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The prevalence of recordings of the signs of critical conditions and emergency responses in hospital wards—the SOCCER study☆

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Abstract

Objective: To estimate the prevalence of recordings in case notes of disturbed physiological variables in adult admissions in general hospital wards.
Design and setting: Retrospective cross-sectional survey of 3160 admissions in general wards in five hospitals in a 14-day period.
Main outcome measures: Recordings of 26 potential early signs (ES) and 21 potential late signs (LS) of critical conditions. Eight late signs were classified as Liverpool Hospital Equivalent Calling Signs (LES).
Results: 54.7% admissions had at least one recording of early signs, 16.0% late signs and 6.4% LES. When ranked in order of recordings per 100 admissions, the top five ES were SpO_2 90–95% (193.7), systolic blood pressure (SBP) 80–100 mmHg (85.2), pulse rate 40–49 or 121–140 b/min (32.0), SBP 181–240 mmHg (23.0) and "Other" (22.1) (mainly breathlessness or temperature >38 °C). The top five LS were SpO_2 < 90% (31.5), pulse rate <40 or >140/min (6.6), SBP <80 mmHg (4.2), GCS ≤8 (3.8) and unresponsiveness to verbal commands (2.4). There were average signs per admission of ES 4.4, LS 0.6 and LES 0.19. Although there were differences in rates of recordings of signs across the five hospitals, the patterns of top 10 most frequent were similar.
Conclusions: There was a high incidence of recordings of disturbed physiological variables in general ward patients. Changes to hospital emergency response systems to include rapidly responding teams to patients with the signs of developing critical conditions should be supported by training programmes for ward staff on the early recognition and management of patients with the warning signs.

Keywords: Medical emergency team; Emergency medical services; Emergency treatment; Training

1. Introduction

Some hospitals have established medical emergency teams (MET) [1] or patient at risk teams (PART) [2] in the hope of preventing serious adverse events (SAE) in ward patients e.g. unexpected death, cardiac arrest, severe respiratory problems and/or unplanned admission to an acute care area. There is lack of agreement on the most appropriate calling criteria [3] in part because of paucity of data on the prevalence of disturbed physiological variables in hospital patients and the predictive value of the signs. This paper reports a cross-sectional study of the prevalence of recordings of disturbed physiological variables in the case notes of adult patients in the general wards in five hospitals during a 14-day period. Subsequent papers will report the incidence of SAE, the predictive values of the disturbed

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variables for SAE and the response of medical and nursing staff.

2. Materials and methods

2.1. Approval for the study

Approval for the study was obtained from the Managements of five hospitals in the South East Health Area of New South Wales, Australia and the Hospital Ethics Committees.

2.2. Characteristics of the five hospitals

The characteristics of the hospitals are shown in Table 1. The hospitals selected were the facilities in the Health Area with a case mix of acute medicine and surgery without a single dominant specialty. A hospital for women's health was excluded on this criterion.

2.3. Case notes review

Two intensive care trained Registered Nurses reviewed retrospectively the case notes of all eligible patients who were in-patients for the whole or part of the study period, 6th December 2000 to 19th December 2000. These dates avoided atypical in-patient activity around the Sydney Olympic Games in September and the holiday periods of December and January 2001.

Data entered into an Access database were hospital and patient demographics, recordings in the case notes of symptoms or signs of critical illness and the response (if any) of the medical and nursing staff to the signs.

The signs to be entered were provided to the Project Nurses in 2 lists of 26 potential early signs (ES) and 21 late signs (LS) of critical conditions. The lists had been developed before the study by an expert panel of intensive care doctors and nurses. Some of the signs were left vague in their definitions to permit the Project Nurses to interpret non-objective observations recorded by staff (e.g. poor peripheral circulation, alteration in mentation, > expected drain fluid loss). Eight LS were regarded as Liverpool Equivalent Signs (LES) i.e. the MET calling criteria described by Liverpool Hospital, Sydney [1]. When recordings of a sign occurred frequently without note of concern by the staff, they were coded "Usual for the Patient" by the Project Nurses. Where a sign was recorded at more than one place in the case notes e.g. Vital Signs Chart and Progress Notes around the same time, it was entered into the data base only once for that time point.

The sample could be seen as representing four categories of relationship of the admission and discharge dates to the study period (SP):

- Category 1. Admission pre SP-discharge during SP (25.3%).
- Category 2. Admission pre SP-discharge post SP (8.1%).
- Category 3. Admission during SP-Discharge during SP (42.1%).
- Category 4. Admission during SP-Discharge post SP (24.5%).

