Characteristics and outcomes of patients reviewed by intensive care unit liaison nurses in Australia: a prospective multicentre study

The Australian Intensive Care Unit Liaison Nurse Investigator Forum

Recently there has been an increased focus on the recognition of, and response to deteriorating patients in Australian hospitals.[1,2] One strategy to address this need is the use of intensive care unit liaison nurses (ICU LNs), also known as ICU nurse consultants, who are present in at least 31 Australian hospitals.[3] There is considerable literature on the use of rapid response teams (RRTs) in Australia, but much less is known about ICU LN services or the patients they review.[4-6]

A recent systematic review of programs that provide transition services for patients discharged from the ICU to a general ward revealed that most studies occurred in the United Kingdom, Australia and New Zealand, and found that these programs were associated with a reduced risk of ICU readmission.[7] ICU LN services are beginning to emerge in other countries. For example, an evaluation of the ICU LN role in Argentina found that 95.3% of patients seen by the ICU LN were patients discharged from the ICU, with the remaining 4.7% being ward patients with complex needs.[8]

ICU LNs appear to function in both reactive and pre-emptive roles. They review patients who have already deteriorated and are referred directly via ward staff or via the RRT, and they also review and follow up at-risk patients, particularly those discharged from the ICU. We recently reported on the uptake and pattern of case referrals for 17 Australian ICU LN services and showed that ICU discharges, post-RRT review, and de novo ward referrals comprised 59.3%, 21.7% and 19.0% of reviews, respectively.[9] A single-centre study examined in detail the characteristics and outcomes of patients subject to ICU LN review.[10] It reported a similar breakdown of referral sources, and also reported that patients reviewed by the ICU LN service had an inhospital mortality of 8.9% and a median overall hospital length of stay of 13 days. The generalisability of these findings to other hospitals is not known.

Our aim was to provide further clarification of the ICU LN case load and the characteristics of the patients reviewed by Australian ICU LNs. We conducted a prospective observational study to assess the characteristics and outcomes of patients screened by ICU LN services in 20 Australian hospitals. We report here the number and source of referrals as well as the number of reviews performed for each patient. We also report the baseline characteristics of

ABSTRACT

Background: Intensive care unit liaison nurse (ICU LN) services are one strategy to manage deteriorating hospital patients. Studies on the characteristics and outcomes of patients reviewed by ICU LNs have been from single centres and surveys.

Objectives and methods: To conduct a 20-hospital, prospective observational study on the characteristics and outcomes of patients reviewed by Australian ICU LNs over 2 months.

Participants and outcome measures: All patients screened by ICU LNs over the study period were included. Details included the source of initial review, patient demographics and initial physiological parameters, case load, interventions and patient outcome.

Results: Only two hospitals provided a 24-hour, 7-day service, and in 14 hospitals, an ICU LN participated in the rapid response team (RRT). There were 3799 patients screened (54.6% men, mean age 62.9 years [SD, 19.4 years]), of whom 1330 (35%) had no interventions (were screened only). The remaining 2469 patients received interventions; 978 (39.6%) were reviewed once, and 1491 (60.4%) were reviewed multiple times. The three commonest reasons for screening patients were after ICU discharge (1734 [45.6%]), as part of the RRT review (914 [24.1%]), or for a ward patient review meeting with a "worried" criterion (412 [10.8%]). Patients who did not receive interventions were younger, more likely to be surgical patients, less likely to have dementia, less likely to be seen during an RRT review, had more favourable vital signs and were less likely to be discharged to a nursing home or die in hospital. The commonest interventions included ordering a diagnostic test, administration of medication, initiating an interprofessional referral and increasing limitations of therapy. The inhospital mortality was 10.2% overall, and 4.6% in patients who were screened but did not receive any interventions. Several predictors of inhospital mortality were identified.

Conclusions: Most ICU LN reviews occur after ICU discharge or in association with an RRT review. The inhospital mortality of ICU LN-reviewed patients is high (about 10%). ICU LNs effectively screen patients and often participate in end-of-life care planning.

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the patients who were reviewed and received interventions, compared with those who did not receive interventions. Finally, we report on patient outcomes, including status at discharge from the ICU LN case load, as well as discharge destination and survival at hospital discharge.

