

Adverse drug events and medication errors in Australia

WILLIAM B. RUNCIMAN^{1,2}, ELIZABETH E. ROUGHEAD³, SUSAN J. SEMPLE³ AND ROBERT J. ADAMS⁴

¹Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital and University of Adelaide, ²Australian Patient Safety Foundation, Adelaide, ³Quality Use of Medicines and Pharmacy Research Centre, School of Pharmaceutical, Molecular and Biomedical Sciences, University of South Australia, Adelaide, ⁴Department of Medicine, University of Adelaide, Australia

Abstract

Purpose. To review information about adverse drug events (ADEs) and medication errors in Australia.

Data sources. Systematic literature reviews and reports from data collections of the Australian Bureau of Statistics, Institute of Health and Welfare, Council for Health Care Standards and Patient Safety Foundation.

Results (medical record reviews): We have shown that 2–4% of all hospital admissions, and up to 30% for patients >75 years of age, are medication-related; up to three-quarters are potentially preventable.

Results (routine data collections): Routine death certificate and hospital discharge data coded using the International Classification of Diseases capture less than half as many ADEs as medical record reviews. Of coded adverse events that contributed to death, 27% involved an ADE, as did 20% of adverse events identified at discharge and 43% at general practice encounters. There is a strong correlation between increases in medication use and rates of adverse drug reactions (ADRs) associated with hospitalization.

Results (drugs implicated): These were similar in all the above studies: anticoagulants, anti-inflammatory drugs, opioids, anti-neoplastics, antihypertensives, antibiotics, cardiac glycosides, diuretics, hypoglycaemic agents, steroids, hypnotics, anticonvulsants, and antipsychotics.

Results (clinical indicators): An ADE is reported in 1% of hospital admissions, while some hospitals do not report ADRs to the national collection. Only three-quarters of patients with acute myocardial infarction receive thrombolytics within 1 hour of presentation. Five per cent of patients on warfarin record an international normalized ratio >5, and 1%, 0.05%, and 0.2% suffer abnormal bleeding, cerebral haemorrhage, or death, respectively.

Results (the Australian Incident Monitoring System): Twenty-six per cent of 27 000 hospital-related incidents were medication-related, as were 36% of 2000 anaesthesia-related incidents, and 50% of 2500 general practice incidents.

Results (errors): Errors occur in 15–20% of drug administrations when ward stock systems are used and 5–8% when individual patient systems are used. Previous allergic reactions to drugs may not be recorded more than 75% of the time.

Conclusion. ADEs are common in the Australian health system. Anticoagulant, anti-inflammatory, and cardiovascular drugs feature prominently as preventable, high impact problems, and collectively make up over one-half of all ADEs. Methods for monitoring and preventing ADEs should be progressively improved.

Keywords: adverse drug events, adverse drug reactions, clinical indicators, incident monitoring, medication errors

Australia has a population of ~19 million and has a universal taxpayer-funded health care system that costs 8.3% of gross domestic product [1]. Every year in Australia almost 200 million prescriptions are dispensed; nearly 10 per person. In any 2-week period, medication has been taken by 70% of the overall population and >90% of the elderly [2]. The Australian Pharmaceutical Benefits Scheme facilitates access to certain

prescribed medicines for Australian citizens. Medications listed in the Pharmaceutical Benefits Schedule and Repatriation Pharmaceutical Benefits Schedule (the equivalent for the Australian Veterans Administration) are subsidized by the government. Recipients pay less than US\$15 for each prescription; this is reduced to less than US\$3 for pensioners and those on Social Security, or when the amount spent by an

Address reprint requests to W. B. Runciman, Department of Anaesthesia and Intensive Care, Level 5, Eleanor Harrauld Building, Royal Adelaide Hospital, North Terrace, Adelaide, SA 5000, Australia. E-mail: wrunciman@bigpond.com

individual or family exceeds US\$400 in a calendar year [3]. The overall cost to the community of subsidizing these medications exceeded US\$2 billion in the year 2001 [4]. It has been estimated that at least an additional US\$500 million is consumed by adverse drug events (ADEs) each year (1% of the total amount spent on health nationally) [1,5].

This paper reviews the available information about these events in Australia.

Methods

The types of events reviewed range from ‘adverse drug reactions’ (ADRs; responses to drugs that are noxious and unintended, and that occur at doses normally used in humans for the prophylaxis, diagnosis, or therapy of disease, or for the modification of physiological functions) [6] through to ADEs, which encompass both harm that results from the intrinsic nature of a medication (an ADR) as well as harm that results from medication errors associated with the manufacture, distribution, or use of medicines—including those that result from under-use of medicines or failure to prescribe a medicine when indicated [7,8]. Medication errors may be related to professional practice, health products, procedures, and systems, including prescribing, ordering, product labelling, packaging, nomenclature, compounding, dispensing, distribution, administration, education, monitoring, or use [8,9]. Other terms relating to specific studies that will be referred to include ‘medication incident’ (an event or circumstance associated with medication use that could have, or did lead to unintended and/or unnecessary harm to a person, and/or a complaint, loss or damage—including errors of omission, under-use and failure to prescribe [10]), and ‘medication-related problem’ (which includes adverse reactions as well as too little or too much of a correct drug, a wrong or unnecessary drug, and a drug being taken inappropriately) [11].