The high percentage of admissions in Category 3 was important because that subgroup contained all the recordings

Table 1
Characteristics of the five contributing hospitals

	Hospital				
	1	2	3	4	5
Type	Tertiary, referral	Tertiary, referral	District and community	Emergency and short stay	Tertiary, referral
Beds open (% total)	362 (25.4%)	236 (16.5%)	224 (15.7%)	72 (5.0%)	534 (37.4%)
Case notes reviewed (% total)	828 (26.2%)	575 (18.2%)	461(14.6%)	220 (7.0%)	1076 (34.1%)
Patients (% total)	815 (26.2%)	570 (18.4%)	453 (14.6%)	217 (7.0%)	1051 (33.8%)
Top five medical specialties in eligible admissions	Cardiovascular medicine	Cardiovascular medicine	General surgery	Emergencies	Cardiology
	Aged care	Cardiothoracic transplant	General medicine	Opthalmology and eye surgery	Orthopaedics
	Orthopaedics	Orthopaedics.	Respiratory medicine	General medicine	Respiratory medicine
	Respiratory medicine	Aged care	Aged care	Plastic surgery	Emergencies
	Neurosurgery	Haematology	Emergencies	General Surgery	GIT Medicine and surgery
Cardiac surgery	Yes	Yes	No	No	Yes
Obstetrics	No	No	Yes	No	Yes
ICU	Yes	Yes	Combined ICU/CCU	No	Yes
CCU	Yes	Yes	As above	No	Yes
HDU	No	No	No	Yes	Yes
MET	No	No	No	No	No

ICU: intensive care unit; HDU: high dependency unit; MET: medical emergency team; GIT: gastrointestinal tract.

of signs made by staff during the admission. The other subgroups had admissions with sign within and outside SP but only those signs within SP were entered into the database.

2.4. Exclusion criteria

To facilitate the generalisation of results to other adult wards, case notes were not reviewed for:

- age under 14 years;
- day only admissions;
- emergency department patients not admitted to wards;
- deaths in the operating theatre before a ward was reached;
- patients in the intensive care unit (ICU) throughout the study period;
- patients in stand-alone specialised units e.g. psychiatry, palliative care or rehabilitation.

To maintain the focus of the study on signs in non-acute care wards, no data were extracted from the case notes for periods whilst general ward patients were in ICU, HDU, the emergency department, labour ward or operating theatre.

2.5. Definitions

2.5.1. Sign

An item on the lists of abnormal conditions or disturbed physiological variables considered by an expert panel to be potential early or late evidence of a critical condition.

2.5.2. Total recordings of a sign

All recordings of an early or late sign in the case notes within the study period.

2.5.3. Sign recorded at least once

The first of at least one recording in an admission of an early or late sign.

2.5.4. Total length of stay

The days between admission and discharge inside and outside the study period.

2.5.5. Study period length of stay

The days between admission and separation within the study period only.

2.5.6. Do not attempt resuscitation (DNAR)

Patients for whom there was written documentation in the case notes by the senior medical officer in charge of the patient that the patient was not to receive cardiopulmonary resuscitation in the event of a cardiorespiratory arrest.

2.6. Statistical analysis

Chi-square tests were used for analysis of difference between proportions and Student's *t*-tests for difference between means. Hospital 4 was found to be statistically different from the others on most demographic variables and prevalence of early and late signs. It was not excluded from the aggregate data analysis but when considered appropriate, the data were analysed with and without Hospital 4.

3. Results

3.1. Sources of data

3.1.1. Number of eligible admissions

1428 beds were open in the five hospitals during the study period. Of the 4617 in-patient admissions, 3164 (68.5%) were not ruled out by exclusion criteria. Four sets of these case notes were not reviewed because relevant pages were missing from the notes, leaving 3160 admissions (3106 patients) whose case notes were reviewed.

The hospitals contributed significantly ($P < 0.00001$) different proportions of admissions with Hospital 5 highest (34.1%) and Hospital 4 lowest (7.0%). The difference remained significant ($P < 0.0001$) after Hospital 4 was removed from the analysis. 78.5% of admissions came from the three tertiary referral hospitals.