Methods

Ethics approval and funding

We obtained approval for our study from the human research ethics committees (HRECs) of all participating hospitals (see approval numbers in Appendix). The study was funded by a project grant from the Intensive Care Foundation in October 2010.

Study design and hospital recruitment

We conducted a 2-month prospective observational study. Expressions of interest to participate in the study were sought via an email sent to all members of the Australian College of Critical Care Nurses ICU LN special interest group. After 28 initial expressions of interest, 20 sites enrolled in the study. Site investigators were required to sign an investigator protocol agreement. Of the 20 participating hospitals, 17 started data collection on 23 March 2012, with the last hospital starting on 31 May 2012.

Study infrastructure and coordination

The study was conceived in April 2010 as part of the Australian ICU LN forum, and it was overseen and coordinated by a management and writing committee (see Appendix). The committee developed and promulgated the study protocol, developed a paper-based scannable case report form (CRF) and data dictionary, prospectively devised a statistical analysis plan, drafted and revised manuscripts and sent interim reports to sites in compliance with local HREC requirements.

The chief investigator assisted with completion of ethics permission submissions, responded to all data dictionary and case report queries, and helped in auditing data with site verifications before electronic scanning of CRFs. When data variables were significantly outlying, we resolved the data queries by cross-referencing between the spreadsheet generated by the automated scanning process and the handwritten text on the CRF.

Case report forms

The CRFs were adapted from the International Liaison Committee on Resuscitation guidelines.[11] This framework was used for two reasons. First, there is currently no consensus on what a minimum dataset for ICU LN services should be. Second, a substantial proportion of patients reviewed by ICU LN services are referred during or shortly after RRT review.

Minor changes were made to the CRF after piloting them in three hospitals. Investigators recorded data corresponding to a data review episode, and each data element had tick boxes for categorical responses. Each episode had its own unique identifier. Patients were followed up until they were perceived to be well enough to not need further follow-up, at which time they were discharged from the service. The patient may have been readmitted to the service if they returned to the ICU, experienced subsequent deterioration, or underwent a subsequent hospital readmission. When a patient was discharged from the service and readmitted to the service at a later date, this was treated as a separate review episode, and the subsequent reviews were assigned a new unique identifier. After error checking and data query resolution by investigators at participating sites, completed CRFs were scanned and automatically entered into an electronic database. A separate patient log was maintained at all participating hospitals to permit re-identification for data queries.

Data collection

We collected data on participating hospitals, including total inpatient beds, ICU beds, high dependency beds and coronary care beds. Information on the composition and structure of the ICU LN service, including the days and hours of operation, and whether they were part of the cardiac arrest team, medical emergency team, rapid response team or a tiered response, was also collected.

We collected details on baseline patient demographics, including sex, age, and the presence of a limited number of comorbidities (dementia, liver disease, cardiovascular disease, respiratory disease, renal disease, compromised immunity and diabetes). Additional details included the date of hospital admission and, where appropriate, the date and time of ICU admission. We also collected details of the parent unit (medical, surgical, obstetric, paediatric or other) and the location of initial review.

At the initial review, we recorded the primary reason for ICU LN review and values for the following vital signs: respiratory rate, oxygen saturation, systolic blood pressure, pulse, temperature and level of consciousness (using the "alert, voice, pain, unresponsive" scale), presence of pain, whether the estimated urine output was less than 30 mL/hour and if the patient was on intravenous therapy.

It is usual practice for ICU LNs to review patients to ascertain whether they need regular follow-up and/or intervention, so patients may be screened, but not formally entered into the ICU LN case load. Patients were deemed to have had "screening only" if they had only one review and received no interventions during this review. Details of

patient reviews included the location and date, and the time the review started and finished. A detailed list of interventions was also recorded during each review, including implementation of limitations of medical treatment, referrals to hospital staff, medication administration, conduct of investigations, and a list of nonmedication-related therapies. The extent and scope of ICU LN practice will be detailed in a separate publication.

We also recorded the patient's clinical status at the time of discharge from the ICU LN case load, including the date and time of discharge from ICU LN case load, vital status, vital signs, and location of ongoing care (ie, if the patient remained on the ward, was transferred to the ICU, high dependency unit, coronary care unit, another area for an intervention or another acute care hospital, or "other").

Finally, we recorded the patient status at hospital discharge, including vital status, discharge destination (ie, if they were still in hospital, going home, going to an aged care facility or were being transferred to another hospital), and the date of death or discharge from an acute care hospital.