The Australian data sources on these types of events reviewed for this paper include the Quality in Australian Health Care study, drug-related hospital admission studies, routine data collections, including the mortality data collection, the national and state hospital morbidity data collections, drug utilization data from the Pharmaceutical Benefits Advisory Committee, the Australian Council for Health Care Standards indicator reports, studies of medication errors, the Australian Incident Monitoring System, annual surveys of general practice activity, and the quality use of medicines in the community implementation trial.

Quality in Australian Health Care Study

The results of the Quality in Australian Health Care Study were reviewed. In this study, 14 179 medical records representative of private and public acute-care hospitals in Australia were reviewed to identify adverse events [12]. Criteria for inclusion were unintended injury or harm to a patient, caused by health care management rather than a disease process, which led to hospitalization, prolongation of hospital stay, morbidity at discharge, or death. The proportion of hospital admissions

associated with ADEs, the drug groups implicated, and the proportion considered avoidable were extracted and tabulated; events due to errors of commission as well as of omission (under-use of medication or failure to prescribe an indicated medication) were included.

Drug-related hospital admission studies

A systematic review of Australian studies assessing drug-related hospital admissions was undertaken. Studies were included if they had been conducted within Australia since 1988, and had the primary aim of identifying drug-related hospital admissions as determined by clinical pharmacists or medical practitioners. The Medline and Aushealth databases were searched using the following terms; drug-related, admissions, readmissions, hospitalization and iatrogenic. Conference proceedings of major Australian Pharmacy meetings were also searched, including the Society of Hospital Pharmacists’ Conference, the Australasian Pharmaceutical Science Association and the Australian Society of Clinical Pharmacologists and Toxicologists meetings. The total number of admissions assessed, the proportion considered drug-related (due to ADRs, non-compliance, or overdose), the drug groups implicated, and the proportion considered preventable were extracted and tabulated.

Routine data collections

Mortality data. Data on the causes of all deaths registered in Australia are published by the Australian Institute of Health and Welfare [13]. The cause of death is determined from information on death certificates provided by doctors or coroners; both the underlying cause of death and contributory causes are coded using the International Classification of Diseases (ICD-10 AM). This includes both disease codes and external cause codes that relate to adverse events. Using the external cause codes, death can be categorized into misadventures, complications, or adverse events. One of the codes can be used to monitor ADRs as the cause of death (correct drug properly administered in therapeutic or prophylactic dosage as the cause of any adverse effect). As some deaths that could have been attributed to an adverse event would have been coded to external causes that are not specific to adverse events, the number of deaths involving an adverse event would have been underestimated.

The Hospital Morbidity Data Collections

Tabulated national data concerning hospital separations associated with ADRs were obtained from the National Morbidity Data Collection [14] and the South Australian Department of Human Services. The national hospital morbidity database contains data on all hospital separations from public and private hospitals. Its primary purpose is to record reasons for hospitalizations (including diagnoses), the procedures the patient underwent, and the external causes of injury and poisoning. It is not designed to provide information on adverse events. However, adverse events may be identified

using the nature and external cause of injury codes. Coding is based on the information documented in the medical record and is undertaken within individual institutions by trained staff. All hospital separations where an ADR was recorded were analysed (as identified by ICD-10 Codes Y40–59). The South Australian dataset was included in the analysis because all hospitals in South Australia have been reporting since 1988, enabling trends to be analysed.

Drug utilization data. The association between ADR trends and medication use was examined using prescription dispensing data obtained from the Drug Utilisation Subcommittee (DUSC) of the Pharmaceutical Benefits Advisory Committee. The Pharmaceutical Benefits Advisory Committee is an independent body that makes recommendations to the Federal Minister for Health about which medicines should be made available on the Pharmaceutical Benefits Schedule. The DUSC of the Pharmaceutical Benefits Advisory Committee collects and analyses data on drug utilization in Australia. The DUSC dataset [15] only provides data at the state level on prescriptions from 1990/1991 onwards and only includes prescriptions dispensed under the Pharmaceutical Benefits Schedule (PBS) and the Repatriation Pharmaceutical Benefits Schedule (RPBS), which are forwarded to the government for reimbursement. Government-reimbursed prescriptions represent ~70% of all prescriptions dispensed [16]. There are no data publicly available that provide a complete picture of drug use at the state level. Relevant state population statistics were used to calculate the defined daily doses per 1000 of the population per day (DDD/1000/day) [16].

