The incidence and cost of adverse events in Victorian hospitals 2003–04

Jonathon P Ehsani, Terri Jackson and Stephen J Duckett

ABSTRACT

Objectives: To determine the incidence of adverse events in patients admitted in the year 2003–04 to selected Victorian hospitals; to identify the main hospital-acquired diagnoses; and to estimate the cost of these complications to the Victorian and Australian health system.

Design: The patient-level costing dataset for major Victorian public hospitals, 1 July 2003 – 30 June 2004, was analysed for adverse events by identifying C-prefixed diagnosis codes denoting complications, preventable or otherwise, arising during the course of hospital treatment. The in-hospital cost of adverse events was estimated using linear regression modelling, adjusting for age and comorbidity.

Main outcome measures: Cost of each patient admission ("admitted episode"), length of stay and mortality.

Results: During the designated timeframe, 979 834 admitted episodes were in the sample, of which 67 435 (6.88%) had at least one adverse event. Patients with adverse events stayed about 10 days longer and had over seven times the risk of in-hospital death than those without complications. After adjusting for age and comorbidity, the presence of an adverse event adds $6826 to the cost of each admitted episode. The total cost of adverse events in this dataset in 2003–04 was $460.311 million, representing 15.7% of the total expenditure on direct hospital costs, or an additional 18.6% of the total inpatient hospital budget.

Conclusion: Adverse events are associated with significant costs. Administrative datasets are a cost-effective source of information that can be used for a range of clinical governance activities to prevent adverse events.

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Patient safety and quality are now clearly on the health policy agenda, with high profile problems in several Australian states[1-3] receiving regular commentary in medical journals.[4-6] Added to the real personal costs of adverse events are the financial costs, and a business case can be made to invest in new systems to prevent or at least reduce the number of these events. Here, we identify the incremental costs of adverse events in 2003–04 for a sample of Victorian hospitals.

Previous Australian studies have estimated that direct hospital costs of adverse events in Australia range between $483 million[7] and $900 million per annum.[8] International rates for adverse events (variously defined) range between 3.7% and 45.8% of all admissions,[9] with the Australian rate found to be 16%.[8] It is estimated that half of these adverse events are preventable.[7]

Methods for estimating in-hospital costs of adverse events have several limitations.[10] Previous cost estimates based on additional length of stay[8] do not account for the resource intensity needed to treat complications, nor do they adjust for the age or level of comorbidity of the patient group. Hence, there is a need to refine the basis for estimating in-hospital costs of adverse events so that it reflects resource use more closely.

In Australian hospitals, diagnoses and procedures for all separations (patients who were discharged, transferred, or died in hospital) are coded according to the International classification of diseases, 10th revision, Australian modification (ICD-10-AM).[11]

The ICD has a range of codes that by definition imply an adverse event:

- Codes in the range T80–T88.9 (complications of surgical and medical care not elsewhere classified) in Chapter XIX (Injury);
- Codes from other chapters of the ICD-10-AM classification which are used for complications of care specific to the diagnoses in the chapter, termed here "end of chapter" codes; and
- External cause codes contained in the range Y40–Y84.9 (complications of medical and surgical care), and the code Y95 (nosocomial condition) indicating the external cause of an injury diagnosis.

In Victoria, the coding guidelines also require a prefix to the ICD-10-AM diagnosis code to indicate whether the diagnosis was present on admission to hospital or arose during the course of hospital treatment (the latter being designated by a C prefix). The C prefix can apply to any diagnosis (eg, pneumonia), not only those described above that imply an adverse event. It may only be assigned when the acquired diagnosis necessitated further treatment or extended the patient's length of stay. This closely parallels the National Council on Safety and Quality in Health Care's definition of an adverse event as "an incident in which unintended harm resulted to a person receiving health care".[12]

The purpose of our study was to explore the incidence of adverse events in patients admitted in the financial year 2003–04 to selected Victorian hospitals, to identify the main hospital-acquired diagnoses, and to estimate the in-hospital cost of these complications to the wider health system.

METHOD

Data source

We used the patient-level costing dataset that the Victorian Department of Human Services uses to set hospital payment relativities for casemix funding.[13] Costs are estimated using computerised clinical costing systems that identify the costs of hospital care for individual patients.[14] The 45 hospitals contributing to the dataset are the larger Victorian hospitals, accounting for 86.4% of weighted inpatient activity (ie, weighted according to complexity) for the period 1 July 2003 – 30 June 2004.

