

Observational study of patients admitted to intensive care units in Australia and New Zealand after interhospital transfer

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The centralisation of complex health care is increasing, partly because of the need for expensive and complex technology, and partly because of evidence that high-volume, centrally coordinated care improves patient outcomes.¹ For example, improved outcomes have been seen at dedicated centres for major trauma,^{2,3} cardiac, vascular and cancer surgery,^{4,5} and acute myocardial infarction.⁶ There is also evidence supporting the centralisation of critical care services, with reduced mortality seen in high-volume intensive care units^{7,8} staffed by specialist intensivists.⁹

Centralisation of health care raises the problem of equity of access, and may increase the need for interhospital transfer (IHT), as patients in hospitals remote from central services must be referred and transported to hospitals that can provide the requisite service. This has the potential to delay treatment¹⁰ and increase morbidity and mortality.^{11,12} The risk is likely to be greatest for critically ill patients, because of their greater illness severity and support requirements. In addition, critically ill patients are sometimes transferred between hospitals because the referring site has insufficient resources to deliver care it is competent to deliver, not because of a need for higher-level care.^{13,14}

An understanding of the demographic and illness characteristics of patients who undergo IHT may assist with planning future provision and accessibility of health care resources. Comparisons of regional differences and patterns of IHT may provide a basis for evaluating factors that influence the occurrence and outcome of IHT. The aim of this study was to describe the patient and illness demographics and outcomes for adult intensive care patients who underwent IHT from within Australia or New Zealand.

Methods

The study was a retrospective review of data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD).¹⁵ This quality-assurance dataset collects de-identified data on adult patients admitted to participating Australian and New Zealand ICUs. Patients were included in the analysis if they were aged 16 years or older, admitted between 1 January 1994 and 31 December 2003, had known hospital and ICU source of

ABSTRACT

Objective: To describe the demographics, illness categories and outcomes of adult intensive care unit patients who underwent interhospital transfer (IHT).

Design: Retrospective review of data from the Australian and New Zealand Intensive Care Society Adult Patient Database (ANZICS APD), a binational intensive-care quality-assurance dataset.

Participants and setting: 332 009 patients from 125 Australian and New Zealand adult ICUs, who were aged 16 years or older, and had a known hospital and ICU source of admission between 1 January 1994 and 31 December 2003.

Results: Tertiary ICUs contributed 47.9% of patients, metropolitan 20.9%, private 16.7% and rural/regional 14.5%. Patients admitted to an ICU after IHT had more severe illness, longer hospital stay, and a higher intubation rate, mortality and rate of discharge to another hospital. Over 10 years, the proportion of IHTs increased for rural/regional ($R^2 = 0.639$; $P = 0.006$) and tertiary ($R^2 = 0.703$; $P = 0.002$) hospitals, and for the diagnoses of sepsis ($R^2 = 0.877$; $P < 0.001$) and respiratory infection ($R^2 = 0.679$, $P = 0.003$); decreased for trauma ($R^2 = 0.612$; $P = 0.007$); and was associated with fewer ICU admissions after elective surgery ($\beta = -1.47$; 95% CI, -2.19 to -0.74 ; $P < 0.001$) and from the operating theatre ($\beta = -0.78$; 95% CI, -1.46 to -0.1 ; $P = 0.03$). IHT was most common during July–October and on Fridays and Saturdays. There were significant variations between Australian states and territories and New Zealand.

Conclusions: Patients admitted to an ICU after IHT have significant resource implications based on their severity of illness, hospital stay and mortality, and adversely affect ICU capacity for elective and operating theatre admissions. Regional differences and temporal trends have implications for planning of ICU resources and require ongoing surveillance.

admission, and known ICU and hospital outcome. Patients whose hospital source of admission was a chronic care facility were excluded.

