

Literature review: medication safety in acute care in Australia

Prepared for:

Australian Commission on Safety and Quality in Healthcare

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July 2008

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Executive summary

This literature review encompasses studies examining medication related problems in the acute care setting. The extent of medication-related problems appears unchanged, with approximately 2%-3% of hospital admissions being medication-related. Of the studies that have assessed preventability, estimates remain relatively consistent with approximately 50% potentially preventable (range 32%-77%). Of note is a new study assessing adverse drug reactions amongst oncology patients, finding 74% of admissions were associated with an adverse drug reaction (cause of admission or occurred during hospital stay) with 48% considered potentially preventable. Of note also is a study demonstrating that adverse events within hospital transfer were also high, with one study showing 10% of discharges from an intensive care unit to other wards within the hospital were associated with an adverse event within 72 hours of discharge. While not medication specific, the majority of adverse events involved IV fluids.

Results of incident reporting are now published, with consistent results observed in South Australia, Western Australia and New South Wales. Medication remains the second most common type of incident reported, mostly reported by nurses. Omission or overdose of medication is the most frequent type of medication incident reported, with analgesics and anticoagulants being the medicines most commonly implicated, and incidents most commonly occurring at breakfast time or in the evening. Of note is a South Australian survey that found 100% of nurses surveyed stated they always reported a medicine error that required giving patient corrective treatment, compared to only 40% of the doctors surveyed, however, less than 20% of doctors or nurses indicated they reported near-misses medication incidents.

One new study that assessed the overall incidence of prescribing errors on discharge prescriptions found an 11.6% error rate for computer generated prescriptions compared with 5.0% for hand written prescriptions. Studies undertaken overseas have shown computerised prescribing, entry and ordering systems do reduce adverse drug events. The authors of the Australian study conclude that the results suggest computerised prescribing systems without decision support may not reduce prescribing errors. There were no new studies located that assessed administration or dispensing errors. One study, assessing administration error rates for IV fluids found an error rate of 18%. The existence of peripheral lines being a significant factor associated with increased risk.

There is now a much stronger Australian research base demonstrating that systems factors are contributing to medication errors, with team, task, environmental, individual and patient factors contributing to error. Environmental factors included issues such as staffing levels, skill mix, workload, workflow design, administrative and managerial support. Task factors included issues such as the medication chart design, protocols and availability and accuracy of test results. Individual factors included knowledge and skills, motivation, and individual health. Team factors included issues such as communication, supervision and structure, while

patient factors included condition and communication ability. Organizational factors and work flow are noted as factors contributing to error.

In 2002, the former Australian Council for Safety and Quality in Health Care, in its national report on medication safety, highlighted a number of systems solutions known to be effective in improving medication safety. These included individual patient medication supply systems; clinical decision support systems; adverse drug event alerts; systems that provide adequate checking, such as bar coding; as well as provision of clinical pharmacy services and discharge medication management services. No new studies were located that have assessed the impact of individual patient supply, adverse drug event alerts or bar coding and the extent of their implementation across Australia is unknown.

New strategies that have been assessed included double checking versus single checking by nurses for safe medication administration and patient self-administration. The study that assessed whether single checking by nurses is as effective as double checking found no difference between groups, however, the study was small, only located in one hospital and possibly had insufficient power to detect differences, so does not provide sound evidence of effectiveness. The study assessing patient self-administration compared to nurse administration, undertaken within constraints where patients were only able to self-administer after demonstrating competence, also found no difference between groups, however it too was small, only located in one hospital and possibly had insufficient power to detect differences, so does not provide sound evidence of effectiveness. Other strategies that have been implemented but the impact on medication error rates not reported included leu incompatible systems to avoid incorrect route of administration for intravenous and intrathecal injections as well as the removal of concentrated potassium chloride from wards, with replacement by pre-mixed solutions. The National Inpatient Medication Chart, a standardised medication chart, has been implemented widely, with studies showing improvements in process measures likely to be associated with a reduction in adverse medication events.

There are now studies assessing education and training for medication error, with error scenarios used for nurse and medical student education. Academic detailing has been demonstrated to reduce errors in prescriptions for schedule eight medicines where error rates were high and an education program was also shown to be effective in reducing the use of error prone prescribing abbreviations in the emergency department setting.

Studies have assessed the implementation of computerised prescribing and decision support, suggesting computerised prescribing alone without decision support, may lead to increased error, and that implementation must include education and training for staff as well as a change management strategy. In one study the use of the system in the acute ward setting had to be discontinued after six weeks in a rural hospital and eight weeks in a metropolitan hospital. The barriers to effective implementation were perceptions of increased clinical risk; workload issues; lack of medical staff commitment; insufficient computer access and technical and software limitations (including inadequate interaction and allergy checking, and problems with version control). The experience in the sub-acute ward setting in both hospitals

was different, with its use becoming accepted practice and the system being rolled out to other sub-acute wards. In order to implement the system effectively provision of training in the system away from the clinical areas was considered important. A committed clinical champion for the system was also suggested as a means of improving staff commitment to the technology. It was concluded that implementation of electronic prescribing and clinical decision support systems requires a highly organised approach at all levels of the institution, giving consideration to the technical issues as well as the culture and environment in which it is to be used. Similarly, the need for standardisation of systems has been acknowledged with one study finding the majority of clinicians favoured the idea of a state-wide system which would mean staff changing between institutions would not need to re-learn a system and communication and transfer of patient information between different institutions would be facilitated. Similarly the need for integrated systems was highlighted so that there was no need to log into different systems for different types of results.