For the purpose of descriptive analysis, the sample was stratified into single-day (length of stay ≤ 1 day) and multiday (length of stay > 1 day) patient admissions. As the diagnosis-related group (DRG) sys-

1 Patient characteristics and outcomes of adverse events from selected Victorian hospitals, 2003–04

	All admitted episodes (n = 979 834)				Multiday admitted episodes (n = 307 672)			
	Separation without adverse event (n = 912 399)		Separation with adverse event (n = 67 435)		Separation without adverse event (n = 247 469)		Separation with adverse event (n = 60 203)	
	Mean (95% CI)	Range	Mean (95% CI)	Range	Mean (95% CI)	Range	Mean (95% CI)	Range
Age (years)	48.2 (48.1–48.3)	0–107	62.9 (62.7–63.0)	0–109	43.8 (43.7–43.9)	0–106	63.9 (63.7–64.1)	0–109
Length of stay (days)	2.49 (2.48–2.50)	1–671	12.61 (12.48–12.74)	1–778	6.49 (6.46–6.54)	2–671	14.00 (13.86–14.15)	2–778
Charlson score	0.067 (0.066–0.068)	0–18	0.184 (0.179–0.189)	0–13	0.111 (0.109–0.113)	0–18	0.192 (0.187–0.197)	0–13
Cost ($)	2 181 (2 171–2 190)	33–776 508	14 027 (13 865–14 187)	50–621 215	5 355 (5 323–5 387)	106–776 508	15 429 (15 252–15 605)	157–58 758
In-hospital case fatality rate	0.64 (0.62–0.66)		7.32 (7.12–7.51)		1.54 (1.49–1.59)		7.35 (7.14–7.55)	

tem allocates some patients to particular DRGs based on whether or not the patient was mechanically ventilated, such patients were reassigned to the appropriate DRG, disregarding mechanical ventilation. As DRG assignment may be influenced by adverse event diagnoses, adjacent DRGs (those with subcategories for complications and comorbidities) were collapsed into a single "adjacent DRG" (adjDRG) to reveal the relationships between complexity of care, complications and resource use.

The coded clinical data for Victoria have been used previously in patient safety research to analyse the epidemiology of hospital-acquired sepsis[15] and to predict in-hospital morbidity.[16] Studies of the coding quality of the dataset report high degrees of accuracy of core data elements.[17-20]

Identifying adverse events

Based on a method developed in a previous study,[21] adverse events were identified using the C prefix to the ICD-10-AM diagnosis code. Patients can have multiple adverse events; identification of the leading adverse event was undertaken using the hierarchy of codes described in the Introduction. Thus, when a case was found to have a T code, it was flagged with a T marker variable and excluded from further allocation; remaining cases containing "end of chapter" codes were then identified, flagged and excluded from further allocation; then remaining cases with the listed Y codes were flagged and likewise excluded from further allocation. All remaining complication types were identified by selecting the ICD-10-AM code corresponding to the first appearing C prefix. Individual diagnoses were then grouped on the basis of their ICD-10-AM code to characterise the most frequently recorded code groups in the sample.

Costs of adverse events

AdjDRGs from the dataset were analysed for the difference in cost between cases with and without complications. The cost of adverse events was calculated by two methods. First, the mean cost was calculated for cases with and without a recorded adverse event for each adjDRG. Second, an analysis of the combined effect of age, comorbidity and the presence of an adverse event on the cost of an episode of care was calculated using coefficients from a linear regression model, with the total cost of the admitted episode as the dependent variable. The length of stay variable was excluded from the model, as it is both a predictor and outcome of an adverse event.

The 10 adjDRGs contributing the greatest dollar value attributable to adverse events were identified by establishing the mean difference between episodes with and without adverse events, and multiplying by the number of cases in each group. The incremental cost of adverse events in these individual adjDRGs was also estimated using linear regression, adjusting for age and pre-existing comorbidity, with the total cost of the episode as the dependent variable.

The adjustment for presence and severity of pre-existing comorbidities was calculated using the ICD-10-CM mapping of the Charlson index[22] by Sundararajan et al,[16] a validated and widely accepted measure of comorbidity.[23,24] C-prefixed diagnosis codes were excluded from this analysis to ensure that the Charlson index adjusted for comorbidities present on admission and not complications arising during the episode of care.