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Table 1. Demographic characteristics and outcomes of patients recorded in the ANZICS APD, 1994–2003, with a known source of hospital and ICU admission and known outcome*

	Hospital admission source		ICU admission source [†]			
	Home	Other acute hospital	Operating theatre	Emergency department	Ward	Other acute hospital
No. of patients	268156	63853	154102	92012	54109	28780
Age (years) [‡]	60.1 (60–60.2)	57.1 (57–57.3)	62.7 (62.6–62.8)	54.1 (54–54.2)	63 (62.3–63.2)	55.7 (55.4–55.9)
Male sex (%)	60.4%	59.2%	63.7%	57.6%	55.8%	56.8%
Intubated (%) [‡]	46.3%	62.3%	55.5%	40.2%	39.8%	67.1%
APACHE II score [‡]	14.9 (14.8–14.9)	17.4 (17.3–17.5)	13.1 (13.1–13.2)	15.4 (15.3–15.4)	19 (19–19.1)	18.2 (18.1–18.3)
APACHE II risk of death [‡]	0.21 (0.21–0.21)	0.28 (0.28–0.28)	0.15 (0.15–0.15)	0.22 (0.22–0.23)	0.33 (0.33–0.33)	0.31 (0.30–0.31)
SMR [‡]	0.68 (0.67–0.69)	0.75 (0.74–0.77)	0.51 (0.50–0.52)	0.75 (0.73–0.76)	0.94 (0.92–0.96)	0.78 (0.76–0.80)
No. of patients for SMR calculation (% of total no.)	225752 (84.2%)	53800 (88.8%)	114443 (74.3%)	87339 (94.9%)	50596 (93.5%)	27472 (95.5%)
ICU length of stay (days) [‡]	3.4 (3.4–3.4)	5.1 (5.0–5.1)	3 (3.0–3.0)	3.4 (3.4–3.4)	4.9 (4.9–5.0)	5.4 (5.3–5.5)
Pre-ICU hospital stay (days) [‡]	3.4 (3.3–3.4)	2.6 (2.5–2.7)	3.52 (3.5–3.6)	0.7 (0.6–0.8)	8 (7.8–8.1)	
Hospital length of stay (days) [‡]	17.5 (17.4–17.6)	19.5 (19.2–19.7)	19.2 (19.1–19.4)	11.8 (11.6–11.9)	26.4 (26.1–26.7)	15.6 (15.3–15.9)
Discharge to another hospital (%) [‡]	7.5%	22.3%	6.0%	12.1%	10.7%	26.6%
Hospital mortality (%) [‡]	14.0%	21.1%	7.6%	16.7%	31.1%	23.6%

ANZICS APD = Australian and New Zealand Intensive Care Society Adult Patient Database. SMR = standardised mortality ratio.

* Values are mean and 95% CI unless otherwise indicated. † Patients whose ICU source of admission was listed as another ICU in the same hospital are omitted. ‡ $P < 0.001$ for both hospital and ICU source of admission.

Not all Australian and New Zealand ICUs contributed data to the database; in 2003, participation was 60% overall, 78% for Australian ICUs, and 37% for New Zealand ICUs.¹⁵ Data from individual ICUs that began contributing part way through a calendar year were excluded if the number of admissions they contributed in that year was less than 10% of the number in the following year.

Variables analysed were age, sex, hospital and ICU source of admission, APACHE II score, predicted risk of death and diagnostic category, intubation (endotracheal intubation within the first 24 hours of ICU admission), date of hospital and ICU admission, and hospital outcome. Details of the receiving ICU type (rural, metropolitan, tertiary or private) and location (Australian states or territories or New Zealand) were also sought.

Descriptive statistical methods were used for patient and illness demographics. Results were presented as means and 95% confidence intervals. Statistical significance was set at $P < 0.05$. Associations between variables and hospital or ICU admission source were examined using Pearson's correlation coefficient after testing for linearity, χ^2 tests for categorical data, and a linear regression model for yearly temporal trends over the study period. All analyses were performed using SPSS version 11.0.4 statistical software (SPSS, Chicago, Ill, USA). Standardised mortality ratio (SMR) was defined as the ratio of observed to predicted deaths by

APACHE II; 95% confidence intervals for SMR were calculated according to the ANZICS APD methodology.¹⁶

Results

Over the 10-year period 1994–2003, the ANZICS APD recorded 356 455 patients aged 16 years or over from 125 ICUs. Of these patients, 332 009 (93.1%) had a recorded hospital and ICU source of admission and recorded outcome and were not admitted from a chronic care facility.