3.1.2. Sources of the data in the case notes

Total recordings of ES ($n = 13796$) were 7.7 times more frequent than total recordings of LS ($n = 1786$). Most (83.2% recordings of ES and 71.3% recordings of LS) were found in either the vital signs chart, or in multiple sources (e.g. vital signs chart, progress notes or pathology). There was a higher rate of recordings of LS in the progress notes than of ES. Nurses made 86.1% of ES recordings and 76.3% of the LS recordings. Doctors recorded LS one and half times and allied health staff three and one half times more often than ES.

3.2. Rates and patterns of recordings of signs aggregated for the five hospitals (including DNAR admissions)

3.2.1. Rates of admissions with at least one sign

At least one ES or LS was recorded in 1746 (55.3%) of the 3160 admissions. In the 3160 admissions, there was at least one recording of the following:

- ES in 54.7%,
- LS in 16.0%,
- LES in 6.4%.

Admissions with at least one LES represented 39.6% of admissions with at least one LS.

Of the 1746 admissions with recordings of at least one sign:

- 71.0% had recordings of ES only,
- 28.1% had recordings of ES and LS,
- 1.0% had recordings of LS only.

Table 2
Total recordings of early signs (ES) in case notes

ES description	Total recordings of the ES sign			Admissions with ES signs	
	Frequency (% total)	Recordings per 100 admissions	Rank order	% Admissions with the sign	Rank order
SpO_2 90–95%	6120 (44.4)	193.7	1	37.1	1
SBP 80–100 mmHg	2692 (19.5)	85.2	2	20.6	2
Pulse rate 40–49 or 121–140/min	1012 (7.3)	32.0	3	8.2	4
SBP 181–240 mmHg	728 (5.2)	23.0	4	6.8	5
Other	699 (5.1)	22.1	5	11.4	3
BSL 16–25 mmol/l	462 (3.3)	14.6	6	3.2	9
Complaint of chest pain	431 (3.1)	13.6	7	5.6	6
Alteration in mentation	421 (3.1)	13.3	8	4.5	8
Note of decreased urine output	314 (1.0)	9.9	9	5.0	7
Urine output <200 ml/8 h	178 (1.3)	5.6	10	2.3	10
GCS <9–11 or alteration in GCS >2	134 (1.0)	4.2	11	0.9	15
Respiratory rate 5–9 or 31–40 breaths/min	123 (0.9)	3.9	12	1.4	11
BSL 1–2.9 mmol/l	112 (0.8)	3.5	13	1.4	11
Uncontrolled pain	61 (0.4)	1.9	14	1.1	13
Any seizure	48 (0.3)	1.5	15	0.4	21
New bleeding from any site	42 (0.3)	1.3	16	0.8	17
>Expected blood loss	38 (0.3)	1.2	17	0.6	18
PaO_2 50–60 mmHg	35 (0.3)	1.1	18	1.0	14
New pain	33 (0.2)	1.0	19	0.9	16
>Expected drain fluid loss	26 (0.2)	0.8	20	0.4	21
$PaCO_2$ 51–60 mmHg	25 (0.2)	0.8	21	0.5	19
Partial airway obstruction (excluding snoring)	24 (0.2)	0.8	22	0.5	19
Poor peripheral circulation	15 (0.1)	0.5	23	0.4	21
Base deficit −5 to −8 mmol/l	11 (0.1)	0.3	24	0.3	24
pH 7.2–7.3	7 (0.1)	0.2	25	0.2	25
Pain changed in location or character	5 (<0.1)	0.2	26	0.1	26
Total	13796 (100.0)	436.6			

SBP: systolic blood pressure; GCS: Glasgow Coma Score; BSL: blood sugar level (laboratory or ward glucometer).

3.2.2. Rates of early signs

When ES were ranked in descending order of signs/100 admissions (Table 2), potentially adverse changes in SpO_2, blood pressure, pulse rate, hyperglycaemia or chest pain ranked highly. "Other" which ranked fifth, contained 43 additional categories of signs. The most frequent were shortness of breath, temperature >38 °C, symptoms or signs of a postural fall in blood pressure and haemoglobin count <80 g/l. At least one recording of SpO_2 90–95% was made in 37.1% admissions and of systolic blood pressure 80–100 mmHg in 20.6%.

There was an average 4.4 ES recordings per admission (S.D. 8.1, 95% CI 4.1–4.6) at an average 1.2 different ES per admission (S.D. 1.5, 95% CI 1.1–1.3, maximum 11 different ES in an admission).