Studies have also continued to assess discharge planning or liaison pharmacy services primarily focusing on implementation issues now that funding is available for community based services. Some of the barriers to home medication reviews after discharge included time factors for both general practitioners and pharmacists and lack of patient interest as well as the ability to engage an accredited pharmacist within a timely manner. One new model assessed included a transition co-ordinator to assist transfer of medication information for patients discharged from hospital to residential aged-care facilities. The model included a medication transfer summary, coordination of a medication review by the pharmacist contracted to the facility and a case conference including the pharmacist coordinator, family physician, community pharmacist and registered nurse from the facility. The model demonstrated an improvement in medication appropriateness compared to controls, however there was no significant impact on adverse drug events seen with the intervention. Another model studied was the 'Heartlink' medication management pathway for patients with chronic heart failure which involved both a community liaison pharmacist and medication management review facilitator. Only process measures were assessed with participants considering the service improved transfer of information.

While there is now a stronger evidence base demonstrating that systems factors are major contributors to medication errors, there is very limited research assessing the impact of an integrated set of activities on medication safety, with no Australian studies located that have assessed the impact of these activities using adverse drug events as the outcome.

The extent and causes of medication related problems in acute care

Medication-related hospital admissions

There are two new studies since 2002 that give additional insight into the incidence of medicine-related hospital admissions^{1,2}. One, used the hospital morbidity records to determine the incidence of adverse drug reactions, finding 1.3% of admissions were associated with an adverse drug reaction at the time of the admission and that required treatment.¹ Interestingly, another 0.3% of admissions had an adverse drug reaction identified at the time of admission, but not treated. A further 1.2% of admissions were associated with an adverse drug reaction that occurred during hospital stay¹. It should be noted that use of morbidity records alone is likely to under-estimate the incidence of these events as it has been demonstrated that while accurate, the adverse drug reaction codes are under-reported.³ The second study assessed the incidence of adverse drug reactions in oncology patients². It included both adverse drug reactions present on admission and occurring during hospital stay, with the finding that 74% of oncology admissions were associated with an adverse drug reaction, with a median of 2 adverse drug reactions per admission. It determined that 47% were potentially preventable. Patients were asked to rate the impact on the adverse drug reaction on a scale from 0 (no impact at all) to 6 (totally changed my life) with 53% rating the reaction at four or above and 19% rating the adverse drug reaction as “totally changed by life.”²

The inclusion of these studies with the results from the previous quality and safety report (table 1) still suggest an overall rate of medicine related hospital admissions of between 2% and 3%. Attendances to the emergency department have also been added to table one, as there is one new study undertaken in the paediatric population⁴ and one new study in the adult population.⁵ Results from the general population of 8.3% of adult emergency attendances (not admitted) being medicine related⁶ pertain to data collected in 1993. A more recent study found an adverse drug reaction rate of 1.4% in emergency department attendances (including those subsequently admitted) and another 18 adverse drug events documented,⁵ but an overall incidence rate of emergency department attendances due to medication-related problems was not able to be calculated. This is not dissimilar to the community estimates that 10.4% of people attending a general practitioner had had an adverse drug event in the previous six months.⁷ Preventability estimates for medication-related hospital admissions and adverse drug reactions associated with hospitalization still suggest between one third and three quarters are potentially preventable (table 2).

Two other studies that also give insight into adverse drug reactions during hospitalization, but not incidence figures, used the hospital morbidity coding records for Western Australia^{8,9}. One found the trend over time in adverse drug reactions associated with hospital admissions had increased five-fold between 1981-2002, from 2.5 per 1000 person years to 12.9 per 1000 per years⁸. This is similar to what was reported from South Australia,¹⁰ with the South Australian results showing a strong correlation with medication use, suggesting the increase is related to changes in medication use rather than an increased incidence of events. The second study reported “repeat” adverse drug reactions, finding that “repeat” adverse drug related hospitalizations increased at a faster rate than the overall rate of adverse drug reaction hospitalisations, with estimates that repeat adverse reaction hospitalisations accounted for 30% of all adverse drug reaction hospitalisations by 2003⁹. This result should be interpreted cautiously. “Repeat” adverse drug reactions include another admission for an adverse drug reaction not a repeat admission for the same adverse drug reaction. Further, the results have

not been adjusted for length of follow-up, which potentially biases the results. Cytotoxics and hormones accounted for a larger proportion of repeat admissions than second admissions,⁹ which may indicate that treatment patterns for the underlying diseases impacted on the overall population available for repeat admissions, as the study by Lau et al.², demonstrated high rates of adverse drug reactions in the oncology population.

Table 1: Medication-related hospital admissions or readmissions: Australia 1988 - 2007