The 125 ICUs that contributed data were classified as tertiary (47.9% of admissions), metropolitan (20.9%), private (16.7%) and rural/regional ICU (14.5%). Of the 125, 14% contributed to each year, and 10% for any one year, of the 10-year study period. The average contribution was 5.5 years. No Tasmanian ICUs contributed in 1994, and no New Zealand ICUs in 2000.

Epidemiology

Patients who were transferred from another acute hospital had more severe illness, longer ICU and hospital stay, and higher mortality and SMR than patients admitted to hospital from home (Table 1). Patients admitted to the ICU from a ward or another hospital had the highest APACHE II scores, SMR and hospital mortality. Patients admitted to the ICU after IHT were younger than patients admitted from the

Table 2. The 20 most common APACHE II diagnostic categories at the time of ICU admission, as a percentage of all patients whose hospital source of admission was another hospital, by ICU type*

APACHE II diagnostic category	Metropolitan	Private	Rural/regional	Tertiary	Total
Sepsis	8.69	5.66	7.46	6.86	7.09
Gastrointestinal other	5.88	4.90	7.06	5.01	5.43
Drug overdose	9.58	3.62	5.39	4.29	5.13
Respiratory infection	5.81	4.55	5.30	4.29	4.67
Respiratory other	4.42	4.50	4.47	4.43	4.44
Head-only trauma	2.35	1.42	2.60	5.53	4.26
Intracranial haemorrhage	2.14	2.66	1.97	5.20	4.05
Neurological other	3.45	3.40	2.93	4.10	3.77
Cardiovascular other	2.35	5.29	6.21	3.17	3.71
Post-cardiac arrest	4.92	2.92	3.46	3.57	3.68
Multiple trauma	2.20	1.58	3.04	4.47	3.66
Postoperative gastrointestinal perforation/obstruction	4.64	3.17	6.22	2.46	3.39
Postoperative intracranial haemorrhage	1.10	2.00	0.30	3.95	2.82
Renal other	3.60	2.24	3.66	2.43	2.76
Postoperative peripheral vascular disease	2.76	2.22	2.18	2.84	2.67
Chronic obstructive pulmonary disease	4.42	1.45	2.39	2.08	2.39
Postoperative multiple trauma	2.37	1.54	2.68	2.36	2.33
Coronary artery disease	1.62	2.70	6.36	0.95	2.01
Cardiogenic shock	1.86	1.80	1.26	2.14	1.94
Seizure disorder	2.02	1.17	1.67	1.80	1.75

* $P < 0.001$ across all ICU types and diagnostic categories listed.

ward and otherwise similar, but were more likely to be intubated.

Most IHT patients were admitted directly to the ICU (44.2%), while 25.8% were admitted via the operating theatre, 17.2% via the emergency department (ED), 11.6% via a ward and 1.3% via another ICU within the same hospital. IHT patients were also more likely to be discharged to another hospital (Table 1). This pattern varied according to ICU type. Tertiary ICUs had the highest proportion of patients whose hospital and ICU source of admission was another hospital (23.3% and 10.2%, respectively), followed by rural/regional (19.4% and 5.9%), metropolitan (12% and 6.7%) and private (10.7% and 5.1%) ($P < 0.001$). Patients from a rural/regional ICU were most likely to be discharged to another hospital ICU (6.1%) or another hospital (15.5%) compared with patients from a tertiary ICU (0.7% and 8.5%), a metropolitan ICU (1.9% and 8.2%) or a private ICU (1.2% and 4.6%) ($P < 0.001$).

Table 2 shows the most common diagnostic categories for patients whose hospital source of admission was another hospital, by ICU type. Sepsis and gastrointestinal disorders were common to all ICU types, with trauma being more common in tertiary ICUs, overdose in metropolitan ICUs, and coronary artery disease in rural/regional ICUs.