Statistical analysis

The analysis was undertaken using Stata statistical software, version 8.0 (StataCorp, College Station, Tex, USA).

RESULTS

Patient characteristics (Box 1)

A total of 979 834 patient admissions (designated "admitted episodes") were included in the sample of selected Victorian hospitals for the period 1 July 2003 to 30 June 2004. Over two-thirds (68.6%) had a length of stay of 1 day or less. Of the total of admitted episodes in the sample, 67 435 (6.88%) had at least one C prefix. Multiday episodes (patients staying for more than 1 day) had nearly three times the incidence of adverse events (19.57%) compared with all admitted episodes. Patients with an adverse event were older (mean age, 62.9; 95% CI, 62.7–63.0 years) than those without adverse events (mean age, 48.2; 95% CI, 48.1–48.3 years). The mean Charlson score for pre-existing comorbidity was significantly higher ($P < 0.001$) for those who experienced an adverse event (mean, 0.184; 95% CI, 0.179–0.189) than those who did not (mean, 0.067; 95% CI, 0.066–0.068).

Characteristics of adverse events: length of stay and mortality outcomes (Box 1)

Episodes with an adverse event differed in the three key measures: length of stay, in-hospital mortality and cost. Among all

2 Ten leading groups of recorded incident adverse events: selected Victorian hospitals, 2003–04

ICD-10-AM codes	Descriptor	Incident cases (% with complications)	Associated mortality rate
E86–E87.8	Dehydration and metabolic imbalances	5 563 (8.25%)	7.86
I47–I49; R00	Atrial fibrillation and other heartbeat irregularities	3 698 (5.48%)	7.25
T81.1–T81.9	Other procedural complications*	3 521 (5.22%)	2.84
I95.9	Hypotension unspecified	2 930 (4.34%)	9.11
R11	Nausea and vomiting	2 607 (3.87%)	0.96
N39.0	Urinary tract infection, site not specified	2 457 (3.64%)	4.88
T81.0	Haemorrhage and haematoma complicating a procedure not elsewhere classified	2 335 (3.46%)	1.71
D50; D62; D64.9	Anaemia due to blood loss, anaemia unspecified	2 064 (3.06%)	3.29
J12–J22	Pneumonia and lower respiratory tract infections	1 627 (2.41%)	18.25
R50–R50.9	Fever	1 569 (2.33%)	2.00
All other C-prefixed diagnoses		39 064 (57.93%)	1.10

* Including shock, accidental puncture, wound infection and sepsis, foreign body left in body cavity. ◆

admitted episodes, patients with adverse events had a considerably longer length of stay, about 10 days longer than those without adverse events: 12.61 days (95% CI, 12.48–12.74) compared with 2.49 days (95% CI, 2.48–2.50). Episodes with an adverse event had over seven times the risk of in-hospital mortality than those without complications (risk ratio, 7.09; 95% CI, 6.94–7.25). Patients who died in hospital were more likely to have a complication recorded (45.76%) than those discharged alive (6.45%). It is not possible to determine from the data the extent to which the adverse event contributed to the death.

Among multiday episodes, patients with adverse events stayed about 7.5 days longer than those without: 14.00 days (95% CI, 13.86–14.15) compared with 6.49 days (95% CI, 6.46–6.54). The in-hospital case fatality rate of those with an adverse event was very close to that for the entire sample (7.35%), and the risk of in-hospital mortality was almost three times (risk ratio, 2.88; 95% CI, 2.82–2.94) that for multiday episodes without complications.

Incidence of adverse events

The 10 leading groups of recorded incident adverse events are shown in Box 2. About a quarter (27.9%) of these leading groups were identifiable from the C prefix only; the others comprised codes related by definition to adverse events.

The group "dehydration and metabolic imbalances" (E86–E87.8) was the leading type of adverse event, with 5563 cases (8.25% of all adverse events), and was associated with an in-hospital mortality rate of 7.86%, although no causation can be inferred. The second most frequent was "atrial fibrillation and other heartbeat irregularities" (I47–I49; R00), representing 5.48% of all recorded adverse events, with an associated mortality rate of 7.25%. "Pneumonia and lower respiratory tract infections" (J12–J22) had the highest associated mortality rate (18.25%), followed by "hypotension" (I95.9), with a 9.11% in-hospital mortality rate.