	Total admissions reviewed	Total medicine related	Type of medicine related admission			
			Adverse drug reaction	Non-compliance	Over-dose	Other
All hospital admissions assessed						
Carroll et al., 2003 ¹	50712	643 1.27%	643 1.27%	N/A	N/A	N/A
Gleeson 1988 ¹¹	947	34 (3.6%)	34 (3.6%)	N/A	N/A	N/A
Larmour et al 1991 ¹²	5623	136 (2.4%)	90 (1.6%)	5 (0.09%)	40 (0.7%)	1 (0.02%)
Admissions via Emergency Department assessed						
Galbraith 1993 ⁶	751	48 (6.4%)	Unknown	Unknown	7 (0.9%)	Unknown
Dartnell et al 1996 ¹³	965	68 (7%)	26 (2.7%)	15 (1.6%)	13 (1.3%)	14 (1.5%)
Admissions to Medical Wards assessed						
Sarkawi & Daud 1995 ¹⁴	419	49 (11.7%)	21 (5%)	12 (2.9%)	14 (3.3%)	2 (0.5%)
Stanton et al. 1994 ¹⁵	691	81 (11.7%)	21* (3%)	10* (1.4%)	26* (3.8%)	11* (1.6%)
Leishman & Vial 1998 ^{al6}	217	33 (15.2%)	10 (4.6%)	8 (3.7%)	11 (5.1%)	4 (1.8%)
Unplanned readmissions assessed						
Blackbourn 1991 ¹⁷	180	29 (16%)	12 (6.7%)	14 (7.8%)	1 (0.6%)	2 (1.1%)
Hewitt 1995 ¹⁸	131	46 (35%)	29 (22%)	1 (0.8%)	0	16 (12.2%)
Greenshields et al., 1997 ¹⁹	63	17 (27%)	unknown	unknown	unknown	unknown
Stowasser et al., 2000 ^{a20}	28	9 (32.1%)	unknown	unknown	unknown	unknown
Paediatric admissions assessed – medical only excluding oncology						
Easton, 1998 ²¹	1682	58 (3.4%)	10 (0.6%)	29 (1.7%)	10 (0.6%)	9 (0.5%)
Easton et al 2004 ²²	2933	127 (4.3%)	29 (1.0%)	38 (1.3%)		

Table 1: Medication-related hospital admissions or readmissions: Australia 1988 – 2007 (cont.)

	Total admissions reviewed	Total medicine related	Type of medicine related admission			
			Adverse drug reaction	Non-compliance	Over-dose	Other
Geriatric admissions via emergency departments assessed						
Ng 1996 ²³	172	31 (18%)	18 (10.5%)	5 (2.9%)	1 (0.6%)	7 (4.1%)
Atkin et al 1994 ²⁴	217	48 (22.1%)	41 (18.9%)	5 (2.3%)	1 (0.5%)	1 (0.5%)
Wong et al. 1993 ²⁵	245	49 (20%)	35 (14.3%)	13 (5.3%)	1 (0.4%)	N/A
Wong et al. 1993 ²⁵	541	81 (15%)	61 (11.3%)	19 (3.5%)	1 (0.2%)	N/A
Harding, 1998	16	6 (37.5%)	4 (25.0%)	1 (6.25%)	0	1 (6.25%)
Chan et al., 2001 ²⁶ (>=75 years)	240	73 (30.4%)	32 (13.3%)	9 (3.8%)	1 (0.42%)	31 (12.9%)
Cardiac patients admitted to the coronary care unit or medical wards						
Lee & Oldenburg 1993 ²⁷	112	37 (33%)	14 (12.5%)	11 (9.8%)	0	12 (10.7%)
All admissions: ADRs during hospital stay or on admission						
Carroll et al., 2003 ¹	50712		1389 2.7%	N/A	N/A	N/A
Oncology patients ADRs during hospital stay or on admission						
Lau et al., 2004 ²	171	127 (74.3%)	127 (74.3%)	N/A	N/A	N/A
Emergency department attendances						
Galbraith 1993 (adults)	594 (not admitted)	51 (8.6%)	8 (1.3%)			
Easton 2003 ⁴ (paediatrics)	8601 (includes admissions)	280 (3.2%)	118 (1.4%)			
Hendrie et al., 2007 ⁵	3332 (includes admissions)	45 (1.4%)	45 (1.4%)			

N/A = Not assessed

* = only definite or probable drug-related admissions reported (all other results report definite, probable or possible drug related admissions)

1 = medical and respiratory wards and endocrinology unit

a= assessed by medical file review and examination of medication changes

Table 2: Preventability of adverse medicine events associated with hospitalisation or admissions due to medication-related problems

		Total number of medicine-related problems or admissions	Percentage considered definitely avoidable	Percentage considered probably or possibly avoidable	Percentage considered probably not or definitely unavoidable
Titchen et al., 2005 ²⁸	Hospital Paediatric NSAID ADRs	25	36%		
Easton et al., 2004 ²²	Paediatric admissions	81	46.9%		30.9%
Easton-Carter et al., 2003 ⁴	Paediatric emergency department attendances	187	51.3%		36.9%
Chan et al., 2001 ²⁶	Geriatric admissions	73	53.4	23.3	23.3
Lau et al., 2004 ²	Hospital Oncology ADRs	454	1.6%	46.1%	53.4%
Dartnell et al 1996 ¹³	General admissions	55*a	5%	60%	35%
Sarkawi et al, 1995 ¹⁴	Medical admissions	35*	23%	46%	31%
Easton 1998 ²¹	Paediatric admissions	48* ⁺	#	67%	29%
Ng 1996 ²³	Geriatric admissions	31	3%	29%	68%

* - overdose excluded

- category not used

+ - 2 cases unassessable

Note: estimates of adverse drug event preventability in the community from one study were 23%.⁷

Adverse events associated with intra-hospital transfers

Evidence also highlights the potential problem of intra-hospital transfer. A study assessing adverse events occurring within 72 hours of discharge from the intensive care unit in 2006 found 17 (10%) of 167 discharges were associated with an adverse event and that 52% were preventable. While not focused specifically on medications, 47% of the adverse events were related to fluid management. Eighty-two percent of the discharges associated with adverse events were discharges that occurred after hours or at weekends.²⁹