Clinical indicators. The Australian Council on Healthcare Standards (ACHS) is a not-for-profit organization that was formed in 1974 to improve the quality of health care via hospital accreditation. In 1989 a national clinical indicator program was developed; >1000 health care services were enrolled [17]. The ACHS clinical indicators were developed in consultation with medical colleges, associations, and specialist groups. The published rates are weighted means derived from reports by the health care organizations (HCOs) enrolled for the relevant indicators. Hence, large HCOs have a greater impact on the overall rates. In addition to mean rates, the 20th and 80th percentiles are published for some indicators. These are based on the rank of the HCOs for each indicator and represent the rates for which 20% of HCOs are below and 20% are above.

Medication incidents. The Australian Incident Monitoring System (AIMS) [18] collects information on actual or potential incidents routinely collected from participating public hospitals. Currently all public hospitals in South and Western Australia participate, with some hospitals from Victoria and New South Wales, and hospitals from the Northern and Australian Capital Territories contributing. General medical practitioners have also started participating in the process. The database included >27 000 incident reports at the end of 2002.

Medication errors. Information about medication errors in Australia was obtained by reviewing studies identified using searches of Medline, Current Contents, and AustHealth, in addition to hand searches of conference proceedings, including the Society of Hospital Pharmacists, the Australasian Pharmaceutical Science Association, and the Australasian Society of

Clinical and Experimental Pharmacologists and Toxicologists. Search terms included 'drug-related', 'iatrogenic', 'administration error', 'medication' or 'drug administration', 'prescription' or 'prescribing error' and 'dispensing error'.

Adverse drug events in the community

General practice surveys: Bettering the Evaluation and Care of Health (BEACH). Data concerning general medical practice activity are routinely collected in Australia from an ongoing representative cross-sectional survey involving ~1000 GPs and ~100 000 consultations annually [19]. The data collection includes patient demographics, reason for encounter, problems managed, and actions taken, including referral, medication use, and use of diagnostic services.

Quality use of medicines in the community implementation trial. Pharmacists are now funded to provide medication management services in Australia. The service focuses on the identification and resolution of drug-related problems. The service includes an interview with the patient and collaboration with the patient's community care providers. Pharmacists keep case notes of each service. An independent review of the pharmacist case notes of 1000 people considered to be at high risk of medication problems [20] was undertaken to identify the number and type of medication-related problems observed.

Results

The Quality in Australian Healthcare Study (QAHCS)

In the original report, 233 admissions were found to be associated with an ADE (1.6% of admissions to acute-care hospitals). Overall, 43% were deemed preventable; this ranged from 9% for anti-neoplastic drugs to 74% for cardiovascular drugs [12]. When inclusion criteria were limited to those used in a similar US study of 15 000 medical records drawn from the same year, 1992 [21], and the adverse events were classified into clinically relevant categories, 174 admissions were associated with specific medication-related adverse events [22] (see Table 1). However, there were >100 further admissions associated with medication-related problems that were classified into categories other than ADEs, such as poor management of left ventricular failure and poor prophylaxis of asthma or seizures, which would suggest that, overall, ~2% of admissions were associated with a harmful ADE [22] (see Table 1).

Drug-related hospital admission studies

The percentages of admissions attributed to medication-related problems in identifiable groups of patients are shown in Figure 1 [23–35]. The medications and problems most commonly involved were the same as those listed in Table 1. Estimates of percentages of problems that were potentially preventable ranged from 32% to 77% [26,35,36].

Although most of the studies were conducted at single hospitals, the findings are quite consistent within the groups

Table 1 Clinically relevant categories with two or more adverse drug events from the Quality in Australian Healthcare Study

	Number of cases
Heparin: thromboembolism due to failure to prescribe prophylaxis	36
Non-steroidal anti-inflammatory drugs: gastrointestinal bleed	24
Warfarin: for embolic strokes (failure to prescribe) (4) to bleeds (9)	13
Allergies to new medications	13
Antihypertensives: hypotension/syncope	12
Antineoplastics: related problems	11
Hypoglycaemic agents: difficulty controlling blood sugar level	10
Opioids: respiratory depression (4), constipation (3)	7
Antibiotics: diarrhoea	6
Diuretics: dehydration/hypokalaemia	5
Digoxin: toxicity	3
Gentamicin: acute renal failure	3
Phenothiazines: dystonic effects	2

There were other clinical categories in which medication-related problems would have played a role in many cases: post-operative pain (16 cases); post-operative nausea and vomiting (20 cases); no/delay/inadequate treatment of heart failure (13 cases); no/inadequate prophylaxis for asthma (7 cases); seizure following cessation/reduction/non-prescription of anti-epileptic drug (6 cases); and inadequate antibiotic prophylaxis for an indeterminable number of wound infections (112 cases).

of patients studied, and suggest that 2–4% of all admissions are medication-related, with higher rates for emergency admissions, yet higher rates for admission to medical wards, and the highest rates in the elderly, rising to >30% for unplanned admissions in patients >75 years of age.

Routine data collections

Mortality data. ADRs were implicated in 1473 out of 5533 deaths (27%) to which adverse events contributed in the years 1997 and 1998. Note the death certificates only code ADRs. Extrapolation of ADEs from the QAHCS figures [12] would suggest that ADEs, which include ADRs, account for four times this number of deaths.

