) and emergency department (ED) groups**

| Diagnostic category | Number | Age (years) (95% CI) | Male sex | APACHE II score (95% CI) | Risk of death (95% CI)* |
|---|---|---|---|---|---|
| COPD | | | | | |
| DIHT group | 519 | 66.4 (65.6–67.2) | 52.4% | 20.3 (19.7–20.9) | 0.31 (0.30–0.33) |
| ED group | 519 | 66.4 (65.6–67.2) | 52.4% | 19.7 (19.2–20.2) | 0.29 (0.28–0.31) |
| Unmatched DIHT group | 31 | 57.1 (52.3–61.9) | 54.8% | 13.7 (10.6–16.9) | 0.19 (0.11–0.26) |
| Respiratory infection | | | | | |
| DIHT group | 954 | 58.4 (57.3–59.5) | 61.1% | 20.7 (20.2–21.3) | 0.40 (0.38–0.41) |
| ED group | 954 | 58.5 (57.4–59.6) | 61.1% | 20.6 (20.1–21.1) | 0.40 (0.38–0.41) |
| Unmatched DIHT group | 80 | 57.3 (53.4–61.3) | 35.0% | 16.4 (14.5–18.4) | 0.29 (0.24–0.34) |
| Sepsis | | | | | |
| DIHT group | 1420 | 58.7 (57.8–59.6) | 53.8% | 24.4 (23.9–24.9) | 0.53 (0.51–0.54) |
| ED group | 1420 | 58.5 (57.7–59.4) | 53.8% | 23.7 (23.3–24.2) | 0.51 (0.50–0.53) |
| Unmatched DIHT group | 49 | 64.9 (60.7–69.0) | 34.7% | 11.5 (10.5–12.4) | 0.16 (0.14–0.18) |
| Cardiac arrest | | | | | |
| DIHT group | 816 | 63.2 (62.2–64.3) | 62.4% | 25.3 (24.7–25.9) | 0.61 (0.59–0.62) |
| ED group | 816 | 63.4 (62.4–64.4) | 62.4% | 24.8 (24.2–25.4) | 0.60 (0.58–0.62) |
| Unmatched DIHT group | 46 | 57.7 (52.0–63.3) | 39.1% | 11.1 (9.7–12.5) | 0.20 (0.17–0.23) |
| Multiple trauma | | | | | |
| DIHT group | 864 | 41.0 (39.8–42.3) | 78.0% | 12.9 (12.4–13.4) | 0.09 (0.08–0.09) |
| ED group | 864 | 41.0 (39.8–42.3) | 78.0% | 12.7 (12.2–13.2) | 0.08 (0.08–0.09) |
| Unmatched DIHT group | 75 | 55.4 (51.9–59.0) | 34.7% | 21.3 (19.6–23.0) | 0.21 (0.17–0.25) |
| Head injury | | | | | |
| DIHT | 1097 | 35.8 (34.8–36.9) | 79.2% | 15.5 (15.1–16.0) | 0.19 (0.18–0.20) |
| ED group | 1097 | 36.4 (35.3–37.3) | 79.2% | 15.6 (15.2–16.1) | 0.20 (0.19–0.21) |
| Unmatched DIHT group | 27 | 68.7 (65.1–72.3) | 14.8% | 16.9 (13.9–20.0) | 0.22 (0.14–0.29) |
| Intracranial haemorrhage | | | | | |
| DIHT | 1158 | 55.3 (54.5–56.2) | 50.8% | 20.4 (19.9–20.8) | 0.54 (0.52–0.55) |
| ED group | 1158 | 55.4 (54.6–56.3) | 50.8% | 20.2 (19.7–20.6) | 0.53 (0.52–0.55) |
| Unmatched DIHT group | 134 | 55.1 (51.8–58.4) | 46.3% | 13.2 (12.3–14.0) | 0.31 (0.28–0.33) |
| Overdose | | | | | |
| DIHT group | 1209 | 37.7 (36.9–38.5) | 53.3% | 13.2 (12.7–13.6) | 0.01 (0.013–0.017) |
| ED group | 1209 | 37.7 (36.9–38.5) | 53.3% | 13.0 (12.6–13.5) | 0.01 (0.012–0.015) |
| Unmatched DIHT group | 37 | 71.3 (69.0–73.7) | 59.5% | 18.4 (15.3–21.4) | 0.037 (0.014–0.060) |

COPD = chronic obstructive pulmonary disease. * Based on APACHE II.

arrest patients had the highest overall rates of intubation (> 90%) (Figure 2).