Medication incidents in acute care

Incident reporting from Western Australia and New South Wales has been compared with that from South Australia reported in the Second National Report on Patient Safety: improving medication safety (table 3). Medication incidents remain the second most frequent incident reported, with falls being the predominant incident. As a proportion of all incidents, medication incidents are similar across WA and SA, with lower percentage reported in NSW. Omission and overdose remain the most common type of medication incident, with failure to read or misreading of the chart and failing to follow protocol the most commonly cited cause. The majority of medication incidents cause no or minor harm. Analgesics and anticoagulants appear to be the medicines most commonly implicated. The peak time of day for medication incidents is at 0800 – 0900 hours and 2000 – 2100 in both WA and NSW. Nurses reported the majority of incidents. A South Australia survey of 186 doctors and 587 nurses (70.7% and 73.6% response rate respectively) found that 100% of nurses stated they always reported a medicine error that required giving patient corrective treatment, compared to only 40% of the doctors, while less than 20% of each group stated they reported near miss medication errors³⁰. Lack of feedback, the form taking too long to complete, perception that the incident was trivial and the ward being busy were the most common reasons cited for not reporting an incident.³⁰

Table 3: Medication incident reports, SA, WA and NSW

	SA (pre 2002) ¹⁰	WA 03/04 ³¹	WA 04/05 ³²	WA 05/06 ³³	NSW 05/06 ³⁴
Number of incidents	26999	23189	21693	20799	123404
Medication incidents	7155 (26.5%)	23.5% [#]	24.0% [#]	5068 (24.4%)	17367 (14.1%)
Outcome					
No injury	69% [@]	87.0%	85.0%	85.0%	82% [*]
Most common type of medication incident					
Omission	27.9%	36.0%	36.0%	37.0%	
Overdose	19.5%	18.0%	17.0%	19.0%	
Prescription or order error				14.0%	
Unclear or incomplete order				6.0%	
Dispensing error	3.3%			2.0%	
Most common reason cited for medication incident					
Failure to read or misread	52%	49.0%		36.0%	
Failure to follow policy		23.0%		26.0%	
Medicines implicated					
	Cardiovascular Analgesics, CNS, Endocrine, Antibiotics	Analgesics Anticoagulants Diuretics Respiratory Proton Pump inhibitors		Analgesics Anticoagulants Diuretics Steroids	Analgesics Anticoagulants Insulins Diuretics

@ = none or minor; # = estimated from graph ;* = SAC 3 or SAC4

Three other articles which give some insight into medication incident rates in specific areas of practice are summarised in Table 4.

Table 4: Medication incident rates: anaesthetics and intensive care

	Type of incident	Denominator	Medication incidents n	Rate
Freestone et al., 2006 ³⁵	Anaesthetic incidents	4441 procedures	10	0.2% of procedures
Chacko et al., 2007 ³⁶	Critical incidents in intensive care	8346 ICU days	42	0.5 per 100 ICU days
Parke 2006 ³⁷	Medication use in a district hospital	24174 medication dispensings	425	1.8%

Prescribing errors in acute care

There was one new study that assessed the overall incidence of prescribing errors on discharge prescriptions, comparing hand written discharge medication prescriptions with computer generated discharge prescriptions, finding much higher rates of error with computerised systems (11.6%) compared with hand written systems (5%) ($p < 0.001$). Additional errors which appeared to be associated with computer systems were excessive duration (primarily associated with antibiotic durations extending to the default quantity), dosing errors and inclusion of medicines intended to be ceased.³⁸

One study was located that assessed documentation of medicines by emergency department doctors compared to pharmacy researcher medication history, finding very high rates of discrepancy, with emergency department doctors only documenting 16% of the medicines subsequently documented by the pharmacist researcher. This was primarily due to the fact that when the emergency department doctor had documented on the emergency department admission form “see accompanying medication list”, rather than rewrite the medicines on to the form, this was classified as omitted medication³⁹. While this method is not directly comparable to studies that have used chart review to compare histories taken by different health professionals, the results of this study highlight the potential for error in the emergency department due to poor documentation and potential for forms and lists to be separated. Another study, also undertaken in the emergency department, assessing medication errors prior to an intervention, found 88 errors amongst 56 patients over a five day period. On average the patients were prescribed 7.2 medicines, suggesting a very high error rate of 22%.⁴⁰

Two other relevant studies included one that assessed whether patients were weighed in hospital prior to prescription of renally excreted medicines⁴¹ and another looking at the dosage of medicines in people with renal failure.⁴²

Failure to weigh patients who are prescribed renally excreted medicines has been identified as a risk for medication error in a NSW study. It included patients admitted over a 3 month period to one medical ward and one surgical ward. Only 26% of the 38 persons prescribed renally excreted medicines were weighed prior to prescription. The study also reported a

significant increase in bleeds amongst those prescribed anticoagulants who weren't weighed compared to those who were weighed⁴¹.

A retrospective study of 192 patients admitted to a Queensland hospital over a four month period with a creatinine clearance of 40 ml/ min or less found that 45% of prescriptions for renally excreted medicines had an inappropriately high dose, with the majority of these being present on admission⁴².

There have also been a number of studies assessing factors contributing to prescribing error resulting in a much stronger Australian evidence base for the contribution of systems factors to medication errors.

A qualitative study undertaken in Queensland examining reasons for 21 prescribing errors by hospital interns found causation was multifactorial with a median of four (range 2-5) types of factors contributing to error⁴³. Environmental factors contributed in 19 (90%) of cases; team factors contributing in 16 (76%) of cases; individual factors contributing in 16 (76%) of cases; task factors contributing in 16 (76%) of cases and patient factors contributing in 13 (62%) of cases. As the study was qualitative these percentages should be considered indicative only. Environmental factors included issues such as staffing levels, skill mix, workload, workflow design, administrative and managerial support. Task factors included issues such as the medication chart design, protocols and availability and accuracy of test results. Individual factors included knowledge and skills, motivation, and individual health. Team factors included issues such as communication, supervision and structure, while patient factors included condition and communication ability⁴³.