The cost of adverse events

The mean cost of all admitted episodes without an adverse event was $2181 (95% CI, $2171 – $2190) compared with $14 027 (95% CI, $13 865 – $14 187) for an episode with an adverse event. The mean cost for multiday episodes was $5355 (95% CI, $5323 – $5387) compared with $15 429 (95% CI, $15 252 – $15 605) when the episode had at least one adverse event recorded (Box 1).

A linear regression model was used to estimate cost, with age, pre-existing comorbidity (modified Charlson score), the presence of an adverse event and an adjDRG (the latter two as 0–1 coded indicators) as independent variables for all admitted episodes. All parameter coefficients in the final model achieved statistical significance at $P < 0.05$ (df = 407, $r^2 = 0.38$), with the exception of 11 of the 405 adjDRGs. After adjusting for age and comorbidity, the presence of an adverse event, as estimated by the regression coefficient, adds $6826.

The total cost of adverse events in this dataset in 2003–04 was $460.311 million, representing 15.7% of total in-hospital costs, or an additional 18.6% on the total inpatient hospital budget.

Ten adjacent DRGs contributing the greatest dollar value attributable to adverse events (Box 3)

Linear regression modelling was used to estimate the cost for selected adjDRGs using age, comorbidity and recorded adverse event as independent variables. All models achieved statistical significance of $P < 0.05$ or greater. The adjDRGs with the greatest dollar value attributable to adverse events are dominated by neurosurgery, cardiac surgery and hip surgery categories. The greatest dollar value contributor to adverse events was "B02 Craniotomy", with an incremental cost of $16 664 (df = 3; $P < 0.001$; $r^2 = 0.12$) when an adverse event was present, adding a total of $20.130 million to direct hospital costs.

The presence of an adverse event added $11 858 (df = 3; $P < 0.001$; $r^2 = 0.07$) to each episode of "G02 Major small and large bowel procedures" adding $17.135 million to direct hospital costs. The incidence of adverse events for this adjDRG was 61.57%, with a case fatality rate of 6.22%. The total cost for the 10 leading adjDRGs contributing the greatest dollar value to adverse events was $105.461 million.

DISCUSSION

Adverse events are associated with higher costs, longer length of stay and higher mortality rates. The incremental cost of adverse events represents 15.7% of the total in-hospital cost in the sample. The costing dataset sample used here includes 86.4% of Victoria's weighted inpatient activity and 90% of the direct hospital expenditure in Victoria. Assuming other Victorian hospitals have the same adverse events profile, the cost of adverse events for Victorian weighted inpatient activity would be about $511.457 million per annum. As Victoria represents about 25% of national hospital expenditure, the financial toll of adverse events for Australian inpatients is estimated

3 Incremental costs and characteristics of adverse events in Victoria (2003–04). Selected statistics: 10 adjacent diagnosis-related groups (adjDRGs) contributing the greatest dollar value attributable to adverse events, and data for total admitted episodes