Hospital morbidity data. In 1997–1998 there were 264 347 discharges where an adverse event was identified, representing 4.75% of discharges. ADRs accounted for 53 388 of these (20%) [37]. In 1999–2000, the number of ADRs recorded was 69 766. Note that the coding process only identifies ADRs. Extrapolation of the QAHCS figures would suggest that ADEs, including ADRs, account for double this number [22]. It has been shown that even when appropriate codes exist for ADRs, they are so coded in only 11–31% of cases [38]. A breakdown of ADRs by type of drug is presented in Figure 2 [39]. The drugs involved are similar to those identified in the Quality in Australian Health Care Study [22] (see Table 1).

Drug utilization data: ADR trends and medication use

When trends in ADRs reported in the hospital data collection for South Australia data [40,41] are plotted with routinely collected data from the Pharmaceutical Benefits Scheme [15] and tracked over time, it may be seen from Figure 3 that ADRs increased >4-fold between 1988/1989 and 2000/2001,

and that there is a strong correlation between increasing medication use and increasing rates of ADRs (Spearman correlation = 1; $P=0.01$).

Clinical Indicators. Rates for the year 2000 are cited unless otherwise indicated [17].

Adverse drug reactions. Two indicators related to these are used by the ACHS. One is a measure of reporting to the Australian Adverse Drug Reactions Advisory Committee (ADRAC) as a proportion of ADEs reported internally within HCOs. ADRAC was established in 1970 to collect ‘suspicions of ADRs’ via a voluntary spontaneous reporting system; it currently receives ~1000 reports per month. Most reported rates for individual HCOs were 0% or 100%, which seems most likely to be a reflection of the mechanisms for reporting within each HCO.

The other indicator is reporting the number of ADRs reported per 100 admissions to hospital. The overall mean rate was 1%, with low rates generally. An interesting feature of this indicator is the ACHS interpretation that HCOs with higher rates have more problems and need to improve. This is inconsistent with current expert opinion, suggesting that higher rates of reporting may reflect greater awareness and a better ‘safety culture’.

Warfarin complications. This is an indicator for monitoring rates of warfarin complications, specifically INR >5, cerebral haemorrhage, abnormal bleeding, and death. The denominator for each of these is non-same-day discharges receiving warfarin. For INR >5, the mean rate was 5.1% (80th percentile, 9.0%; 20th percentile, 4.8%). For abnormal bleeding the mean rate was 1% (20th percentile, 0.8%; 80th percentile, 1.5%), for cerebral haemorrhage the mean rate was 0.05%, and for death the rate was 0.2%.

Thrombolytic use. The overall mean rate (78%) indicates that only three-quarters of patients who present with myocardial infarction receive thrombolytics within 1 hour of presentation.