These results were confirmed in a Western Australian study which explored 29 medication errors, with 21 of these errors being due to a slip/lapse error⁴⁴. The eleven administration or dispensing errors were all slip/lapse errors, while 10 of the prescribing errors were slip/lapse and eight knowledge based. Individual, team, patient and environmental factors were all implicated in contributing to the error. The authors noted "errors were more likely to occur during tasks being carried out after hours by busy, distracted staff, often in relation to unfamiliar patients".⁴⁴ Communication problems and difficulty accessing information were noted to contribute to prescribing errors⁴⁴.

The contribution of the delivery of information has also been assessed in a Victorian study, which found that it wasn't the availability of the information that was the problem but inaccessibility to on-line information and lack of connectivity between applications.⁴⁵ In this study electronic prescribing, ordering and dispensing systems were available as were electronic clinical and scheduling management systems and electronic systems for managing test and radiology results, again highlighting the contribution of environmental factors to error.

Table 5: Types of errors: Prescription errors: Australian hospitals 1985-2007

Reference	Number of prescriptions or charts audited	No. of errors detected (rate)	Major findings
Discharge prescriptions			
Coombes et al. 2004 ³⁸	605 medications on 100 hand written prescriptions	30 (5.0% of medications)	The most common types of errors were omissions (2.6%) and dosing errors (0.8%).
Coombes et al. 2004 ³⁸	700 medications on 100 computer generated prescriptions	81 errors (11.6% of medications)	The most common types of errors were dosing errors (3.6%), duration errors (1.9%), medication not required on discharge (2.1%) and omissions (1.7%).
Inpatient and discharge prescriptions from medical and surgical wards assessed			
Coombes et al., 2001 ⁴⁶	2978 prescriptions	71 errors with potential to cause an ADE (2.4%)	The most common error types found were wrong or ambiguous dose (1.0% of prescriptions), dose absent from prescription (0.6% of prescriptions), frequency absent from prescription (0.4% of prescriptions*)
Medication charts in a paediatric department assessed			
Dawson et al., 1993 ⁴⁷	212 medication charts [#]	52 major errors** (24.5% of med'n charts)	The most common error types were dose errors (12.3% of charts reviewed), error of administration frequency (5.7% of charts reviewed), error of administration route (5.2% of charts reviewed), error in drug name/formulation (1.4% of charts reviewed).
Dawson et al., 1993 ⁴⁷	325 medication charts [#]	35 major errors** (10.8% of med'n charts)	The most common error types were dose errors (4.9% of charts reviewed), error of administration route (2.5% of charts reviewed), error of administration frequency (1.8 % of charts reviewed), error in drug name/formulation (1.5% of charts reviewed).
Errors in medical, surgical, children's wards and a critical care unit assessed			
Leversha, 1991 ⁴⁸	6641 medication chart checks	241 (3.6% of chart checks)	Prescribing errors detected were incorrect dose (1.2% of chart checks), no strength specified (1.0%), insufficient information (0.2%). It was also found that failure to record the patient's current (ongoing) medication on the chart occurred in 69 cases (1.0% of chart checks)
Prescriptions presenting to pharmacy department assessed			
Fry et al., 1985 ⁴⁹	10 562 prescriptions	574 (5.4%),	Included assessment of legal requirements, (eg patient name and address, doctor's signature) as well as clinical requirements (eg dose, frequency,) The strength was missing or incorrect in 0.7%, the directions inappropriate or omitted in 0.4%, and the wrong drug in 0.06%.

* Percentage of prescriptions for regular and 'as required' medications only.

** Major errors included errors in drug name, dose, formulation, route or frequency of administration

Note: unit of analysis is medication chart, which may include one or more prescriptions.

Administration errors in acute care

There were no new studies located that assessed the overall incidence of administration, errors, however, one study analysed rates of omitted medicines⁵⁰ and other assessed error rates for IV administration⁵¹. Other studies of administration errors that were located and are described relate to insulin administration⁵², and administration of “when required” medicines.^{53, 54} Most other studies located were case reports or examined a single type of medicine and have not been included.

Table 6: Medication administration errors: Australian hospitals 1988-2007

	Total opportunities for error	Error rate (excluding minor timing errors)	Type of medication error				
			Timing error	Wrong dose	Omission	Wrong formul'n or route	Other
WARD STOCK -BASED SYSTEMS							
Stewart et al., 1991 ⁵⁵	2017	369 (18.3%)	75 (3.7%)	46 (2.3%)	82 (4.1%)	6 (0.3%)	160 (7.9%)
McNally et al., 1997 ⁵⁶	494	76 (15.4%)	22* (4.5%)	20 (4.0%)	13 (2.6%)	2 (0.4%)	19 (3.8%)
Lawler et al. 2004 ⁵⁰	4887	Omission only assessed			369 (7.6%)		
COMBINATION SYSTEMS							
Rippe and Hurley, 1988 ⁵⁷	312	52 (16.7%)	24 (7.7%)	6 (1.9%)	12 (3.8%)	3 (0.96%)	7 (2.2%)
Camac et al., 1996 ⁵⁸	370 [†]	47 (12.7%)	25 (6.8%)	N/G [‡]	N/G [‡]	N/G [‡]	N/G [‡]
INDIVIDUAL PATIENT SUPPLY							
de Clifford et al., 1994 ⁵⁹	164	10 (6.1%)	1 (0.6%)	2 (1.2%)	5 (3.0%)	0	2 (1.2%)
McNally et al., 1997 ⁵⁶	502	24 (4.8%)	12* (2.4%)	2 (0.4%)	7 (1.4%)	0	3 (0.6%)
Thornton and Koller 1994 ⁶⁰	242	20 (8.3%)	2 (0.8%)	0	13 (5.4%)	0	5 (2.1%)
IV FLUID ADMINISTRATIONS							
Han et al., 2005 ⁵¹	687	124 (18%)					

* Major timing errors included, minor timing errors excluded – a deviation of 2 or more hours from the ordered time. All other studies define a ‘timing error’ as a deviation of one or more hours from the ordered time.