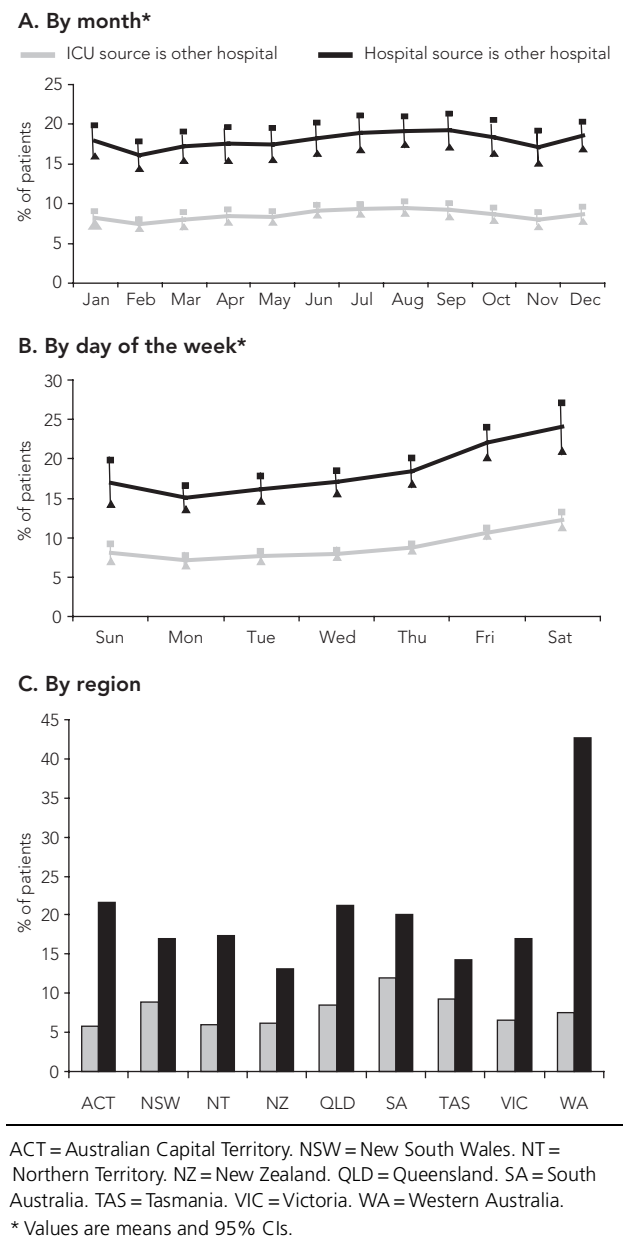
Impact of IHT patients

The proportion of admissions to an ICU after IHT showed an inverse relationship with ICU admissions from the operating theatre ($\beta = -0.78$; 95% CI, -1.46 to -0.1 ; $P = 0.03$), and the ED ($\beta = -0.63$; 95% CI, -1.26 to -0.01 ; $P = 0.047$) and with admissions after elective surgery ($\beta = -1.47$; 95% CI, -2.19 to -0.74 ; $P < 0.001$), but a positive relationship with admissions from the ward ($\beta = 0.37$; 95% CI, 0.18 to 0.57 ; $P < 0.001$). The proportion of ICU admissions from the ED was also inversely related to admissions from the operating theatre ($\beta = -0.96$; 95% CI, -1.06 to -0.87 ; $P < 0.001$).

Trends for IHT patients

The proportion of IHT patients increased significantly over the 10-year study period ($R^2 = 0.567$, $P = 0.01$), but only for rural/regional and tertiary ICUs ($R^2 = 0.639$, $P = 0.006$; and $R^2 = 0.703$, $P = 0.002$; respectively). The proportion of patients admitted directly to an ICU from another hospital remained virtually unchanged ($R^2 = 0.042$, $P = 0.35$), regardless of the type of ICU. Of the diagnostic categories for IHT patients, only sepsis ($R^2 = 0.877$, $P < 0.001$) and respiratory infection ($R^2 = 0.679$, $P = 0.003$) increased significantly over the study period, while gastrointestinal disorders decreased ($R^2 = 0.569$, $P = 0.01$). This pattern was similar for IHT patients admitted directly to an ICU, with the addition of an