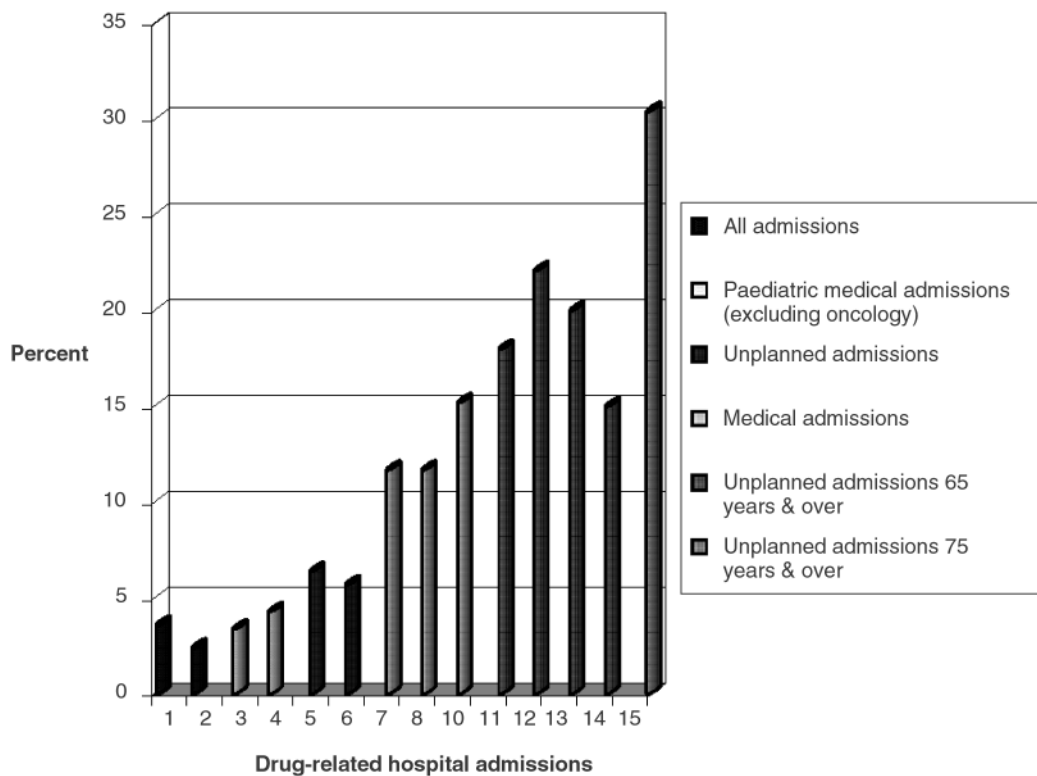


Figure 1 Results of Australian studies (numbered 1–14) assessing drug-related hospital admissions, 1988–2001. The following data refer, respectively, to population group [reference number]/number of admissions assessed/number of drug-related admissions. Study number 1: all admissions [23]/947/34; 2: all admissions [24]/5623/136; 3: paediatric medical admissions excluding oncology [25]/1682/58; 4: paediatric medical admissions excluding oncology [26]/2949/127; 5: unplanned admissions [27]/751/48; 6: unplanned admissions [28]/965/55; 7: medical admissions [29]/419/49; 8: medical admissions [30]/691/81; 9: medical admissions [31]/217/33; 10: unplanned admissions ≥ 65 years [32]/172/31; 11: unplanned admissions ≥ 65 years [33]/217/48; 12: unplanned admissions ≥ 65 years [34]/245/49; 13: unplanned admissions ≥ 65 years [34]/541/81; 14: unplanned admissions ≥ 75 years [35]/240/73. This figure was reproduced with permission [42].

The 20th percentile rate was 70%, and 12 HCOs (11%) had rates of $< 50\%$; the 80th percentile was 86%. There were large variations between states, which did not appear to be related to population size or density. This indicates that there is substantial potential for improvement in some states.

Pulmonary embolism. This indicator is the rate of pulmonary embolism in patients with a post-operative stay of ≥ 7 days. The pulmonary embolism rate may reflect some errors in omission of indicated medications because it is partly attributable to failure to prescribe anticoagulants appropriately. The criteria for diagnosis and inclusion of pulmonary embolism in the datasets vary from HCO to HCO, and thus the overall figure is an approximation, but does include instances of non-prescription of indicated prophylaxis. The mean rate has remained stable at $\sim 0.4\%$ for the last 3 years, and the 20th and 80th percentiles are relatively close to the mean (0.3% and 0.7%, respectively). Overall, there were 14 HCOs with statistically higher rates than expected in the year 2000, which resulted in 98 excess cases of pulmonary embolism. There were no differences between states, suggesting a reasonable degree of consistency in spite of non-standardized methods for diagnosing pulmonary embolism.

Medication prescription to allergic patients. This indicator is the rate of prescription of medication to patients with a known adverse reaction to that medication, without a documented reason from the prescriber. In 1998, 151 HCOs reported 736 cases, with 19 reporting more than nine cases, in 1999 134 HCOs reported 530 cases, with 13 reporting more than nine cases, and in 2000 19 HCOs reported 614 cases, with 17 reporting more than nine cases. This suggests ongoing problems with recording of previous adverse reactions and cross-checking medications against recorded reactions. The indicator does not enable determination of whether or not an actual ADR occurred.

The ACHS indicators were an early attempt at outcome measures. They have the merit of targeting some activities throughout the health care system, and of having been established in consultation with the relevant specialist groups. However, they possess significant weaknesses, including an absence of rigour and difficulties in data collection. They provide no information about process and further studies have to be undertaken to identify appropriate corrective actions. Also, as they cover only a few areas of clinical importance, there is the

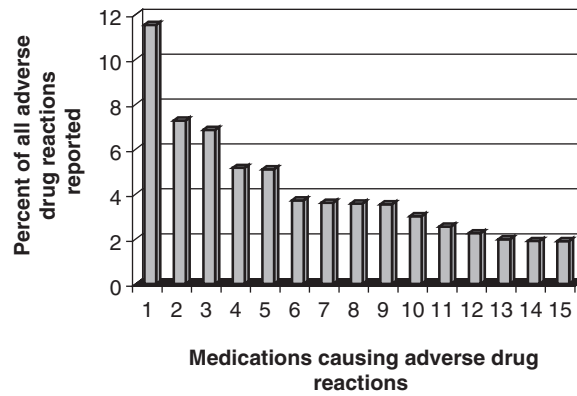


Figure 2 Drug groups most commonly reported as causing an adverse drug reaction associated with hospitalization (Australia, 1999/2000). The following data refer, respectively, to: drug group/ICD-10-AM code(s). Drug group number 1: antineoplastics/Y431, Y432, and Y433; 2: anticoagulants/Y442; 3: opioids/Y450; 4: NSAIDs/Y451, Y452, and Y453; 5: glucocorticoids/Y420; 6: antihypertensives (excluding beta blockers and diuretics)/Y521, Y524, and Y525; 7: cardiac glycosides/Y520; 8: antipsychotics/Y493, Y494 and Y495; 9: penicillins/Y400; 10: diuretics/Y542, Y543, Y544, and Y545; 11: anti-epileptics/Y460, Y461, Y462, Y463, and Y464; 12: cefalosporin/Y401; 13: B antagonists/Y517; 14: coronary vasodilators/Y523; 15: antidepressants/Y490, Y491, and Y492. This figure was reproduced with permission [42].