† Total data using two different storage sites – ward bay medication drawer and patient’s bedside locker.

‡ N/G – insufficient data given to calculate rate of individual error types

A small study involving 67 inpatients with a total of 4887 medication administrations found an omission of medicine rate of 7.6% (369 cases). Omission was defined as complete omission (i.e. the dose was not given before the next dose of medicine was due). Nurse initiated and when required doses were excluded. In the majority of cases, 74% (273 cases), the reason for omission was documented, with most documented as withheld (84 cases), refused (63 cases), unable to accept (51 cases) and fasting (33 cases). One hundred and twenty cases were assessed for severity on a scale from zero to ten where zero = no harm and 10 = death, the majority of cases were scored at two or less.⁵⁰

A study made six hundred and eighty seven observations of 639 IV fluid administrations in 3 surgical wards across a four week period in 2003. Observations were made between 0900 and 1600 as well as 2000 to 0300. It found 18% of observations were associated with a medication error. Of these, 79% of errors were incorrect administration rate. The predominant factor associated with increased error rate was the presence of a peripheral line (OR 3.5, 95%CI 1.9-6.5), while IV infusion control devices (OR 0.12, 95%CI 0.06-0.25), nasogastric feeds (OR 0.09, 95% CI 0.01-0.64) and permanent staff (OR 0.48, 95% CI 0.31-0.76) were predominant factors associated with decreased risk.⁵¹

One observational study assessing 195 insulin administrations over two months found blood glucose testing was undertaken within 30 minutes of the insulin dose in only 22% of cases for rapid acting insulin and 41% of cases for conventional insulin, while 94% of rapid acting insulin doses were administered within an acceptable time of the meal delivery, compared to only 43% of conventional insulin doses.⁵² This study excluded long acting insulins, incomplete or illegible records and all those in palliative care, thus the rate may not be a true error rate.

Two studies assessed when required medication administration orders finding that documentation was often inadequate.⁵⁴ One study assessing paracetamol orders in children found that lack of documentation resulted in miscommunication between doctors and nurses, with different understandings of the intention for use and when to use.⁵⁴ Another study assessing psychotropic medication use amongst 43 patients in a psychiatric unit found on 9% of occasions no reason for use was recorded, on 39% of occasions it could not be determined who initiated the request for medicine and on 41% of occasions no outcome of the effect was recorded.⁵³

While not assessing errors, one study assessed the quality of opioid prescribing, finding that 90% of prescribing orders did not comply with at least one of 13 quality statements that had been developed to assess performance.⁶¹ It should be noted that not all of the quality statements would necessarily be judged as inappropriate prescribing, however, the study does highlight that documentation of opioid prescribing could be improved.

As with prescribing errors, there are now studies assessing factors contributing to administration errors resulting in a much stronger Australian evidence base for the contribution of systems factors to medication errors.

One Victorian study surveyed 154 registered nurses employed in regional hospitals, with 79 (51%) respondents⁶². Interruptions and distractions was the most common environmental factor cited by 25% as contributing to error, followed by poor communication (13%). The most common human factor cited was stress/high workload (25%) followed by fatigue/lack

of sleep (17%). Twenty nine percent of respondents agreed with the statement “I need further training in medication administration”.⁶² These results were confirmed in a Queensland study also involving nurses working in rural or remote areas.⁶³ High workloads, low staffing levels and high doctor expectations were all associated with a higher rate of errors, while higher levels of knowledge were found to be protective against errors.⁶³ A further study demonstrated how individual distress impacted on violations (deviation from rules) which in turn impacted on error rates⁶⁴. Individual distress however, was in turn impacted on by factors such as organizational climate and quality of work life⁶⁴, again emphasizing the importance of the system to error prevention. Information flow was also found to be a problem for nurses in a qualitative study involving paediatric nurses, with difficulty using computers and physically accessing computer terminals because of their location and number, identified as an issue⁶⁵. Similarly, policy adherence was reported to be affected by the busyness of the ward, with less policy adherence when wards were busiest.⁶⁵ Another qualitative study found that nurses were more likely to assess patients prior to medication administration than after administration, with assessment of the effect of the medication more likely to be limited to symptomatic therapy (eg pain relief) than other therapies,⁶⁶ and that this was often poorly documented.⁶⁷

Gaps in practice: Adverse drug reaction communication

A survey of all directors of pharmacy in Australia was undertaken in 2001 to assess adverse drug reaction reporting⁶⁸. The response rate was 49.5%. Of note from this survey was that adverse drug reaction reporting was centralized in 61%, with the collection of ADR reports predominantly by pharmacists. Only 18% of hospitals indicated they had implemented methods to assess the preventability of adverse drug reactions. Feedback to reporters by the hospital was only reported by 22.5%, although general feedback was reported by 62%. Only 13% of hospitals reported provided a reward/fee (type not stated) to reporters.