More than 10 total recordings of ES in an admission occurred in 24% of admissions with ES. The two highest were 85 total recordings of SpO_2 90–95% and 84 of a combination of systolic blood pressure 80–100 mmHg, pulse rate 121–140/min and SpO_2 90–95%.

3.2.3. Rates of late signs

When LS were ranked in descending order of signs/100 admissions (Table 3), potentially adverse changes in SpO_2, blood pressure and pulse rate ranked highest. Adverse neurological signs, failure to reverse a variable within one hour and changes in respiratory rate also ranked highly. LS "Other" categories ranked lower than ES "Other". In it, there were a few recordings of peripheral circulatory failure or severe breathlessness. Over 11% of the admissions had at least one recording of SpO_2 <90%, 2.2% pulse rate <40 or >140/min and 2% systolic pressure <80 mmHg.

There was an average of 0.6 LS recordings per admission (S.D. 2.3, 95% CI 0.5–0.7) at average 0.2 different LS per admission (S.D. 0.6, 95% CI 0.18–0.22, max 7 different LS in an admission). More than four total recordings of LS during a single admission occurred in 23% of admissions with LS. The maximum was 46 recordings of GCS ≤8.

3.2.4. Rates of LES

Of the total of 1786 recordings of LS, 592 (33.1%) were LES. Six of top 10 total recording per 100 admissions were LES (Table 3).

There was an average of 0.19 LES recordings per admission (S.D. 1.3, 95% CI 0.14–0.23) at average 0.07 different LES per admission (S.D. 0.3, 95% CI 0.05–0.08, max 3 different LES in an admission). The majority (95.8%) of admissions with LES had only 1 (79.7%) or 2 (16.1%) different

Table 3
Total recordings of late signs (LS) in case notes

LS description	Total recordings of the LS sign			Admissions with LS sign	
	Frequency (% total)	Recordings per 100 admissions	Rank order	% Admissions with the sign	Rank order
SpO_2 <90%	996 (55.8)	31.5	1	11.2	1
Pulse rate <40 or >140/min*	208 (11.6)	6.6	2	2.2	2
SBP <80 mmHg*	134 (7.5)	4.2	3	2.0	3
GCS< or = 8*	119 (6.7)	3.8	4	0.9	6
Unresponsive to verbal commands	77 (4.3)	2.4	5	1.5	4
Failure to reverse variable <1 h*	63 (3.5)	2.0	6	1.2	5
Resp rate <5 or >40/min*	29 (1.6)	0.9	7	0.5	8
Airway obstruction/stridor-complete*	27 (1.5)	0.9	8	0.1	17
Urine output <200 ml/8 h	21 (1.2)	0.7	9	0.5	8
PaO_2 <50 mmHg	21 (1.2)	0.7	9	0.6	7
Anuric	18 (1.0)	0.6	11	0.3	11
Other	18 (1.0)	0.6	11	0.5	8
$PaCO_2$ >60 mmHg	16 (0.9)	0.5	13	0.3	11
Cardiac arrest*	9 (0.5)	0.3	14	0.3	11
BSL >25 mmol/l	9 (0.5)	0.3	14	0.2	14
Base deficit <−8 mmol/l or less	7 (0.4)	0.2	16	0.2	14
pH <7.2	5 (0.3)	0.2	17	0.2	14
SBP >240 mmHg	4 (0.2)	0.1	18	0.1	17
Two or more Seizures with no return to baseline consciousness between*	3 (0.2)	0.1	19	0.03	19
Excess blood loss unable to be controlled by local staff	1 (0.1)	<0.1	20	0.03	19
BSL <1 mmol/l	1 (0.1)	<0.1	20	0.03	19
Total	1786 (100)	56.5			

SBP: systolic blood pressure; GCS: Glasgow Coma Score; BSL: blood sugar level (laboratory or ward glucometer).
* Liverpool equivalent sign.

LES. The maximum number of total recordings in a single admission was 46 of GCS ≤8.

3.2.5. Comparison of rates of recordings of non DNAR and DNAR patients

The average recordings per 100 admissions of ES in DNAR patients (Table 4) was 3.0 times that of ES in non DNAR patients (1238.6/406.6). For LS, the average ratio was 7.1 (329.8/46.3) (Table 4). Because of the small number of DNAR patients (114), there was only a minor impact in the recordings per 100 patients in the total sample of case notes.