Over the study period, mortality decreased significantly for both the DIHT and ED group for patients with respiratory infection ($R^2 = 0.563$, $P = 0.01$, and $R^2 = 0.857$, $P < 0.001$, respectively) and intracranial haemorrhage ($R^2 = 0.426$, $P = 0.04$, and $R^2 = 0.560$, $P = 0.01$), and for the ED group for those with sepsis ($R^2 = 0.436$, $P = 0.04$).

Table 2 compares the demographics of patients in the DIHT and ED groups. There was no significant difference between the ED groups for the admitting day of the week or month of the year, except for overdose patients within the ED group, who had a lower proportion of admissions on a Friday and Saturday. Table 2 also compares patients from the DIHT group who could not be matched with a patient from the ED group. Unmatched patients with COPD, respiratory infection, post-cardiac arrest and ICH had less severe illness, while patients with sepsis, multiple trauma, head injury alone and overdose were older and had more severe illness than patients from the DIHT group who could be matched.

Outcomes of matched patients from the DIHT and ED groups are compared in Table 3. Patients from the DIHT group with diagnoses of COPD, respiratory infection, sepsis, multiple trauma and head injury alone had significantly longer ICU stays. DIHT patients with multiple trauma and head injury alone had longer hospital stays, those with ICH and cardiac arrest had shorter stays, and there was no

**Table 3. Hospital and ICU length of stay, outcome and standardised mortality ratio compared between the DIHT and matched ED groups**

| Diagnostic category | Number | ICU stay (days) (IQR) | Hospital stay (days) (IQR) | Hospital mortality | Odds ratio (95% CI)* | Discharged to another hospital | Standardised mortality ratio |
|---|---|---|---|---|---|---|---|
| COPD | | | | | | | |
| DIHT group | 519 | 4 (2–8) | 12 (7–19) | 19.8% | 0.85 (0.63–1.15) | 28.3% | 0.64 (0.60–0.66) |
| ED group | 519 | 3 (1–7) | 10 (6–17) | 22.5% | | 10.8% | 0.78 (0.73–0.80) |
| *P*† | | < 0.001 | 0.05 | 0.29 | | | |
| Respiratory infection | | | | | | | |
| DIHT group | 954 | 7 (3–12.5) | 15 (8–25) | 28.1% | 1.66 (1.34–2.05) | 25.5% | 0.70 (0.69–0.74) |
| ED group | 954 | 5 (2–11) | 13 (7–24) | 19.1% | | 6.3% | 0.48 (0.47–0.50) |
| *P*† | | < 0.001 | 0.92 | < 0.001 | | | |
| Sepsis | | | | | | | |
| DIHT group | 1420 | 5 (2–11) | 12 (4–27) | 38.7% | 1.57 (1.34–1.83) | 25.1% | 0.73 (0.72–0.76) |
| ED group | 1420 | 3 (1–8) | 14 (8–24) | 28.7% | | 12.5% | 0.56 (0.54–0.57) |
| *P*† | | < 0.001 | 0.54 | < 0.001 | | | |
| Post-cardiac arrest | | | | | | | |
| DIHT group | 816 | 2 (1–4) | 4 (2–11) | 59.3% | 1.28 (1.06–1.56) | 14.1% | 0.97 (0.96–1.01) |
| ED group | 816 | 2 (1–5) | 7 (3.5–15) | 53.2% | | 12.8% | 0.87 (0.86–0.92) |
| *P*† | | 0.045 | < 0.001 | 0.01 | | | |
| Multiple trauma | | | | | | | |
| DIHT group | 864 | 4 (1–11) | 17 (7–44) | 11.0% | 2.3 (1.6–3.34) | 26.3% | 1.22 (1.21–1.38) |
| ED group | 864 | 2 (1–6) | 6 (1–20) | 5.1% | | 34.1% | 0.64 (0.57–0.66) |
| *P*† | | < 0.001 | < 0.001 | < 0.001 | | | |
| Head injury | | | | | | | |
| DIHT group | 1097 | 3 (1–8) | 13 (5–27.5) | 16.9% | 1.28 (1.01–1.62) | 32.1% | 0.89 (0.85–0.94) |
| ED group | 1097 | 3 (1–7) | 10 (2–26) | 13.7% | | 27.0% | 0.69 (0.65–0.72) |
| *P*† | | 0.001 | < 0.001 | 0.04 | | | |
| Intracranial haemorrhage | | | | | | | |
| DIHT group | 1158 | 2 (1–6) | 7 (2–23) | 49.9% | 1.34 (1.14–1.58) | 21.7% | 0.92 (0.91–0.96) |
| ED group | 1158 | 2 (1–6) | 10 (2–25) | 42.6% | | 16.9% | 0.80 (0.77–0.82) |
| *P*† | | 0.40 | < 0.001 | | | | |
| Overdose | | | | | | | |
| DIHT group | 1209 | 1 (1–2) | 3 (1–6) | 3.9% | 1.09 (0.72–1.67) | 26.4% | 2.6 (2.3–3.0) |
| ED group | 1209 | 1 (1–2) | 2 (1–5) | 3.6% | | 38.8% | 2.8 (2.4–3.0) |
| *P*† | | 0.71 | 0.96 | | | | |