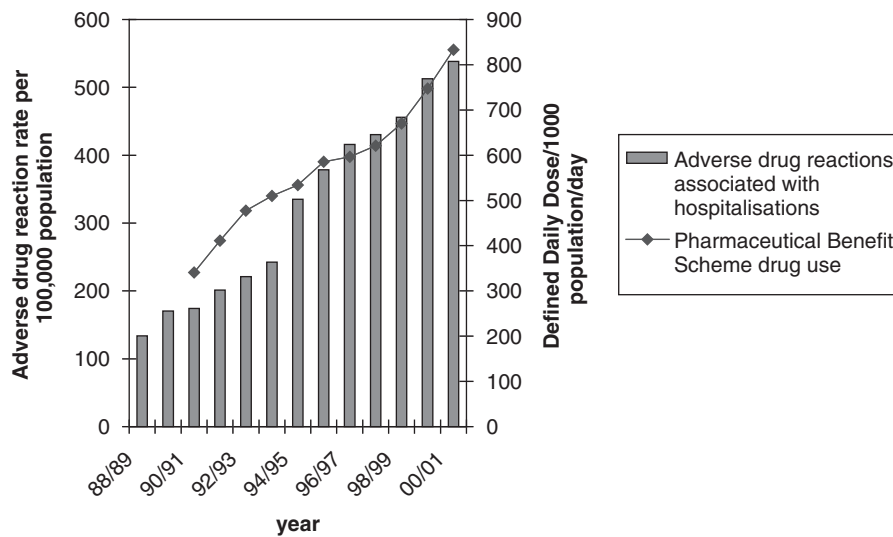


Figure 3 Trends in rates of adverse drug reactions (ADRs) associated with hospitalizations and trends in medication use (South Australia, 1988/1989 to 2000/2001). This figure was compiled from data supplied by the Integrated South Australian Activity Collection [all hospitalizations where an ADR code was reported (ICD-10-AM codes Y40.0 to Y59.9)] [40], the Australian Bureau of Statistics (population data) [41], and the Drug Utilisation Subcommittee of the Commonwealth Department of Health and Ageing (medications dispensed under the Pharmaceutical Benefits Scheme) [15]. South Australian data were used as the National Data set is only complete from 1996 onwards. This figure was reproduced with permission [42].

risk of ‘gaming’ by organizations, i.e. concentrating on these areas whilst ignoring other problems. Nevertheless, they do provide some indication to HCOs of areas that may need improving, and they can progressively be refined [18].

Medication incidents

Of the 27 000 incidents collected in hospitals up to 2002, 7155 (26%) were medication-related [42]. Of the medication

incidents, 4563 named a specific substance. The major drug groups implicated were similar to those shown in Table 1.

In 469 medication incidents, the cause of error was identified. A failure to read or misreading of the chart accounted for the majority of errors, with prescription or order errors and an unclear or incomplete order being the next two categories most commonly identified. The results of these errors are shown in Figure 4. Two-thirds were considered to have no or minor sequelae, 19% moderate sequelae, and 3% significant sequelae [42].

Table 2 Incidents due to drugs amongst the first 2000 anaesthesia-related incidents reported to the Australian Incident Monitoring System

	No.	Percentage ¹
Overdosage	160	8
Other drug incident	133	7
Side-effect	117	6
Syringe swap/ampoule	113	6
Underdosage	68	3
Allergy phenomenon	62	3
Inappropriate drug	49	2
Interaction	21	1
Total	723	36

¹Percentage of the first 2000 anaesthesia-related Australian Incident Monitoring System incidents. This table was reproduced with permission [43].

AIMS also has collections of incidents from medical specialties. Of the first 2000 anaesthesia-related incidents, over one-third were medication-related (see Table 2) [43]. Some categories representing problems of particular significance to anaesthetists have been subjected to further study (e.g. syringe/ampoule swap with intravenous injection [44]).

A voluntary anonymous system was also set up to identify incidents in general practice. Of 2582 reports, half (1294) involved medication-related problems [45]. More common in general practice than in hospitals were problems with therapeutic use (26% versus 8%), and prescribing of contraindicated medications (15% versus 5%). In the latter group, 64 reports (4%) involved prescription of a medication to which the patient was known to be allergic, 66 (4%) medications for which there was a recognized potential for a drug interaction,

and 68 (4%) medications contraindicated due to pathophysiological factors.

The collections of incidents from hospitals, various specialties, and general practice have so far used different classification systems. There are plans to cross-map all these to a new national classification system which has been developed by the Australian Patient Safety Foundation [18].