Statistical analysis

We initially assessed all data for normality. Group comparisons were made using the χ^2 test for equal proportion (with results reported as *n* and percentages); student *t* test or analysis of variance for normally distributed data (with results reported as means and standard deviations); and the Wilcoxon rank-sum or Kruskal–Wallis tests otherwise (with results reported as medians and interquartile ranges [IQRs]). We constructed a multivariable model for the prediction of hospital mortality using logistic regression and reported as odds ratios with 95% CIs. This model was developed using stepwise selection and backwards elimination procedures before undergoing a final assessment for clinical and biological plausibility. We considered all variables with less than 5% of missing data for model inclusion. All analysis was conducted using SAS, version 9.3 (SAS Institute) and a two-sided *P* of 0.05 was considered to be statistically significant.

Results

Participating hospitals and hours of ICU LN operation

Data on bed numbers and admissions were available in 18 of the 20 participating hospitals. The median number of available ICU beds was 10.0 (IQR, 6.0–18.8 beds) and median total critical care beds was 13.0 (IQR, 7.8–20.3 beds). The median number of hospital beds for 2012 was 379 (IQR, 171–541 beds). The median number of ICU admissions per hospital for 2012 was 1015.0 (IQR, 649.3–2062.3 admissions) and median annual hospital admissions was 26 695.5 (IQR, 14 338–57 204).

Only two hospitals offered an ICU LN service 24 hours per day, 7 days per week. Among the 20 hospitals, there were 100 possible weekday shifts (20 x 5 week days), and only three shifts (3%) did not have a service provided. In contrast, among the 40 (20 x 2) possible weekend shifts, 12 shifts (30%) did not have a rostered ICU LN. On the days when a service was provided, the median shift duration was 8.5 hours (IQR, 8.5–10.5 hours) on weekdays, and 10.5 hours (IQR, 8.5–10.5 hours) on the weekend. Among the 20 hospitals, 13 ICU LN services participated in the cardiac arrest team and 14 participated in the RRT.

Overall cohort

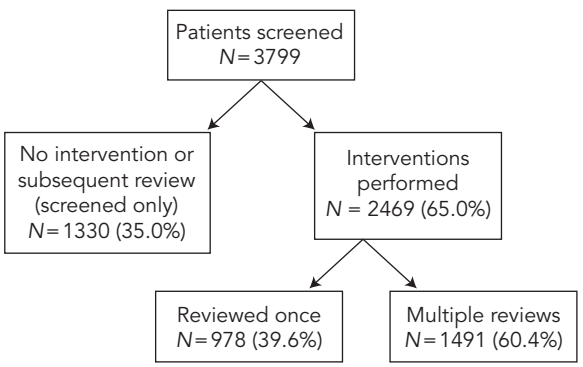
Over the study period, 3799 patients were initially screened by the 20 ICU LN services which had adequate data for analysis (Figure 1). There was a total of 8814 episodic review CRFs submitted, among which 398 (4.5%) were omitted from analysis due to sub-optimal data quality, either due to the absence of the unique identifier (making it impossible to link with outcome data), or due to an absence of outcome data.

Among the 3799 patients, 54.6% were men, and the mean age was 62.9 years (SD, 19.4 years). Most patients were admitted under a surgical unit (1895 [49.9%]) or medical unit (1817 [47.8%]), and a minority were admitted under a paediatric (40 [1.1%]), obstetric (24 [0.6%]) or other (22 [0.6%]) unit. Most patients were initially reviewed in the ICU (2557 [67.3%]) or a general ward (857 [22.6%]) (Table 1).

Referrals and primary reasons for initial review

Among the 3799 patients screened, 1330 (35.0%) had no interventions and did not have ongoing follow-up (were

Figure 1. Review path of patients of intensive care unit liaison nurse services in 20 Australian hospitals*



* "Screened only" patients were seen only once and did not receive an intervention.