DIHT = direct interhospital transfer (patients admitted directly to intensive care unit after transfer from another hospital). ED = emergency department. IQR = interquartile range. COPD = chronic obstructive pulmonary disease.
* Odds ratio for mortality, DIHT group versus ED group. † *P* for comparison of DIHT and ED groups.

difference in stay for those with COPD, respiratory infection, sepsis and overdose. Hospital mortality and SMR in the DIHT groups were higher across all diagnostic categories, other than COPD, but this was statistically significant only for patients with respiratory infection, sepsis, multiple trauma and ICH. DIHT patients with multiple trauma, when compared with similar ED patients, had the highest odds ratio for mortality.

Table 4 shows patient age, severity of illness and hospital mortality for all patients in the DIHT group by region and diagnosis. Patient age, APACHE II score and predicted ROD varied significantly among the regions for all diagnoses other than COPD, post-cardiac arrest and head injury alone. There was significant regional variation for hospital mortality for the diagnostic categories of sepsis, multiple trauma and ICH.

**Table 4. Patient demographics, illness severity and hospital outcome for all DIHT patients, by diagnosis and region**

| Variable | ACT | New South Wales | New Zealand | Queensland |
|---|---|---|---|---|
| COPD (no.) | 23 | 169 | 13 | 79 |
| Age | 67.7 (64.6–70.8) | 66.0 (64.5–67.6) | 67.9 (62.3–73.4) | 64.0 (61.8–66.3) |
| APACHE II score | 18.3 (15.2–21.4) | 20.2 (19.1–21.4) | 17.6 (13.5–21.8) | 20.1 (18.5–21.7) |
| Risk of death | 0.26 (0.17–0.34) | 0.31 (0.28–034) | 0.25 (0.16–0.35) | 0.31 (0.27–0.35) |
| Hospital mortality | 8.7% | 22.5% | 15.4% | 21.5% |
| Respiratory infection (no.) | 39 | 361 | 24 | 179 |
| Age | 61.4 (56.1–66.6) | 60.7 (58.9–62.5) | 62.0 (55.3–68.7) | 54.5 (51.9–57.2) |
| APACHE II score | 19.0 (16.9–21.0) | 21.6 (20.7–22.6) | 22.2 (18.1–26.2) | 19.5 (18.2–20.7) |
| Risk of death | 0.34 (0.28–0.40) | 0.43 (0.40–0.45) | 0.43 (0.32–0.55) | 0.36 (0.33–0.40) |
| Hospital mortality | 23.1% | 30.7% | 33.3% | 23.5% |
| Sepsis (no.) | 55 | 547 | 53 | 233 |
| Age | 60.2 (56.0–64.4) | 61.6 (60.2–62.9) | 55.7 (50.8–60.6) | 55.6 (53.5–57.7) |