Medication errors

Administration errors. A number of studies in hospitals looked at error rates with the administration of medicines for different supply systems. Where administration is based on 'ward stock' systems (i.e. where a ward has bulk stock for many patients that must be measured and dispensed by staff), error rates ranged from 15% to 20% [46,47], but where individual patient supply was used, i.e. when hospital pharmacies measure and dispense doses intended for individual patients, error rates ranged from 5% to 8% [47–49]. Many of these errors have little potential for harming a patient (e.g. omission of a dose, or a dose given early or late), but some do (e.g. use of the wrong formulation, wrong route, or wrong drug). One study estimated that administration errors were clinically significant in one-fifth of cases and potentially clinically significant in two-thirds [48].

Prescription/ordering errors. Medication errors can also occur when prescriptions or orders are written or transcribed from one medication chart to another. Australian studies on prescribing and ordering errors all used different methods; their findings are summarized in Table 3 [50–53]. Only one study assessed the likelihood of prescription errors leading to ADEs. This found that 71 of 2978 prescriptions (2.4%) had the potential to cause an ADE, usually because the dose was wrong or ambiguous (1%), the dose was missing (0.6%), or the directions were unclear or absent (0.5%) [50].

Dispensing errors. Only two Australian studies were identified. One found the rate of dispensing errors from a hospital

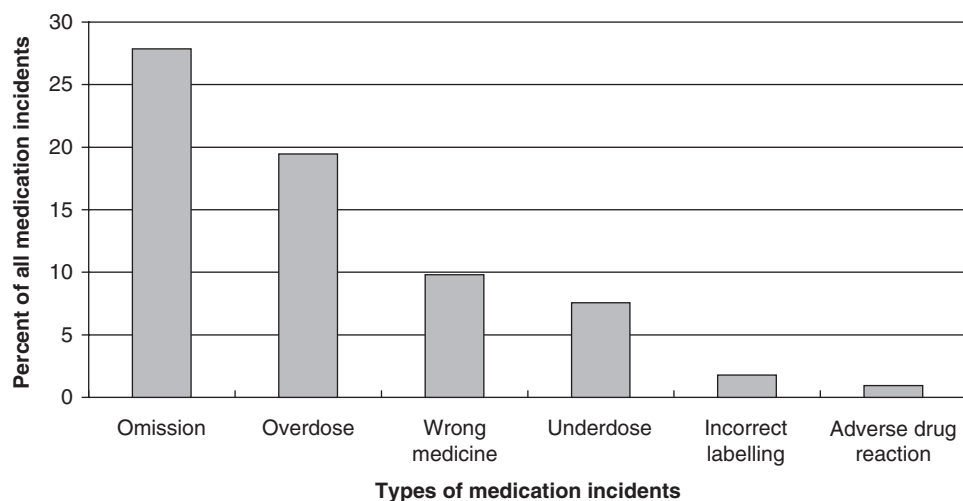


Figure 4 Types of medication incidents reported in the Australian Incident Monitoring System dataset. This figure was reproduced with permission [42].

Table 3 Prescription and transcription errors: Australian hospitals, 1985–2001

Reference	Number of prescriptions or charts audited	Number (%) errors detected	Major findings (percentage of prescriptions or charts)
In-patient and discharge prescriptions in medical and surgical wards			
Coombes <i>et al.</i> , 2001 [50]	2978 prescriptions	71 errors ¹ (2.4%)	Wrong dose (1.0%), missing dose (0.6%), missing frequency (0.4%)
Medication charts in a paediatric department			
Dawson <i>et al.</i> , 1993 [51]	212 medication charts ²	52 major errors (25%)	Wrong dose (12.3%), wrong frequency (5.7%), wrong route (5.2%), wrong name or formulation (1.4%)
Dawson <i>et al.</i> , 1993 [51]	325 medication charts ²	35 major errors (11%)	Wrong dose (4.9%), wrong route (2.5%), wrong frequency (1.8%), wrong name or formulation (1.5%)
Medication charts in medical, surgical, childrens' wards, and a critical care unit			
Leversha, 1991 [52]	6641 medication charts	241 errors (4%)	Wrong dose for the patient's condition (1.2%), no strength specified (1.0%), insufficient information (0.2%), failure to record current (ongoing) medication (1.0%)
Prescriptions presented at pharmacy department			
Fry <i>et al.</i> , 1985 [53]	10 562 prescriptions	574 (5%)	Assessed legal requirements (e.g. signature) as well as clinical requirements (e.g. dose), wrong strength (0.7%), missing directions (0.4%), wrong drug (0.06%)

¹Errors with the potential to cause any adverse event.

²Unit of analysis in medication chart, which may include one or more prescriptions. This table was reproduced with permission [42].

pharmacy department to be 0.8% [54], and the other study found dispensing errors rates of 0.4% and 0.08% [55]. The potential for these errors to lead to patient harm was not reported.

Errors in recording allergy history. Three studies were identified. One reported that 8% of medication histories omitted known allergic reactions [56], and the other two that previously known ADRs were not documented in 48 of 62 cases (77%) [50] and 88 of 117 cases (75%) [57].