Table 1. Patient demographics at initial review by intensive care unit liaison nurse service

Variable	Overall cohort (*N* = 3799)	No intervention; screened only* (*N* = 1330)	Intervention; single review (*N* = 978)	Intervention; multiple reviews (*N* = 1491)	*P*†
Mean age, years (SD)	62.9 (19.4)	60.6 (19.3)	64.3 (19.8)	63.9 (19.0)	< 0.0001
Parent unit, *n* (%)					
Medical	1817 (47.8%)	577 (43.4%)	536 (54.8%)	704 (47.2%)	< 0.0001
Surgical	1895 (49.9%)	726 (54.6%)	406 (41.5%)	763 (51.2%)	< 0.0001
Obstetric	24 (0.6%)	4 (0.3%)	8 (0.8%)	12 (0.8%)	0.17
Paediatric	40 (1.1%)	15 (1.1%)	16 (1.6%)	9 (0.6%)	0.046
Other	22 (0.6%)	8 (0.6%)	12 (1.2%)	2 (0.1%)	0.002
Male, *n* (%)	2076 (54.6%)	767 (57.7%)	507 (51.8%)	802 (53.8%)	0.015
Place of initial review, *n* (%)					
Ward	857 (22.6%)	414 (31.1%)	55 (5.6%)	388 (26.0%)	< 0.0001
Intensive care unit	2557 (67.3%)	796 (59.8%)	801 (81.9%)	960 (64.4%)	< 0.0001
High dependency unit	230 (6.1%)	87 (6.5%)	45 (4.6%)	98 (6.6%)	0.09
Emergency department	23 (0.6%)	2 (0.15%)	5 (0.5%)	16 (1.1%)	0.006
Operating room	15 (0.4%)	1 (0.1%)	7 (0.7%)	7 (0.5%)	0.04
Procedural unit	24 (0.6%)	3 (0.2%)	16 (1.6%)	5 (0.4%)	< 0.0001
Outpatient unit	41 (1.1%)	11 (0.8%)	28 (2.9%)	2 (0.1%)	< 0.0001
Other	52 (1.4%)	16 (1.2%)	21 (2.1%)	15 (1.0%)	0.047
Comorbidities, *n* (%)					
Dementia	207 (5.4%)	54 (4.1%)	64 (6.5%)	89 (6.0%)	0.02
Liver disease	209 (5.5%)	60 (4.5%)	57 (5.8%)	92 (6.2%)	0.14
Cardiovascular disease	1583 (41.7%)	586 (44.1%)	398 (40.7%)	599 (40.2%)	0.09
Respiratory disease	845 (22.2%)	282 (21.2%)	203 (20.8%)	360 (24.1%)	0.07
Renal disease	396 (10.4%)	136 (10.2%)	108 (11.0%)	152 (10.2%)	0.76
Compromised immunity	280 (7.4%)	99 (7.4%)	77 (7.9%)	104 (7.0%)	0.70
Diabetes mellitus	646 (17.0%)	259 (19.5%)	149 (15.2%)	238 (16.0%)	0.01

* "Screened only" patients were reviewed but did not receive any interventions or subsequent reviews. † Comparison across the three categories (no intervention, interventions reviewed once, interventions with multiple reviews).

"screened only"). Among the 2469 patients (65.0%) who received an intervention, 978 (39.6%) were reviewed only once, and 1491 (60.4%) were reviewed more than once (Figure 1).

The five most common reasons for initial ICU LN referral were follow-up after critical care unit discharge (1734 [45.6%]); as part of the RRT review (914 [24.1%]); ward patient review when a staff member was worried about the patient (412 [10.8%]); follow-up after RRT review (294 [7.7%]); and ward patient review when there were abnormal vital signs (188 [4.9%]) (Table 2).

Characteristics and outcomes of patients

There were statistically significant and important clinical differences in the baseline characteristics and outcomes of the 1330 patients who had no interventions (were screened only) compared with patients who received interventions (Table 1 and Table 2). Patients who did not receive interventions were younger, more likely to be admitted under a surgical unit, less likely to have dementia and less likely to be seen during or after RRT review (Table 1). Patients who did not receive interventions had more favourable vital signs and levels of consciousness, a lower frequency of oliguria and were less likely to be receiving oxygen and intravenous therapy (Table 2).

Compared with patients who received interventions, patients who had no interventions were less likely to be discharged to a nursing home or die in hospital. The median hospital length of stay for patients reviewed by ICU LNs multiple times was significantly longer than for those reviewed only once (Table 2).