| APACHE II score | 20.5 (18.1–22.9) | 24.9 (24.1–25.8) | 25.4 (22.6–28.2) | 22.3 (21.1–23.5) |
| Risk of death | 0.41 (0.35–0.48) | 0.54 (0.52–0.56) | 0.55 (0.47–0.63) | 0.46 (0.43–0.49) |
| Hospital mortality | 29.1% | 41.7% | 39.6% | 26.6% |
| Cardiac arrest (no.) | 42 | 342 | 22 | 136 |
| Age | 65.2 (60.9–69.4) | 63.2 (61.6–64.8) | 56.7 (49.7–63.7) | 64.0 (61.5–66.5) |
| APACHE II score | 21.0 (18.3–23.8) | 25.0 (24.0–26.1) | 25.8 (21.2–30.3) | 23.2 (21.6–24.7) |
| Risk of death | 0.49 (0.41–0.57) | 0.60 (0.57–0.63) | 0.61 (0.50–0.72) | 0.55 (0.51–0.59) |
| Hospital mortality | 59.5% | 61.1% | 63.6% | 50.% |
| Multiple trauma (no.) | 12 | 281 | 43 | 341 |
| Age | 35.5 (24.8–46.2) | 43.8 (41.6–46.0) | 40.8 (35.5–46.1) | 41.2 (39.2–43.2) |
| APACHE II score | 7.9 (4.2–11.7) | 15.7 (14.6–16.9) | 13.3 (10.8–15.8) | 13.5 (12.7–14.3) |
| Risk of death | 0.04 (0.01–0.06) | 0.14 (0.12–0.16) | 0.09 (0.06–0.13) | 0.09 (0.08–0.11) |
| Hospital mortality | 8.3% | 16.% | 9.3% | 8.2% |
| Head injury (no.) | 28 | 373 | 92 | 384 |
| Age | 36.4 (30.6–42.1) | 37.3 (35.6–39.1) | 34.2 (30.6–37.8) | 36.5 (34.7–38.3) |
| APACHE II score | 12.5 (9.9–15.1) | 15.0 (14.1–15.8) | 15.7 (14.3–17.2) | 15.9 (15.1–16.6) |
| Risk of death | 0.13 (0.10–0.16) | 0.19 (0.17–0.20) | 0.19 (0.16–0.22) | 0.20 (0.18–0.21) |
| Hospital mortality | 14.3% | 16.6% | 21.7% | 15.4% |
| Intracranial haemorrhage (no.) | 53 | 445 | 93 | 256 |
| Age | 55.0 (50.9–59.2) | 57.5 (56.2–59.0) | 50.0 (46.8–53.2) | 53.9 (52.0–55.7) |
| APACHE II score | 16.7 (14.6–18.8) | 19.4 (18.6–20.1) | 18.8 (17.2–20.4) | 19.0 (17.9–20.1) |
| Risk of death | 0.43 (0.37–0.49) | 0.50 (0.49–0.53) | 0.49 (0.44–0.54) | 0.49 (0.46–0.52) |
| Hospital mortality | 45.3% | 50.6% | 43.0% | 35.5% |
| Overdose (no.) | 28 | 390 | 12 | 313 |
| Age | 42.1 (35.8–48.4) | 41.2 (39.7–42.9) | 34.1 (24.4–43.8) | 36.3 (34.9–37.8) |
| APACHE II score | 10.8 (7.9–13.8) | 13.5 (12.7–14.3) | 10.6 (4.6–16.5) | 10.8 (10.0–11.6) |
| Risk of death | 0.01 (0.01–0.02) | 0.02 (0.01–0.02) | 0.01 (0.01–0.03) | 0.01 (0.01–0.02) |
| Hospital mortality | 7.1% | 3.6% | 0 | 2.9% |

DIHT = direct interhospital transfer (patients admitted directly to intensive care unit after transfer from another hospital).
COPD = chronic obstructive pulmonary disease. ACT =Australian Capital Territory.