3.3. Signs considered by the Project Nurses to be "Usual for Patient"

17.8% of all recordings of ES and 9.0% of LS were judged by the Project Nurses to be "Usual for the Patient". When ES "Usual for Patient" were ranked in descending order of percentage of recordings (Table 4), chronic alteration in level of consciousness or mentation, mild hypoxaemia, hypercarbia, or hypotension featured prominently.

For LS, reductions in the levels of consciousness headed the rank order with anuria/oliguria next. Severe disturbances of oxygenation, blood pressure or pulse rate were less likely than the equivalent ES to be recorded in the notes without a comment of concern.

For most signs DNAR admissions had lower percentages of "Usual for Patient" than non DNAR admissions (Table 4).

3.4. Comparison of rates and patterns of recordings of signs between hospitals

3.4.1. Demographics of the five participating hospitals

The rates of admissions by male sex were significantly ($P < 0.00001$) different across hospitals (Table 5) probably attributable to obstetrics beds in Hospital 3 (14.1% admissions) and 5 (9.1% admissions). The rate of non-booked admissions differed ranging from 39.1% (95% CI 32.6–45.9) in Hospital 4 to 71.4% (CI 67.0–75.4) in Hospital 3. DNAR orders were documented in 3.6% of case notes proportions ranging from 0% (Hospital 4) to 5.9% (Hospital 5).

Average age, total length of stay and study period length of stay also differed, Hospital 4 having the shortest and Hospital 3, the longest averages.

3.4.2. Comparison of admissions with at least one recording of ES, LS or LES signs across hospitals (Table 6)

The percentage of admissions with at least one recording of ES, LS or LES differed significantly ($P < 0.0001$) across the five hospitals with Hospital 4 scoring lowest in all counts. The rate of admissions with at least one LES varied from 0.9% (Hosp 4) to 8.5% (Hosp 3) ($P = 0.0002$) (Table 6).

3.4.3. Comparison of percent of admissions with at least one recording of ES across hospitals (Table 7)

Hospital 4 had lower rates of admissions with at least one recording of any particular sign than the other hospitals. The

Table 4
Recordings of signs considered as "Usual for Patient" by the project nurses

Admissions	All % "Usual"	Non DNAR ($n = 3046$)			DNAR ($n = 114$)		
		Total	Signs/100 admissions	% "Usual"	Total	Signs/100 admissions	% "Usual"
Aggregate early signs	17.8	12384	406.6	18.8	1412	1238.6	9.1
Aggregate late signs	9.0	1410	46.3	10.4	376	329.8	4.0
Early signs (top 10 "Usual for Patient")							
GCS 9–11 or alteration >2	44.0	104	3.4	50.0	30	26.3	23.3
SpO_2 90–95%	26.5	5552	182.3	27.6	568	498.2	15.7
$PaCO_2$ 51–60 mmHg	20.0	23	0.8	21.7	2	1.8	0.0
SBP 80–100 mmHg	20.0	2518	82.7	20.8	174	152.6	8.6
Alteration in mentation	13.5	353	11.6	12.2	68	59.6	20.6
Poor peripheral circulation	13.3	9	0.3	22.2	6	5.3	0.0
Pulse rate 40–49 or 121–140/min	11.5	915	30.0	12.7	97	85.1	0.0
PaO_2 50–60 mmHg	8.6	25	0.8	8.0	10	8.8	10.0
Any seizure	8.3	46	1.5	8.7	2	1.8	0.0
Complaint of chest pain	3.9	403	13.2	3.7	28	24.6	7.1
Late signs (only seven types of LS coded as "Usual for Patient" by the project nurses)							
GCS < or =8	54.6	102	3.3	63.7	17	14.9	0.0
Anuric	38.9	11	0.4	54.5	7	6.1	14.3
Urine output <200 ml/24 h	23.8	5	0.2	40.0	16	14.0	18.8
Unresponsive to verbal commands	18.2	25	0.8	16.0	52	45.6	19.2
Pulse rate <40 or >140/min	5.3	175	5.7	6.3	33	28.9	0.0
SBP <80 mmHg	5.2	125	4.1	5.6	9	7.9	0.0
SpO_2 <90%	5.2	796	26.1	6.4	200	175.4	0.5

Adm: admissions; GCS: Glasgow Coma Score; SBP: systolic blood pressure; DNAR: do not attempt resuscitation.