Case loads

We initially screened a total of 3799 patients, and the number of patients screened in each hospital varied from 48 to 447 over the 2-month period. Over that period, there

Table 2. Referral reason, initial vital signs and outcomes of intensive care unit liaison nurse reviews

Variable	Overall cohort (*N* = 3799)	No intervention; screened only (*N* = 1330)	Interventions; single review (*N* = 978)	Interventions; multiple reviews (*N* = 1491)	*P**
Referral reason, *n* (%)					
Post-critical care follow up	1734 (45.6%)	982 (73.8%)	211 (21.6%)	541 (36.3%)	< 0.0001
Ward staff worried	412 (10.8%)	55 (4.1%)	124 (12.7%)	233 (15.6%)	< 0.0001
Physiological signs on ward	188 (4.9%)	17 (1.3%)	36 (3.7%)	135 (9.1%)	< 0.0001
Part of RRT/RB	914 (24.1%)	113 (8.5%)	455 (46.5%)	346 (23.2%)	< 0.0001
Follow up after RRT/RB	294 (7.7%)	112 (8.4%)	121 (12.4%)	61 (4.1%)	< 0.0001
Tracheostomy round	15 (0.4%)	1 (0.08%)	1 (0.1%)	13 (0.9%)	0.0008
TPN round	39 (1.0%)	2 (0.15%)	3 (0.3%)	34 (2.3%)	< 0.0001
Intravenous line review	24 (0.6%)	2 (0.15%)	11 (1.1%)	11 (0.7%)	0.01
Other	181 (4.8%)	47 (3.5%)	17 (1.7%)	117 (7.8%)	< 0.0001
Vital signs					
Mean RR, breaths/min (SD)	20 (6.4)	18.4 (4.1)	20.9 (8.1)	21 (6.5)	< 0.0001
Mean SpO_2, % (SD)	95.7% (6.1)	96.8% (3.7)	94.6% (8.9)	95.4% (5.3)	< 0.0001
Mean SBP, mmHg (SD)	124 (26.1)	125 (20)	121 (33.5)	124 (25.4)	< 0.0001
Mean HR, beats/min (SD)	89.1 (23.5)	84.3 (17.5)	91.5 (29.1)	91.9 (23.5)	< 0.0001
Mean temperature, °C (SD)	36.6 (1.1)	36.6 (0.6)	36.5 (1.9)	36.7 (0.8)	< 0.0003
On oxygen, *n* (%)	2264 (70.7%)	645 (60.6%)	617 (73.7%)	1002 (77.0%)	< 0.0001
Pain present, *n* (%)	492 (13.0%)	145 (10.9%)	121 (12.4%)	226 (15.2%)	0.003
Level of consciousness, *n* (%)					
Alert	2892 (76.1%)	1105 (83.1%)	663 (67.8%)	1124 (75.4%)	< 0.0001
Voice	437 (11.5%)	116 (8.7%)	152 (15.5%)	169 (11.3%)	< 0.0001
Pain	128 (3.4%)	16 (1.2%)	50 (5.1%)	62 (4.2%)	< 0.0001
Unresponsive	126 (3.3%)	11 (0.8%)	72 (7.4%)	43 (2.9%)	< 0.0001
Urine output < 30 mL/hour, *n* (%)	191 (5.0%)	35 (2.6%)	58 (5.9%)	98 (6.6%)	< 0.0001
On intravenous therapy, *n* (%)	734 (19.3%)	250 (18.8%)	179 (18.3%)	305 (20.5%)	0.35
Median hospital LOS, days (IQR)	5 (2–10)	4 (2–8)	3 (1–8)	6 (3–12)	< 0.0001
Discharged, *n* (%)					
In hospital	95 (2.8%)	25 (2.0%)	17 (2.1%)	53 (4.0%)	0.003
Home	2472 (72.5%)	973 (76.7%)	588 (72.3%)	911 (68.5%)	< 0.0001
Nursing	110 (3.2%)	38 (3.0%)	37 (4.6%)	35 (2.6%)	0.04
Other hospital	734 (21.5%)	233 (18.4%)	171 (21.0%)	330 (24.8%)	0.0003
Died	389 (10.2%)	61 (4.6%)	166 (17.0%)	162 (10.9%)	< 0.0001

RRT = rapid response team. RB = respond blue. TPN = total parental nutrition. RR = respiratory rate. SBP = systolic blood pressure. HR = heart rate. LOS = length of stay. IQR = interquartile range. * Comparison across the three categories (no intervention, interventions reviewed once, interventions with multiple reviews.