## Discussion

This study compared the outcomes of patients admitted directly to an Australian or New Zealand tertiary level ICU after IHT with outcomes of similar patients admitted from the ED. Patients from the DIHT group with a diagnosis of respiratory infection, sepsis, post-cardiac arrest, multiple trauma, head injury alone or ICH had significantly higher mortality than similar patients from the ED group. Overall, IHT patients, with few exceptions, were more likely to have undergone endotracheal intubation, to have longer ICU and hospital stay, and to be discharged to another hospital.

**Table 4. *continued***

| South Australia | Tasmania | Victoria | Western Australia | *P* |
|---|---|---|---|---|
| 199 | 12 | 58 | 38 | |
| 66.5 (65.0–67.9) | 66.5 (60.1–73.0) | 64.9 (62.3–67.5) | 65.6 (62.8–68.4) | 0.63 |
| 20.5 (19.6–21.5) | 17.3 (14.3–20.3) | 19.3 (17.4–21.2) | 18.9 (16.5–21.4) | 0.46 |
| 0.32 (0.29–0.35) | 0.22 (0.14–0.30) | 0.29 (0.24–0.35) | 0.28 (0.22–0.35) | 0.47 |
| 19.1% | 8.3% | 13.8% | 26.3% | 0.51 |
| 253 | 19 | 104 | 89 | |
| 58.1 (56.0–60.1) | 69.9 (65.7–74.1) | 56.9 (53.5–60.3) | 52.9 (49.4–56.4) | < 0.001 |
| 20.8 (19.7–21.8) | 22.0 (17.1–26.9) | 19.2 (17.5–20.8) | 17.3 (15.8–18.7) | < 0.001 |
| 0.40 (0.37–0.43) | 0.41 (0.28–0.53) | 0.36 (0.31–0.40) | 0.30 (0.26–0.34) | < 0.001 |
| 34.4% | 21.1% | 17.3% | 21.3% | 0.02 |
| 298 | 48 | 186 | 130 | |
| 58.8 (56.9–60.7) | 61.2 (56.0–66.5) | 58.3 (55.7–60.9) | 55.0 (52.1–57.8) | < 0.001 |
| 25.5 (24.4–26.6) | 21.9 (19.4–24.4) | 23.8 (22.5–25.0) | 21.6 (20.1–23.1) | < 0.001 |
| 0.56 (0.53–0.59) | 0.46 (0.39–0.53) | 0.50 (0.47–0.54) | 0.45 (0.40–0.49) | < 0.001 |
| 39.9% | 29.2% | 39.8% | 40.% | 0.005 |
| 200 | 8 | 96 | 46 | |
| 62.1 (59.8–64.3) | 57.2 (35.8–78.6) | 62.9 (59.9–65.9) | 60.5 (55.6–65.4) | 0.34 |
| 25.6 (24.2–27.0) | 22.1 (14.0–30.2) | 24.9 (23.1–26.8) | 23.2 (20.8–25.6) | 0.06 |
| 0.61 (0.57–0.65) | 0.55 (0.33–0.77) | 0.59 (0.54–0.64) | 0.55 (0.48–0.62) | 0.09 |
| 59.5% | 50.% | 56.3% | 41.3% | 0.15 |
| 157 | 12 | 196 | 43 | |
| 41.1 (38.2–44.0) | 40.2 (28.2–52.1) | 42.7 (39.8–45.7) | 36.9 (31.5–42.3) | 0.30 |
| 13.7 (12.6–14.8) | 12.5 (6.7–18.3) | 11.1 (10.3–11.8) | 12.1 (10.3–14.0) | < 0.001 |
| 0.09 (0.07–0.10) | 0.10 (0.01–0.20) | 0.06 (0.05–0.06) | 0.07 (0.05–0.08) | < 0.001 |
| 18.5% | 8.3% | 8.7% | 7.% | 0.008 |
| 213 | 67 | 87 | 27 | |
| 34.4 (32.0–36.9) | 36.6 (32.4–40.8) | 42.4 (38.3–46.4) | 37.4 (30.9–43.9) | 0.04 |
| 16.2 (15.0–17.3) | 15.9 (14.3–17.5) | 15.5 (13.7–17.3) | 14.3 (11.5–17.1) | 0.23 |
| 0.21 (0.18–0.24) | 0.19 (0.16–0.22) | 0.19 (0.16–0.22) | 0.16 (0.11–0.22) | 0.32 |
| 20.7% | 11.9% | 17.2% | 14.8% | 0.57 |
| 192 | 76 | 171 | 64 | |
| 54.2 (51.9–56.6) | 54.7 (51.2–58.2) | 55.0 (52.7–57.3) | 54.8 (50.8–58.8) | 0.001 |
| 20.5 (19.3–21.7) | 19.4 (17.8–21.0) | 21.6 (20.5–22.7) | 18.6 (17.1–20.1) | 0.002 |
| 0.54 (0.51–0.57) | 0.51 (0.46–0.56) | 0.58 (0.54–0.61) | 0.48 (0.43–0.53) | 0.001 |
| 58.9% | 36.8% | 48.0% | 39.1% | < 0.001 |
| 282 | 4 | 140 | 117 | |
| 39.2 (37.4–40.9) | 38.7 (28.4–48.9) | 38.5 (36.0–41.1) | 34.9 (32.8–37.0) | < 0.001 |
| 15.5 (14.6–16.5) | 15.0 (1.0–33.0) | 13.5 (12.3–14.8) | 14.5 (13.3–15.7) | < 0.001 |
| 0.02 (0.02–0.03) | 0.03 (0.01–0.09) | 0.02 (0.01–0.02) | 0.01 (0.01–0.02) | 0.24 |
| 4.6% | 0 | 5.0% | 5.1% | 0.82 |