Table 5
Demographics of the participating hospitals

Hospital	Frequency of admissions (% hospital admissions)			Mean (S.D.)		
	Male	Non-booked	DNAR	Age (years)	TLOS (days)	SPLOS (days)
1	447 (54.0%)	497 (60.0%)	18 (2.2%)	62.5 (20.1)	13.4 (22.3)	4.7 (4.2)
2	339 (58.9%)	349 (60.7%)	10 (1.7%)	60.2 (19.6)	11.5 (15.5)	4.9 (4.1)
3	198 (42.9%)	329 (71.4%)	23 (5.0%)	64.5 (22.1)	15.0 (21.6)	5.3 (4.4)
4	127 (57.7%)	86 (39.1%)	0 (0.0%)	57.6 (20.7)	4.0 (5.6)	2.6 (2.7)
5	446 (41.4%)	645 (59.9%)	63 (5.9%)	61.3 (21.5)	11.5 (15.9)	4.5 (3.8)
All	1557 (49.3%)	1906 (60.3%)	114 (3.6%)	61.6 (20.9)	12.0 (18.4)	4.6 (4.0)
P	<0.00001	<0.00001	<0.001	<0.00001	<0.0001	<0.0001
P without Hospital 4	<0.00001	<0.0001	<0.001	<0.00001	<0.0001	<0.0001

DNAR: do not attempt resuscitation; TLOS: total length of stay; SPLOS: study period length of stay.

Table 6
Percentage of each hospital's admissions with different types of signs

Hospital (*N*)	At least one ES or LS		At least one ES		At least one LS		At least one LES	
	n	% Admissions (95%CI)	*n*	% Admissions (95% CI)	*n*	% Admissions (95% CI)	*n*	% Admissions (95% CI)
1 (828)	446	53.9 (50.4–57.3)	444	53.6 (50.1–57.1)	126	15.2 (12.8–17.8)	39	4.7 (3.4–6.4)
2 (575)	371	64.5 (60.4–68.4)	365	63.5 (59.4–67.4)	126	21.9 (18.6–25.5)	37	6.4 (4.6–8.8)
3 (461)	307	66.6 (62.1–70.9)	307	66.6 (62.1–70.9)	70	15.2 (12.0–18.8)	39	8.5 (6.1–11.4)
4 (220)	63	28.6 (22.8–35.1)	62	28.2 (22.3–34.6)	7	3.2 (1.3–6.4)	2	0.9 (0.1–3.2)
5 (1076)	559	52.0 (48.9–55.0)	551	51.2 (48.2–54.2)	178	16.5 (14.4–18.9)	84	7.8 (6.3–9.6)
All (3160)	1746	55.2 (53.5–57.0)	1729	54.7 (53.0–56.5)	507	16.0 (14.8–17.4)	201	6.4 (5.5–7.3)
P		<0.0001		<0.0001		<0.0001		<0.0002
P without Hosp 4		<0.0001		<0.0001		0.0047		<0.022

N: hospital admissions; *n*: admissions with the type of sign; ES: early sign; LS: late sign; LES: liverpool equivalent sign.

Table 7
Comparison of the rank orders of top 10 frequencies of signs in the five hospitals