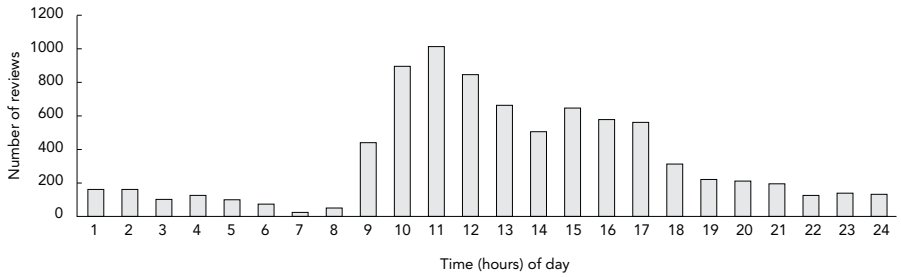
were 8814 screening and review episodes, and the number of episodes performed in each hospital varied from 94 to 1179 (median, 371.5 episodes [IQR, 173.5–531.0 episodes]). Compared with patients who were seen multiple times, those only reviewed once had lower levels of conscious state at their initial review (Table 2).

Interventions

The median duration of each ICU LN patient review was 29 minutes (IQR, 15–40 minutes) in patients who had one review, and 20 minutes (IQR, 10–30 minutes) in patients who had multiple reviews. In keeping with the hours of service, the most common time for ICU LN review was between 10 am and 12 pm (Figure 2), and reviews were less common out of hours (Figure 2) and on the weekend (Figure 3).

In descending order, the most common interventions included ordering a diagnostic test, administration of a medication and initiating an interprofessional referral (Table 3). In addition, patients reviewed only once were subject to a high level of treatment limitations (125/978 [12.8%]).

Figure 2. Distribution of intensive care unit liaison nurse review, by time of day



Clinical status at discharge from ICU LN care

At the time of discharge from the ICU LN workload, patients reviewed only once were more likely to be in the ICU than for patients subject to multiple reviews. In addition, patients reviewed only once tended to have more deranged levels of vital signs and a lower level of consciousness (Table 4).

Predictors of inhospital mortality

The overall inhospital mortality for the 3799 patients was 10.2%, and in patients who were screened but had no interventions, it was 4.6%. The mortality in patients who received interventions but were seen only once was 17.0% and for patients subject to multiple reviews, it was 10.9%.

On multiple variable logistic regression analysis, several variables were shown to be associated with inhospital mortality (Table 5). These included blood pressure, respiratory rate, conscious state, Sao_2 on initial review, patient age, and the presence (at baseline) of respiratory or renal comorbidities or immune suppression.

Discussion

Major findings

We conducted a 2-month, multicentre, prospective, observational study of the characteristics and outcomes of patients reviewed by ICU LN services in Australia. We found that only two services operated 24 hours per day and 7 days per week, and that almost one-third of weekend shifts were not staffed. We have shown that ICU LNs are effective at screening patients who do not need ongoing review, and have confirmed previous findings of single-centre studies and surveys regarding the types of patients reviewed.

Comparisons with previous studies

Elliot and colleagues have previously presented data on the scope of practice of ICU LN services in Australia, in which they found that 31of 113 hospitals (27%) which had an ICU operated an ICU LN service, and in 17 of 25 instances when there was also an RRT (68%), the ICU LN participated as an RRT responder.[3]

We show that ICU LNs screen but do not review about one-third of the patients we initially reviewed. This finding is similar to that of McIntyre and colleagues, who found that 943 of 3009 patients were screened but not reviewed after ICU discharge.[10] Importantly, patients who were screened but not followed subsequently had an overall inhospital mortality less than half that of patients receiving multiple reviews, and one-third that of patients subject to

Figure 3. Distribution of intensive care unit liaison nurse review, by day of week

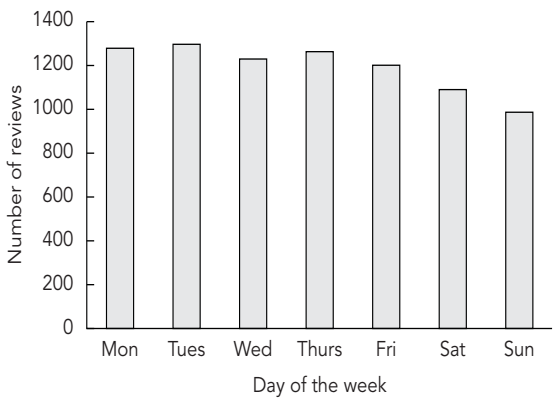


Table 3. Overview of interventions provided during intensive care unit liaison nurse review