Outcome differences between the DIHT and the ED groups varied according to diagnosis, being most significant for patients with major trauma and of no measurable impact for patients with COPD or overdose. The diagnostic groups selected were the eight most common for tertiary ICU patients admitted from another hospital. Previous studies have also shown increased morbidity and mortality for IHT patients,[9,10] and suggested that this effect may be prominent for certain diagnostic groups.[3,5]

Our finding regarding trauma patients might be expected, as patients with major trauma who are not admitted directly to a major trauma centre may have delayed or suboptimal definitive treatment and higher mortality than patients who are admitted directly to such a centre.[11] In our study, IHT trauma patients were not admitted directly to a tertiary hospital but underwent IHT and direct admission to an ICU. If time was a critical outcome determinant for these patients, then it would suggest there may be an additional contribution to morbidity associated with an IHT patient admitted directly to an ICU compared with a non-IHT patient admitted from the ED. Observational studies have shown that time to acceptance after referral is shorter for an ED than for an ICU.[12] Treatment of certain conditions in higher-volume, specialty-staffed ICUs,[13-16] early goal-directed resuscitation[17] and delays in discharge to a hospital inpatient bed from the ED[18,19] are all factors that can influence patient outcome positively or negatively. These factors may, in part, explain our findings.

Patients in the DIHT group had a higher intubation rate than similar patients in the ED group across all diagnostic groups except post-cardiac arrest. The difference for the post-cardiac arrest group may not have reached statistical significance because of the high overall rate of tracheal intubation in that group. Similarly, ICU patients admitted via the ED after IHT, although younger and with a similar severity of illness to non-IHT patients admitted from the ED, also had a higher intubation rate and longer ICU and hospital stay. Intubation in our study was defined as intubation within the first 24 hours of ICU admission. We found that IHT patients had a higher risk of intubation, either before ICU admission, associated with or in preparation for transportation, and after ICU admission.