Figure 1. Percentage of patients whose source of admission to the ICU or hospital was another hospital



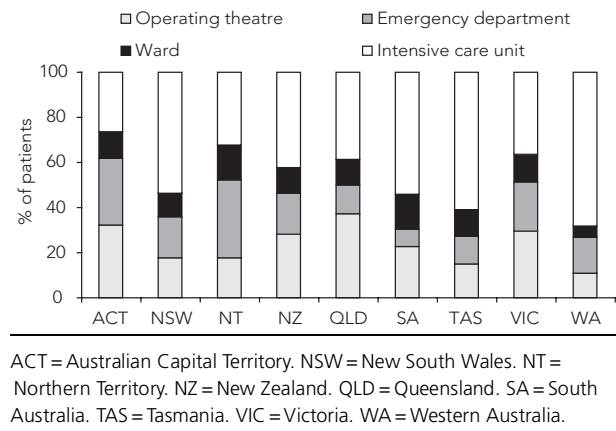
increase in renal disorders ($R^2=0.817$, $P<0.001$) and a decrease in trauma ($R^2=0.612$, $P=0.007$).

The incidence of IHTs was greatest during the months July to October (Figure 1A) and on the days Friday and Saturday (Figure 1B).

Geographic variations

There were regional differences in the pattern of IHT (Figure 1C), the disposition of patients on admission to hospital

Figure 2. Disposition of patients after transfer from another hospital, by region



(Figure 2) and the predominance of diagnostic categories (Table 3 and Table 4). Western Australia had the highest proportion of admissions whose hospital admission source was another hospital, and South Australia had the highest proportion whose ICU source was another hospital. Sepsis was more common in WA, New South Wales, SA, the Northern Territory and the Australian Capital Territory, intracranial haemorrhage and head injury in New Zealand, Tasmania and NT, and overdose in Victoria and Queensland. Head trauma, sepsis and intracranial haemorrhage were the most common diagnoses of intubated patients admitted directly to a tertiary ICU after IHT (Table 4).

The proportion of patients whose hospital source of admission was another hospital increased over the study period for all regions, but the increase was statistically significant only in NSW ($R^2=0.767$, $P=0.02$), SA ($R^2=0.933$, $P=0.03$), Tasmania ($R^2=0.940$, $P=0.01$) and WA ($R^2=0.675$, $P=0.045$).

Discussion

We found that adults admitted to an Australian or NZ ICU after IHT have more severe illness, longer hospital and ICU stay, and higher SMR, hospital mortality and likelihood of discharge to another hospital compared with patients admitted to an ICU from other sources, with the exception of those from a ward. Over the 10-year study period, the proportion of such patients increased significantly for tertiary and rural/regional ICUs and for the common diagnostic categories of sepsis and respiratory infection.

For receiving hospitals, IHT patients are likely to place a high burden on resources, based on their greater severity of illness, longer stay and likelihood of intubation within the first 24 hours of ICU admission. Generally, most Australian and NZ ICUs operate as “closed” units, with admissions

Table 3. The 10 most common APACHE II diagnostic categories, as a percentage of all patients whose ICU source of admission was another hospital, by region*

Diagnostic category	ACT	NSW	NT	NZ	QLD	SA	TAS	VIC	WA	Total
Sepsis	10.69	9.07	24.39	8.32	7.39	9.34	9.00	7.92	11.13	8.84
Drug overdose	5.34	8.11	1.63	2.14	9.95	8.35	1.36	9.97	9.81	8.46
Respiratory infection	7.63	6.21	7.59	3.78	5.51	8.03	5.06	6.52	7.83	6.39
Intracranial, subdural or subarachnoid haemorrhage	10.11	5.43	4.07	12.61	6.74	5.80	11.71	3.97	5.52	5.85
Head-only trauma	5.34	4.71	3.79	14.00	8.97	6.35	10.23	2.52	2.31	5.52
Gastrointestinal other	6.68	5.87	4.34	6.56	4.66	5.74	5.80	5.92	1.32	5.46
Post-cardiac arrest	8.02	6.07	4.07	3.91	4.49	5.97	1.48	5.60	4.12	5.40
Multiple trauma	2.29	3.79	2.98	6.81	7.56	4.64	2.34	4.60	3.71	4.76
Neurological other	4.58	5.50	4.61	6.43	4.25	4.44	4.93	3.76	3.22	4.64
Respiratory other	2.67	4.41	5.96	4.54	4.19	3.25	3.70	3.98	5.19	4.14