	Rank order (% admissions with the sign/hospital admissions)				
	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Hospital 5
Early signs					
SpO_2 90–95%	1 (37.2)	1 (53.0)	1 (39.5)	1(8.6)	1 (33.2)
SBP 80–100 mmHg	2 (14.6)	2 (27.3)	2 (30.4)	3(6.8)	2 (20.4)
Other	3 (9.7)	5 (5.0)	3 (21.9)	4(4.1)	3 (13.6)
Pulse rate 40–49 or 121–140/min	4 (8.5)	3 (8.0)	4 (13.2)	6(1.8)	5 (6.8)
SBP 181–240 mmHg	5 (6.2)	7 (3.3)	6 (10.0)	2(8.2)	4 (7.4)
Complaint of chest pain	6 (6.0)	4 (5.2)	9 (6.5)		6 (6.0)
Note of decreased urinary output	7 (4.7)	6 (4.0)	7 (8.2)	7(0.9)	7 (5.1)
BSL 16–25 mmol/l	8 (4.1)	8 (2.6)	10 (4.8)	5(3.6)	9 (2.1)
Alteration in mentation	9 (3.9)	9 (1.7)	5 (10.4)		8 (4.8)
BSL 1–2.9 mol/l	10 (1.6)			7(0.9)	
Urine output <200 ml/8 h			8 (8.0)		
Respiratory rate 5–9 or 31–40 bpm				7(0.9)	10 (2.0)
Uncontrolled pain				7(0.9)	
GCS 9–11 or alteration >2		10 (1.6)			
Late signs					
SpO_2 <90%	1 (11.5)	1 (16.9)	1 (9.1)	1(2.3)	1 (10.7)
Pulse rate <40 or >140/min*	2 (1.9)	2 (3.0)	3 (2.6)	2(0.5)	3 (2.3)
Unresponsive to verbal commands	3 (1.2)	4 (1.4)	2 (2.8)		5 (1.4)
SBP < 80 mmHg*	4 (1.1)	3 (2.4)	4 (2.0)		2 (2.7)
Failure to reverse variable <1 h*	4 (1.1)	5 (0.9)	5 (1.7)		4 (1.6)
GCS< or =8*	6 (1.0)	6 (0.7)	8 (1.1)		6 (1.2)
PaO_2 <50 mmHg	7 (0.6)	7 (0.5)	10 (0.4)	3(0.5)	8 (0.7)
$PaCO_2$ >60 mmHg	7 (0.6)	10 (0.2)		4(0.5)	
Respiratory rate <5 or >40 bpm*	9 (0.2)		5 (1.7)		8 (0.9)
Other	9 (0.2)	10 (0.2)	9 (0.9)		7 (0.9)
Urine output <200 ml/24 h		8 (0.3)	7 (1.5)		
Cardiac arrest*	9 (0.2)				8 (0.7)
Base deficit <8 mmol/l	9 (0.2)	10 (0.2)			
pH <7.2	9 (0.2)		10 (0.4)		
Anuric		10 (0.2)			8 (0.7)
BSL >25 mm/l		8 (0.3)	10 (0.4)		
Airway obstruction/stridor (complete)*			10 (0.4)		
SBP >240 mmHg				2(0.5)	
Two or more seizures without return to baseline level of consciousness*				2(0.5)	

SBP: systolic blood pressure; GCS: Glasgow Coma Score; BSL: blood sugar level.
* Liverpool equivalent sign.

highest ranking ES in all hospitals was SpO_2 90–95%, ranging from 8.6% of admissions in Hospital 4 to 53.0% in Hospital 2 (Table 7).

The pattern of top 10 in the ranking was similar across hospitals with decreased oxygen saturation, potentially adverse changes in cardiovascular variables and "Other" ranked in the top seven in all hospitals.

3.4.4. Comparison of percent of admissions with at least one recording of LS across hospitals (Table 7)

SpO_2 less than 90% was the highest ranking LS in all hospitals ranging from 2.3% of admissions in Hospital 4 to 16.9% in Hospital 2 (Table 7).

Only six categories of LS were recorded in admissions in Hospital 4, otherwise the pattern of the top 10 in the ranking was similar across the hospitals with decreased oxygen saturation, potentially adverse changes in cardiovascular variables, neurological signs and respiratory rates ranked in the top 8 in all hospitals.

3.5. Admissions documented as DNAR

There were differences ($P < 0.0001$) between the 114 DNAR patients and the 3046 non DNAR patients on all variables shown in Table 5 except gender. DNAR patients had greater proportions of non-booked admissions, higher mean age and longer lengths of stay. DNAR patients also had higher rates of total recordings of ES, LS or LES per admission. When ES were ranked by total recordings of signs per 100 admissions, the patterns of the top 10 were similar for both groups. The patterns of the top 10 for LS were less similar in the two groups. Decreased level of consciousness and low urinary output were more prominent in the DNAR group.

4. Discussion

This estimating of the prevalence of the recordings of the signs of disturbed physiological variables from a cross-

sectional study of admissions in general wards of several hospitals is unique in its scale and its attempt to measure the prevalence of the recordings in admissions with and without serious adverse events (SAE). One previous study used the retrospective methodology of a small case-control study of patients who had suffered SAE [4] and another [5] was a cross-sectional study for only nine and one half hours in one hospital. Other studies have investigated antecedent recordings of signs only in-patients who suffered SAE [6–8]. All studies, including ours, that extract data on recordings of signs are weighted by current protocols and policies for routine observations and additionally subject to the whims of potential recorders of routine observations or commentators on the patient's clinical condition. In the future, it may be better to redefine "routine" observations by reference to the predictive value of signs for SAE and thereby facilitate the development of an optimal set of calling criteria, mandatory for recording, to which staff will respond.