General practice surveys (BEACH data)

An adverse event was managed at 0.89% of encounters in 1998–99 and 0.91% of encounters in 1999–2000. Medication-related adverse effects made up 43% of these problems [37]. As there are >100 million general practice encounters each year in Australia, an extrapolation of these figures suggests there are >400 000 general practice encounters each year at which a medication-related problem is managed [42].

Incidence of medication-related problems in the community

A review of the case notes of 1000 people considered to be at high risk of medication problems identified 2764 medication-related problems (2.8 problems per person). Of these, 37% related to medication selection, 17% to the medication regimen, and 20% to patient knowledge and ability to manage their medicines [20]. The medications most commonly involved were again those listed in Table 1. The number of problems experienced increased with the number of medications taken (Figure 5).

Discussion

If we accept that 2.5% of admissions are medication-related, then there would be 150 000 such admissions each year in Australia (in 1999–2000 there were 5.9 million hospital admissions

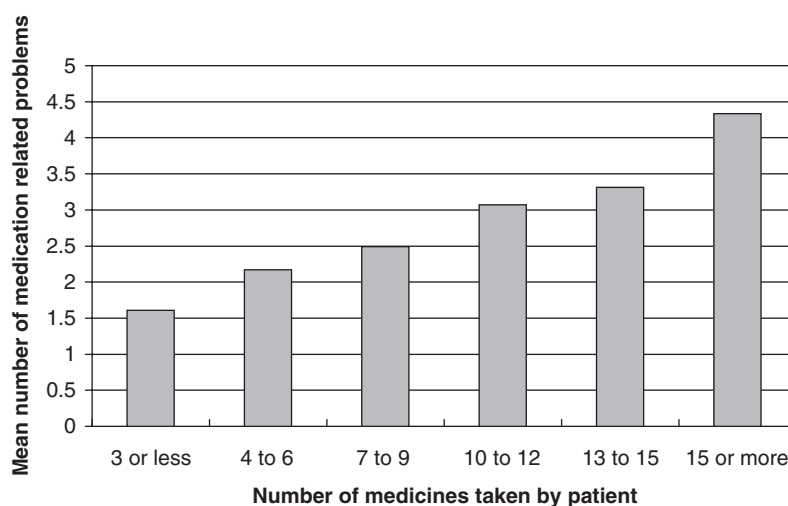


Figure 5 Average numbers of medication-related problems by number of medications being taken by patients.

in Australia) [14]. As the average cost of a hospital admission was AUS\$2728 in 1999/2000 [14], hospital costs alone would amount to over AUS\$400 million per year. Costs are likely to be higher than this as adverse event-related admissions cost substantially more than average [58]. It should also be recognized that this estimate does not include the cost of >400 000 general practice encounters managing medication-related problems per year, or the social and human costs of ADEs.

There is no comprehensive, reliable source of information about ADEs, medication errors, or medication-related problems. Medical record review provides an estimate of frequency but is very 'threshold dependent', with rates varying several-fold between studies even when the same definitions and training manuals were used by reviewers [60]. However, a consistent overall pattern emerges even when different definitions and study methods are used. Problems from failing to prescribe or adequately manage anticoagulants account for up to one-third of potentially preventable adverse medication events, as determined by medical record review (see Table 1, assuming that allergies to new medications are not preventable), and are ranked second after antineoplastic drugs as being responsible for medication-related hospital admissions (see Figure 2). We have previously estimated that, overall, problems with anticoagulants alone could amount to costs of \$AUS100 million each year in Australia [59].

The same classes of drugs are consistently implicated in studies of ADEs (see Table 1), drug-related hospital admissions [23–35], adverse events associated with hospitalizations (see Figure 2 [30]), and medications implicated in incidents [42]. Anticoagulants, non-steroidal anti-inflammatory drugs (NSAIDs), and cardiovascular drugs (including anti-hypertensives, diuretics, vasodilators, and cardiac glycosides) together make up over half of all potentially preventable medication-related events, and anti-neoplastic drugs, opioids, steroids, and antibiotics also feature prominently. The types of errors detected vary considerably between studies and with method of detection, but errors of omission and under-use make up as much as one-third of the total when carefully looked for [22].

The frequencies of some problems seem quite unacceptable and suggest that steps must be taken to improve the systems around drug usage (e.g. medication problems are associated with 30% of admissions in patients >75 years old [35], error rates are up to 20% for drugs administered from ward stocks [46,47], and there is a failure to document previously known ADRs in three-quarters of all cases [50,57]). There is an urgent need to improve, standardize and, where possible, automate methods for recording medication-related problems and ADEs, for medication record review and for gathering data for clinical indicators. The range and utility of indicators should be progressively improved, and detailed root cause analysis conducted for a sample of problems identified by incident monitoring, standard processes for which are being introduced across Australian health care in the years 2003 and 2004. These data should then be used to better prevent and manage ADEs.

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