Variable	Interventions; reviewed once	Interventions; multiple reviews
Patients, *N*	978	1491
Total reviews, *N*	978	6108
Median review duration, min (IQR)	29 (15–40)	20 (10–30)
No intervention, *N* (%)	0	2339 (38.3%)
Nonmedication therapy, *N*	1840	6875
Diagnostic test, *N*	1546	3357
Medication, *N*	628	1908
Referral, *N*	273	803
Treatment limitation, *N*	125	186

IQR = interquartile range.

Table 4. Patient clinical status at time of discharge from ICU LN workload

Variable, *n* (%)	Overall cohort (*N* = 3799)	No interventions; screened only (*N* = 1330)	Interventions; reviewed once (*N* = 978)	Interventions; multiple reviews (*N* = 1491)	*P**
Location if alive					
Ward	3324 (87.5%)	1254 (94.3%)	721 (73.7%)	1349 (90.5%)	< 0.0001
Intensive care unit	229 (6.0%)	23 (1.7%)	132 (13.5%)	74 (5.0%)	< 0.0001
High dependency unit	11 (0.3%)	2 (0.15%)	4 (0.4%)	5 (0.3%)	0.48
Coronary care unit	32 (0.8%)	4 (0.3%)	18 (1.8%)	10 (0.7%)	0.0002
Other area	31 (0.8%)	3 (0.2%)	26 (2.7%)	2 (0.1%)	< 0.0001
Other hospital	33 (0.9%)	6 (0.5%)	9 (0.9%)	18 (1.2%)	0.10
Other	95 (2.5%)	30 (2.3%)	46 (4.7%)	19 (1.3%)	< 0.0001
Vital signs					
Respiratory rate	19.1 (5.0%)	18.1 (3.6%)	20.1 (6.6%)	19.4 (4.8%)	< 0.0001
SpO_2	96.4 (3.2%)	96.7 (2.2%)	96.3 (3.3%)	96 (3.9%)	< 0.0001
Systolic blood pressure	125 (20.8%)	126 (18.1%)	123 (25.2%)	126 (19.8%)	0.001
Heart rate	85.5 (18.2%)	83.3 (15.6%)	88.9 (22.5%)	85.4 (17.0%)	< 0.0001
Temperature	36.5 (0.9%)	36.5 (0.5%)	36.5 (0.7%)	36.5 (1.2%)	0.68
Pain present	1717 (59.0%)	480 (47.6%)	558 (73.0%)	679 (59.6%)	< 0.0001
Level of consciousness					
Alert	3067 (86.8%)	1193 (92.3%)	706 (78.3%)	1168 (87.3%)	< 0.0001
Voice	326 (9.2%)	81 (6.3%)	121 (13.4%)	124 (9.3%)	< 0.0001
Pain	57 (1.6%)	9 (0.7%)	28 (3.1%)	20 (1.5%)	0.0001
Unresponsive	82 (2.3%)	9 (0.7%)	47 (5.2%)	26 (1.9%)	< 0.0001

* Comparison across the three categories (no intervention, interventions reviewed once, interventions with multiple reviews).

single review with interventions. This suggests that the screening process currently performed by the ICU LNs identifies the patients most at risk and in need of subsequent follow-up and intervention.

We found that the most common referral reasons were after ICU discharge; in the context of an RRT or respond blue review; or new ward referrals. This is consistent with the findings of our previous 17-hospital study, and the two single-centre studies of McIntyre and colleagues[10] and Alberto and colleagues.[8] Interestingly, 31.8% of initial reviews in this study occurred during or shortly after an RRT review, compared with 21.7% in our previous study.[9] This apparent increase may represent a selection bias or an increasing role of ICU LNs in the RRT in response to the introduction of national standards.