ACT = Australian Capital Territory. NSW = New South Wales. NT = Northern Territory. NZ = New Zealand. QLD = Queensland. SA = South Australia. TAS = Tasmania. VIC = Victoria. WA = Western Australia. * $P < 0.001$ across all regions and listed diagnostic categories.

Table 4. The 10 most common APACHE II diagnostic categories, as a percentage of all patients whose ICU source of admission was another hospital and who were intubated, by region*

Diagnostic categories	ACT	NSW	NT [†]	NZ	QLD	SA	TAS	VIC	WA	Total
Head-only trauma	5.88	7.37	5.63	19.59	13.73	7.59	19.29	4.85	3.12	8.76
Sepsis	11.03	8.79	27.71	7.74	7.20	8.94	9.32	7.39	7.02	8.32
intracranial haemorrhage	10.54	7.74	3.90	18.91	7.15	6.66	20.58	9.94	4.09	8.32
Drug overdose	6.13	7.22	2.60	1.59	10.44	9.78	0.64	6.06	12.28	8.00
Post-cardiac arrest	10.29	6.89	6.06	4.10	5.49	7.05	2.25	5.58	4.29	6.29
Respiratory infection	8.09	6.42	8.23	4.56	5.82	7.36	5.47	3.82	6.43	6.13
Multiple trauma	1.23	4.75	3.03	6.61	10.11	5.08	3.22	8.18	1.56	6.04
Neurological other	4.90	6.05	5.19	7.06	5.20	4.39	5.14	5.52	3.90	5.38
Gastrointestinal other	4.90	6.05	3.03	5.24	3.24	4.97	4.18	5.64	2.14	5.00
Respiratory other	2.94	4.00	4.76	4.33	3.49	2.62	2.57	4.00	6.82	3.68

* $P < 0.001$ across all regions. † For the NT, hospital type was metropolitan.

being triaged by qualified intensivists who are responsible for the allocation of the limited, locally available ICU resources. Requests for IHT directly to an ICU can be triaged and planned before the patient's arrival. Our study suggests that IHT patients are placing an increasing and unexpected demand on ICU services through bypassing the typical opportunity for ICU triage and being admitted indirectly to the ICU, via the operating theatre, ED or ward. The urgency of these admissions reduces the opportunity to plan and apportion fixed ICU resources, and may explain the inverse relationship identified in this study between ICU admissions after IHT and elective and operating theatre ICU admissions, and the positive relationship with ward ICU admissions.

These events have the greatest impact for tertiary and rural/regional ICUs, which had a high proportion of IHT

patients. Such hospitals are likely to be acting as regional "hubs", providing a relatively higher level of service, with obligations to receive patients referred to them. This may reduce their ability to deal with elective and surgical caseloads.

Rural/regional hospitals were most likely to receive patients from, and discharge them to, another hospital. Potentially, these patients would be exposed to additional risk from yet another IHT. Tertiary ICUs had a similar high proportion of IHTs, but were least likely to discharge patients directly to another hospital. The study was limited by lack of data on the indication for IHT.

Sepsis was a common diagnosis among IHT patients and increased in incidence over the study period. This is consistent with the findings of another large national dataset,

from the United Kingdom.¹⁷ Respiratory infection and renal disorders also increased, while gastrointestinal disorders and trauma decreased. The data were insufficient to explain these findings. The decrease in trauma admissions direct to an ICU after IHT may be explained by increased adherence to trauma bypass protocols and direct admissions to major trauma centres.¹⁸ Rural/regional ICUs had a higher proportion of patients with coronary artery disease, reflecting the fact that they often combine a general ICU and a coronary care unit.