Adjacent DRGs	Number (incidence of adverse events)	Associated mortality rate	Mean length of stay in days (95% CI)	Mean cost ($) without adverse events (95% CI)	Mean cost ($) with adverse events (95% CI)	Adjusted incremental cost ($)*†	r^2	Estimated cost ($) attributable to adverse events in sample
B02 Craniotomy	2 206	7.03	11.9	12 358	28 387	16 664	0.12	20 130 112
	(54.76%)		(11.2–12.7)	(11 790–12 926)	(26 726–30 049)			
G02 Major small and large bowel procedures	2 347	6.22	14.2	10 707	23 112	11 858	0.07	17 134 810
	(61.57%)		(13.5–14.9)	(10 033–11 382)	(21 663–24 561)			
901 Extensive O.R. procedure unrelated to principal diagnosis	1 360	6.76	12.5	7 523	28 054	19 952	0.14	10 734 176
	(39.56%)		(11.5–13.4)	(6 921–8 125)	(24 791–31 318)			
T01 O.R. procedures for infectious and parasitic diseases	883	6.80	18.9	10 598	38 506	27 219	0.17	9 200 022
	(38.28%)		(17.1–20.7)	(9 486–11 710)	(33 554–43 458)			
F08 Major reconstruct vascular procedures	1 174	6.30	11.0	11 609	24 775	12 745	0.11	9 036 205
	(60.39%)		(10.3–11.7)	(10 947–12 270)	(23 066–26 483)			
I08 Other hip and femur procedures	2 927	3.90	11.3	9 321	15 991	6 440	0.11	8 706 880
	(46.19%)		(10.8–11.8)	(9 046–9 595)	(15 308–16 674)			
B60 Established paraplegia/quadriplegia	929	4.70	21.5	8 482	38 878	30 572	0.11	8 621 304
	(30.36%)		(17.7–25.3)	(6 404–10 560)	(31 586–46 170)			
F06 Coronary bypass w/o invasive cardiac investigations	1 560	1.70	9.9	17 157	23 051	5 533	0.05	7 663 205
	(88.78%)		(9.5–10.3)	(16 483–17 831)	(22 271–23 831)			
I03 Hip revision/hip replacement	2 936	2.40	10.5	13 119	17 843	4 863	0.07	7 420 938
	(51.98%)		(10.1–10.8)	(12 838–13 400)	(17 281–18 405)			
F04 Cardiac valve procedures with CPB pump	734	2.60	13.0	23 483	34 676	11 224	0.03	6 812 968
	(82.70%)		(12.2–13.8)	(21 954–25 012)	(32 576–36 777)			
Model/Total for top 10 adjDRGs	17 056	4.70	12.6	10 957	24 084	12 532	0.11	105 460 620
	(55.05%)		(12.3–12.9)	(10 703–11 211)	(23 544–24 624)			
Total admitted episodes	979 834	1.10	3.19	2 181	14 027	6 826	0.38	460 311 310
	(6.88%)		(3.17–3.20)	(2 171–2 190)	(13 865–14 187)			

* $P < 0.005$; † Adjusted for age and comorbidity (calculated using the modified Charlson index). O.R. = operating room; w/o = without; CPB = cardiopulmonary bypass. ◆

at about $2 billion per annum. Of course, not all this money can be saved. One of the limitations of administrative datasets is the inability to distinguish preventable from non-preventable adverse events; however, previous studies have estimated that 40%–50% of adverse events are preventable.[8,25] Even considering the costs of systematic efforts to prevent these events, savings to the health system could be enormous.

Regression analysis has been previously used in estimating the cost of adverse drug events,[26] and the method used in our study represents an advance in the estimation of in-hospital costs, as adjustment for confounding variables is possible. However, this approach underestimates costs associated with adverse events, as it is limited to events and costs identified during the episode of care and not any flow-on costs once the patient is discharged. This is of particular relevance to the two-thirds of the sample that had a 1 day or less length of stay. Adverse events in these cases would generally not become apparent until after discharge and may be treated in the community or occasion a second episode of hospital care — costs which have not been captured here.

The total costs of adverse events are a function of the incremental cost of adverse events in each adjDRG, the number of admitted patients in the adjDRG, and the rate of adverse events in the adjDRG. Thus, the greatest contributors to the cost of adverse events in the health system are not necessarily the most costly episodes of care, but include high-volume episodes of care, such as hip surgery, where the cost is marginally increased due to complications.

We have identified the significant cost to the Australian health care system associated with adverse events, and we have shown how administrative datasets can be used to identify the incidence of adverse events. These data can assist in a wide range of clinical activities to reduce rates of such events, as an alternative to investigating individual cases. We believe that judgements as to the preventability (or otherwise) of particular events are better made at the local level. Abstracted data cannot reflect

nuanced judgements beyond those currently made by Victorian coders: recording the fact of harm (as documented in the medical record) and the timing of that harm (ie, before admission, or during the current episode). Analysis of administrative data is less costly and more timely than purposive record review, and is likely to improve on the sensitivity of voluntary incident reporting. The use of cost data is particularly useful in setting priorities for remedial action and in making the "business case" for programs designed to reduce the rates of adverse events.

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COMPETING INTERESTS

None identified.

AUTHOR DETAILS

Jonathon P Ehsani, MPH(Int), Victorian Public Health Training Scheme Fellow[1,2]
Terri Jackson, PhD, Senior Research Fellow[2]
Stephen J Duckett, PhD, DSc, FASSA, Formerly, Professor of Health Policy[2]

1 Department of Human Services, Melbourne, VIC.
2 School of Public Health, La Trobe University, Bundoora, VIC.

Correspondence: terri.jackson@latrobe.edu.au

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