We found that the median hospital length of stay for patients reviewed by the ICU LN was 5 days, considerably shorter than the 15 days reported by McIntyre and colleagues,[10] but the overall inhospital mortality of 10.2% seen in our study is similar to the 8.9% reported by them.[10]

Our study showed that patients in the intervention group who were reviewed only once had an inhospital mortality of 17%, higher than the 10.9% observed for patients subject to multiple reviews. Patients reviewed only once had lower levels of consciousness at initial review and at the time of discharge from the ICU LN case load. More than one-eighth of patients who were reviewed only once were subject to a treatment limitation. Combined, these findings suggest that ICU LNs are participating in end-of-life care planning of patients they review. McIntyre and colleagues found that 3.8% of patients were discharged from their service due to palliation, and that this was more common in patients seen on the ward (5.6%) compared with those discharged from the ICU (3.1%).

Strengths and limitations

Our study has several strengths, including a prospective design, use of standardised scannable forms with a data dictionary, use of a prospectively defined data analysis plan and oversight by a steering committee. We have shown important findings about the characteristics and outcomes of patients reviewed by ICU LNs, and confirmed previous findings of an inhospital mortality of about 10%. This implies that the acuity of patients reviewed by ICU LN services is substantial.

Our study also has several limitations. Although it was a multicentre study, our findings represent those of only 20 of the 31 hospitals with an ICU LN service, and the study was

Table 5. Predictors of inhospital mortality for patients reviewed by intensive care unit liaison nurse service

Variable	Odds ratio for inhospital death (95% CI)	*P*
Lower initial blood pressure	0.99 (0.99–1.00)	0.0015
Higher initial respiratory rate	1.08 (1.06–1.10)	< 0.0001
Lower initial SaO_2	0.98 (0.97–0.99)	0.01
Higher initial heart rate	1.005 (1.00–1.01)	0.047
Increased age	1.04 (1.03–1.05)	< 0.0001
Initial level of consciousness		
Response to pain	2.16 (1.29–3.61)	0.003
Unresponsive	2.15 (1.24–3.76)	0.007
Comorbidities at baseline		
Any	3.50 (2.29–5.37)	< 0.0001
Respiratory	1.38 (1.04–1.83)	0.03
Renal	1.93 (1.39–2.68)	< 0.0001
Suppressed immunity	2.33 (1.53–3.54)	< 0.0001

conducted over only 2 months. Participating sites were not randomly selected, raising the potential for participation bias from the hospitals included in the study. In addition, we were not able to accommodate repeat reviews, and it is possible that patient deaths were counted twice, slightly overestimating the inhospital mortality. Co-morbidities were simple and pragmatic and did not have strictly defined definitions. We are also unable to comment on the factors contributing to the high observed inhospital mortality of about 10%. Finally, 4.5% of review forms were not included in the data analysis due to a lack of outcome data or unique identifiers.

Clinical and policy implications

We found that patients reviewed by ICU LN services have a mortality of about 10%. Despite this, only two services operated continuously, and reviews out of hours and on weekends were less frequent. These observations have important safety implications for at-risk patients. We also found that ICU LNs are effective at screening patients who need ongoing review. Most patients reviewed by ICU LNs were reviewed as part of a routine ICU review, or in the context of a deteriorating patient seen by the RRT and an environment where RRTs are widespread, embedded and widely used.[12-17] The skill sets and training requirements of staff attending these two patient groups is likely to be different. In addition, the possibility of independent practice and the legal implications of ICU LN-initiated prescriptions and test ordering needs further exploration. Finally, we have found evidence that ICU LNs participate in end-of-life care planning for a substantial proportion of the patients they review.

Future research

We intend to conduct a more detailed analysis of the interventions and scope of practice performed by the ICU LNs in these 20 hospitals. We will focus on the differences in the number and nature of patients reviewed, and variation in the tasks performed among the three major groups reviewed, ie, after ICU discharge, in the context of emergency calls, and new ward referrals.

Competing interests

None declared.

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Appendix. Intensive Care Unit Liaison Nurse Scope of Practice investigators

Writing and management committee: Anna Green (cochair, chief investigator and corresponding author), Daryl Jones (cochair), Tammie McIntyre, Carmel Taylor, Wendy Chaboyer, Michael Bailey

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Barwon Health	12/13	Nigel Bellear, Linda Falla, Matt Jackson
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Gosford Hospital (NSW)	LNR/11/CRGH/283 (CH62/6/2011-194)	Jackie Haines, Kelly Cridland
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