Patients with a diagnosis of overdose or cardiac arrest would usually not be expected to require specialised intensive care or other medical services, yet were a common category of IHT to a tertiary ICU. This finding is likely to reflect insufficient intensive care resources in the referring hospital as the sole indication for transfer.¹⁴ Under such circumstances, patients are exposed to the significant risks of IHT^{19,20} for possibly little additional direct patient benefit. Resource and health policy variations across the Australian states and territories and for NZ,²¹ as well as geography, population density and the presence and capacity of local patient transport (retrieval) services may account for the regional variations noted in this study. It is also possible that a proportion of these patients were from hospitals that lacked an ICU, as data about the referring hospital and indication for transfer were not available. The breadth of the observed diagnostic categories among IHT patients suggests a complex mixture of indications for IHT, which require future evaluation.

IHTs peaked during the winter months of July to October and on the days Friday and Saturday. The predominance of IHT patients, with their associated more severe illness, during winter and on a weekend may reflect constraints on system capacity. It has implications for the capacity of receiving ICU and retrieval services to provide timely review by senior medical staff. Time to first contact of a critically ill patient with a senior critical care physician may be directly related to patient morbidity.²²

Although IHT may contribute to a positive patient outcome in some cases,^{23,24} our study supports previous findings that IHT patients overall have a higher than expected mortality²⁵ and longer hospital stay.^{14,25} The explanations are likely to be complex and may relate to adverse effects during IHT,¹⁹ timeliness of referral and transportation, level of patient escort,²⁶ efficacy of treatment at the referring hospital or a failure of ICU triage at the time of referral. It is likely that the risks and benefits of IHT are not equivalent across all diagnostic groups. In contrast, other studies have shown a benefit from centralisation of certain health services.¹⁻⁶ However, those studies were confined to a single diagnosis, and the contribution of IHT patients to the study

outcome was not clearly identified. There is evidence that the proportion of IHTs can affect an ICU's measures of quality,²⁷ but the impact of IHT on the measurable outcomes of centralisation of health services across a range of specific diagnoses remains ill defined and requires further investigation.

The nature, frequency, disposition after hospital admission and 10-year trend of IHT varied across the regions examined. IHT has the potential to be used as a quality measure for delivery of critical care and other medical services within a particular region. For example, rural/regional hospitals had a rate of IHT comparable to that of tertiary hospitals, but a higher rate of discharges to another hospital. Tertiary ICUs in NZ, Queensland and Tasmania had a relatively higher proportion of direct admissions of IHT patients with head trauma compared with those in Victoria and WA. IHT could also be used to monitor the impact of changes to access to regional medical services over time. It is difficult to foresee the circumstances in which IHT would never be needed, especially within the diverse geopolitical regions of the Australian states and territories and NZ. Indeed, high-level IHT services should be seen as essential to any centralisation of health care resources and expertise.

This study relied on the strength of a large, standardised bi-national dataset of ICU admissions from multiple, unselected, centres throughout Australia and NZ that voluntarily contribute data. In 2003, the dataset captured 78% and 37% of admissions to Australian and NZ ICUs, respectively. The dataset is of high quality based on established criteria.¹⁵ Weaknesses of this study were that it was retrospective; it did not include all Australian and NZ ICUs and thus the full potential pool of IHT patients, so that patient demographics, source of admission and casemix of the study population may not have been representative of the true ICU patient population; and no information was available on the indication for IHT or physical process of transport. The findings also cannot be used to establish causal relationships. Ideally, such datasets would have added value if they included unique patient identifiers allowing tracking of individual patients, and if they were linked to other datasets (such as trauma datasets).

In summary, this study based on a large binational dataset found that ICU patients admitted after IHT have a high severity of illness, hospital mortality and hospital stay. IHT patients may adversely affect ICU capacity for elective and operating theatre admissions. Regional differences and temporal trends have implications for planning of ICU resources and require ongoing surveillance. Future studies are needed to identify the causal effects of the different factors involved in the referral and transport process.

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