Hospitals generally notified the patient of the adverse drug reaction (96%), and the patient's general practitioner (89%) but not usually the patient's community pharmacist (11%). The information was predominantly provided to patients verbally (91%) with only 17% reporting providing the information by card, and 13% by letter (more than one response possible). Fifteen percent reported notifying the doctor via the patient, while 70% provided the advice via the discharge summary, and 26% via a letter⁶⁸.

Strategies for improving medication safety in acute care

Systems ensuring better medication distribution

Individual patient based medication distribution: the evidence

In the previous review of medication safety in Australia¹⁰ it was found that there was evidence to support the use of individual medication supply systems to reduce medication errors. Two Australian studies were located that directly compared different medication distribution methods and resultant errors associated with administration in the Australian setting.

A study undertaken in a Perth hospital a pharmacist observed nurses administering medicines⁵⁶. The study was undertaken in two separate wards and the medicines were supplied via two different systems (ward stock and individual patient supply) using a cross over design. Excluding minor errors of timing, the error rate was 15.4 % (76/494) when the ward stock system was used. When the individual patient supply system was used, the error rate was 4.8% (24/502). This study did not assess harm associated with the errors.

A second study undertaken at four teaching hospitals in Sydney looked at the effectiveness of different distribution systems to reduce errors associated with missed doses⁶⁹. One of the hospitals employed individual patient supply, while the other three hospitals maintained ward stock. In the hospitals using the ward system, there were a total of 3,931 doses reviewed of which 223 (5.7%) were missed. In the hospital using the modified unit dose system, there were a total of 3,287 doses reviewed of which 136 (4.1%) were missed.

Since the previous review in 2002, there have been no further studies published comparing administration error rates or adverse drug events with different medication distribution systems in the Australian healthcare system. There is also a lack of published data on the uptake of individual patient supply systems for medications in Australian hospitals despite evidence to support its use in reducing medication errors. The Society for Hospital Pharmacists of Australia *Standards of Practice for the Distribution of Medicines in Australian Hospitals*⁷⁰ state that unit-dose systems are the preferred method of medicines distribution in terms of patient safety.

Automated dispensing devices: the evidence

It was noted in the previous review that the evidence for automated drug distribution systems was limited¹⁰. Two studies that evaluated automated drug distribution in the Australian health care setting were located.

A study to evaluate an automated drug distribution device, the *Pyxis Medstation 2000 Rx* was undertaken on four wards of a teaching hospital in Adelaide⁷¹. The only type of medication error that was investigated in this study was missed doses, with no significant reduction found with the automated dispensing system (missed doses accounted for 13% of doses before and 12% of doses after implementation).

Another study undertaken at a Brisbane hospital⁷² assessed the frequency and type of medication administration errors with two different medication distribution methods. Over a period of seven days, a ward stock system was used in one ward and an automated system in another. In the ward using the ward stock method, there was an error rate of 16% (or 12% excluding timing errors). In the ward using the automated method, there was an error rate of 12% (or 9% excluding timing errors). This study did not, however, compare individual patient supply with the automated system.

The results of these studies do not provide clear evidence of the efficacy of automated systems for reducing error. No further studies since 2002 evaluating automated dispensing devices on medication errors or adverse drug events in the Australian setting were located.

Systems ensuring adequate checking

Bar coding: the evidence

In the previous review¹⁰ it was found that there was some limited international evidence to support the further investigation of bar coding as a strategy to improve checking and reduce medication error. No published studies had been undertaken in the Australian setting to assess the impact of bar coding on medication errors in the acute setting.

There is an ongoing project now administered by EAN Australia which is aiming to implement an Australian standard coding system for medicines – the Australian Catalogue of Medicines (ACOM). This will ensure that all prescription and non-prescription medicines (including complementary medicines) have a globally unique code. A national coding system is required to allow the electronic transmission, storage and use of medication information. It is hoped that a standard national system will eventually facilitate sharing of medication records⁷³. This also has the potential to facilitate the use of bar coding technology.

There is a need to collect further data on the current status of any initiatives to implement bar coding strategies for medication administration in the acute care setting in Australia.

Computer adverse drug event detection and alerts: the evidence

A review of the published literature failed to identify any studies evaluating the outcomes of using computerised adverse drug event detection and alert systems to reduce medication errors or improve patient safety in the Australian setting. Alert mechanisms on prescribing systems have been considered as part of studies of electronic prescribing and decision support systems in the Australian setting described below.

Single-person versus double-person checking by nurses administering medications: the evidence

It is not clear whether single-person or double-person checking by nurses administering medications in hospital is safest to prevent medication error. A study conducted in a Victorian acute care hospital examined the safety of single-checking by a registered nurse of medications that had required double person checking⁷⁴. These medications included medicines requiring calculations, drugs of addiction, cytotoxics, new drugs, epidurally administered drugs, variable dose insulin, blood products and higher doses of potassium

chloride. Medication incident reports were assessed from the hospital units and services involved in the single checking study for a seven month period and compared to those in the same units in the same months of the previous year when double-person checking was standard practice. While there were no significant difference between the two periods, the number of reported administration errors was low (four in the study period and five in the previous year). This study depended on the use of medication incidents reported through the hospital's reporting scheme by those involved in the incident and did not include any independent assessment of the administration process or medication charts. A convenience sample of 129 nurses completed a survey about the single-person checking trial. The majority viewed the increased autonomy of single-person checking favourably.