Despite our study design that will produce underestimation of the prevalence of recordings of signs through exclusion of those recordings outside the study period, there was still a high count of recordings of signs in a substantial percentage of admissions. Over 50% of admissions had at least one recording of a sign during the study period, 16% had a potentially serious (i.e. late) sign and 6% had what many would regard as a pre-SAE sign (i.e. LES). Nurses and doctors in wards, sometimes inexperienced and/or transient, are constantly challenged to recognise and manage these frequent signs. Each individual recording represented a moment when staff had to respond by ignoring the sign, intervening or seeking assistance. Our findings suggest that systems in which ICU outreach teams respond rapidly to some life threatening changes in ward patients need to be supported by specific clinical programmes of training for ward staff in the recognition and management of all early and late signs of developing critical conditions. Such programmes are essential for ward nursing staff who will be the most likely group to observe and record the signs. Related programmes are also essential for junior medical staff members who are usually the clinicians called upon to initiate medical management.

Programmes should include training in discrimination between stable and deteriorating clinical conditions. Recordings of SpO_2 of 90–95%, and mild to moderate cardiovascular and neurological changes were often scored by the Project Nurses as "Usual for the Patient" but not many severe respiratory, cardiovascular or neurological signs were so scored. There remains a worrying possibility that another reason for failure of expression of concern in the case notes about changing signs was that some staff may have failed to realise the potential significance of repetitive or changing signs. This issue is addressed in our subsequent paper on "Responses".

Whilst the total count of recordings of signs has significant operational and educational implications, the count of the number of admissions with at least one recording of a particular sign is also important for research defining the most cost-effective set of calling criteria and type of response. This count facilitates comparison of the rate of occurrence of the sign across groups, rather than comparing the total count of recordings that may be weighted by admissions with a very high count of recordings of the sign in the admission and routine observations. It also provides a useful variable for modelling the value of sets of calling criteria as most emergency response systems use the principle of a call on the first occurrence of a stated sign or after a small number of observations of the sign or combination of signs that cannot be reversed by ward staff. Although demographics and rates of recordings varied across the five hospitals, and there was weighting to the tertiary referral hospitals, the pattern of top 10 signs in each hospital was similar. However, the smallest hospital had the lowest rate of signs and the least typical pattern. It is interesting to speculate whether this combination of count and pattern makes it more or less suitable for a MET or PART given the absence of an ICU. Differences in case mixes, and rates or types of signs in hospitals, could have implications for the value of different types of rapidly responding teams. In the face of the absence of papers using comparable methods of data analyses to our own, it is difficult to state the potential generalisability of our data to other countries. However, this issue will become increasingly important as Australia and the United Kingdom, in particular, work towards the development of optimal in-hospital Emergency Response Systems to cope with dwindling resources in the wards.

The role and effectiveness of rapidly responding teams for the prevention of SAE have been the focus of considerable recent debate particularly the calling criteria and category of staff that responds. Some of the potential calling criteria that occurred with a high frequency in our study e.g. $SpO_2 < 90\%$ are missing from some sets of recommended calling criteria [9–11] while included in others [2,12–15]. The potential usefulness of a declining urine output, acute breathlessness or elevated temperature as calling criteria also requires assessment. Continuous monitoring of defined critical variables would facilitate studies on the prevalence and predictive value of changes in physiological variables. Whilst it is our belief that the quality of care of patients can be improved by the development of small improved continuous monitors of critical physiological variables, no monitor is effective if not applied to the appropriate patient and no monitor is worthwhile if no appropriate action is taken when defined thresholds are crossed.

DNAR and non DNAR patients differed in most demographics and rate of recordings of signs. We believe DNAR admissions should be omitted in studies of the effectiveness of resuscitation directed responses to disturbed physiological variables.

5. Conclusions

Our study has demonstrated a high incidence of recordings of disturbed physiological variables in general ward

patients. It provides data to assist with local design of sets of calling criteria and the responses. It also provides data for the curricula design or modification of supporting training programmes such as the CCrISP [16] and ALERT [17]. In balancing the contribution of local ward responses and hospital wide responses, the issues of effectiveness and resource utilisation require further study because of the potential impact on ICU resources [18,19]. In studying the balance of effectiveness and resource allocation, the prevalence of signs of critical conditions is important when considered with the predictive value of each sign or combination of signs. The predictive value of recordings of ES, LS and LES for SAE in the SOCCER data and the implications for planning emergency response systems will be presented in a subsequent paper.

Conflict of interest statement

There is no conflict of interest for any of the authors.

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