Influences on patient management during IHT include the need to guard against the physical consequences of transport, the restrictions of different transport platforms, duration of travel and expertise of patient escorts. Institution of invasive ventilatory support is frequently advocated to mitigate the risk of clinical deterioration during IHT but carries its own risks, particularly the loss of the advantages of non-invasive ventilation[20] — a technique which has significant limitations in the typical transport environment. The extent to which the transport process itself contributed to the adverse outcomes identified in our study could not be determined. However, adverse events are not infrequent during IHT and contribute to preventable adverse patient consequences.[21]

This study also highlighted significant regional variations in age of patients, severity of illness and hospital outcome, particularly for patients with sepsis, respiratory infection, multiple trauma and ICH. These findings may be explained by geographical differences, and variations in resources and patient selection, referral and transport processes. Data on these variables were not available to us; they should be examined in future studies as they may be important to building models of IHT associated with better patient outcomes.

A strength of this study was the use of the large standardised national dataset of ICU admissions across many centres. This dataset is of high quality when assessed against established criteria.[8] Its size allowed selection of a larger sample of control cases, using stronger matching criteria and more diagnostic categories than in previous studies, in an area of study where it would be difficult to conduct prospective, multicentre randomised controlled studies.

Weaknesses of our study were that we could not examine specific factors such as the appropriateness of patient intervention before and during IHT, distortion of illness severity measures caused by lead-time bias[6,22] or bias resulting from patient selection for transportation (eg, "too unstable to transfer", "not likely to survive" or "no ICU bed transfer"). The last may explain the selection for IHT of patients for whom similar ED patients could not be identified. Although the study population was large, it did not draw from all Australian and New Zealand ICUs, and may not necessarily be representative of the entire IHT population. Changes in mortality across the diagnostic categories over the 10-year study period were similar for both study groups, other than a small difference for sepsis, and unlikely to have influenced the study's outcome comparisons. Finally, hospital mortality of IHT patients may have been underestimated as these patients were more likely to be discharged to another hospital, where length of stay and outcome were not measured.

Our findings are significant for the planning, funding and equitable distribution of health services. For countries such as Australia and New Zealand, access to tertiary health resources is influenced by geography, population distribution, hospital volume and resource allocation. Transport services for acutely ill patients are essential for bringing either distant resources to the patient or the patient to the resources.[23] IHT patients have disproportionately higher resource implications for receiving hospitals because of their longer ICU and hospital stays. This impact varies according to diagnostic category and particularly affects IHT patients with multiple trauma and head injury, who not only had longer ICU and hospital stays but also, unlike other IHT patients, were no more likely to be discharged to another hospital than non-IHT patients. Patients with sepsis had a longer ICU stay, and those with ICH a longer hospital stay. Thus, receiving hospitals most likely to be financially disadvantaged by IHT patients are those which are designated to receive trauma patients and have a higher-level ICU or specialist neurosurgical services. These findings suggest that the nature and number of IHTs should be a determinant for funding and allocation of critical care resources. The disproportionately higher mortality of DIHT patients and the presence of regional variability highlight the importance of monitoring and evaluating IHT as a quality measure of any regional health service, particularly as it may be related solely to insufficient resources at the referring location.[4]

Measures that may prevent an IHT or, if it is not preventable, minimise its adverse consequences should be thoroughly evaluated and may be generalisable across regions. Examples of such measures include quality tools, such as incident monitoring,[21] resource re-allocation to areas with a high level of IHTs, IHT supervision by experienced senior clinicians, use of transfer checklists,[24] and telemedicine.[25]

In summary, Australia and New Zealand IHT patients admitted directly to a tertiary-level ICU with multiple trauma, head trauma, sepsis, respiratory infections, post-cardiac arrest and intracranial haemorrhage have higher intubation rates and hospital mortality, and longer stays than matched non-IHT patients admitted directly from the ED. There were regional variations for patient demographics, severity of illness and outcome. The occurrence of IHT should be monitored and reported as part of a regional health quality measure. Further evaluations of patient referral and transport factors and their relative contribution to patient outcomes would help tailor interventions to improve the appropriateness of IHT and patient outcome.

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