Further studies are required to provide conclusive evidence about the relative safety of single and double-person checking of higher risk medications by nurses in the Australian acute care setting.

Systems to improve medication administration

Improved drug packaging, storage and administration equipment

A system to prevent infusions being administered by the incorrect route (such as inadvertent administration of intravenous medications into the intrathecal space) has been developed at the Women's and Children's Hospital, Adelaide⁷⁵. This system was designed to overcome the compatibility of intravenous (IV), epidural and spinal equipment, that allows the possibility of administration of a drug by the wrong route when other steps in the administration pathway such as training, experience, protocols and checking fail. The new system developed in the hospital, called the Adelaide Regional Connector (ARC), was under prototype development in 2002. This luer incompatible system (which is also colour coded) was developed to ensure that syringes and other drug administration equipment used to administer epidural and intrathecal doses are not able to be connected to those used to administer IV infusions.

The potential for administration of IV medications by the wrong route has also been highlighted by cases of inadvertent spinal administration of the anti-cancer medication vincristine which was intended for intravenous administration⁷⁶. The Society for Hospital Pharmacists of Australia has recommended various strategies to reduce the risk of error associated with cytotoxic medications, with the abolition of syringes for administration of vincristine in favour of an infusion bag strongly recommended⁷⁶. Other recommendations include: the administration and preparation of cytotoxic medications only by specially trained and designated staff; intrathecal chemotherapy to only be administered during normal working hours in a separate area from the storage and administration of other cytotoxic medications; formal checking procedures; specially designated containers for transport and ward storage of intrathecal medications; and having both the IV infusion bag or syringe and the outer container clearly labelled.

Further research is needed to examine the current state of implementation of these recommended system changes to reduce the risk of inadvertent administration of IV and intrathecal medications by the wrong route and their impact.

Incorrect IV administration of potassium chloride can potentially cause significant patient harm. If this medication is administered as a bolus dose rather than a slower infusion or at too high a dose there is potential for cardiac arrhythmias or arrest to occur.⁷⁷ As part of its work, the Medication Safety Taskforce of the previous Safety and Quality Council produced recommended components to be included in guidelines for potassium chloride⁷⁸ and case management case studies from two Australian hospitals were developed and made available online. Additionally, a review of systems at the Alfred hospital in Melbourne⁷⁹ led to a strategy to prevent administration errors for potassium chloride. A root cause analysis of an incident in which a bolus dose of IV potassium chloride was inadvertently administered in the hospital was used to identify factors that contributed. In response to this analysis, pre-mixed solutions of lower concentration appropriate for preparing potassium replacement solutions for fluid restricted patients were developed by physician consensus and in collaboration with the product manufacturer. This allowed all concentrated potassium chloride preparations to be removed from all general wards of the hospital. A policy for prescribing potassium chloride in millimoles rather than grams was also implemented.

Education and training to reduce administration errors

An orientation program for newly employed registered nurses at a Queensland teaching hospital aimed to examine the ability of nurses to identify medication errors as well as applying strategies to prevent medication incidents⁸⁰. The program used simulated medication administration scenarios in which frequently occurring types of medication errors with potential for patient harm were included. Nurses were allowed to discuss the issues with the cases and to consult reference texts. After each scenario the nurses were asked whether they detected the errors, whether they would have modified their practice and whether they were aware of the error concept. After completion of the cases, nurses were presented with education about concepts of human error and risks, the systems in place in the hospital to prevent medication errors, roles and responsibilities in detecting errors and preventing harm. Feedback was sought about nurses' attitudes and beliefs about their role in medication safety and their views on the education program. The study was conducted over a two-year period with 591 nurses participating. Results for the combined sample of nurses showed that the risk would have been identified and appropriate action taken in a median of 5 and average of 4.23 of the 6 scenarios. Scenarios concerning potassium chloride, dose, frequency and discharge scenarios were detected by a significantly greater proportion of experienced nurses compared to new graduates ($P < 0.01$), however the scenarios involving errors and risks due to a previous adverse drug reaction to a drug and the use of an incorrect dosage form were not different between these groups. Descriptive feedback on the program from participating nurses indicated that the majority found the program content informative and raised awareness of risks and complexity in medication systems. This study did not assess whether this translated into improved recognition of actual medication errors in practice.

The previous medication safety report did not include analysis of the evidence for education and training and its impact on medication errors. The study reported above may not be the only Australian study on this topic.

Systems to support patient self-administration in the acute care setting

A pilot study in a Nursing Convalescent Unit (NCU) of a large metropolitan teaching hospital in Australia examined the effectiveness of an inpatient self-medication program⁸¹. The six

month study examined three levels of administration: 1) registered nurse (RN) administration; 2) patient medication with direct supervision from an RN; and 3) self-medication with indirect RN administration. Patient education about medicines and a medication record card were also key components of the program. Patients progressed through the three levels as deemed appropriate by the study or ward nurses. A total of 220 patients participated in the study. Forty-five percent of patients remained on Level 1, 26% reached level 2 and 29% reached level 3. There were no patient initiated medication errors in the study period. There were two errors involving staff in the study period, compared to one error in the previous six-month period (historical control). There was a low response rate to the patient survey (16%), however those responding reported satisfaction with the program and the staff support and education they were given. Overall, nurses in the unit who completed a survey were satisfied with the self-medication program. This study was conducted in a specialized unit emphasizing the nurses' component of inpatient recovery with an emphasis on patient participation in their recovery. The study findings, therefore, are not generalisable to other acute care settings but warrant further studies in this area.

Systems to improve prescription writing

The National Inpatient Medication Chart

A national medication chart for inpatients common to all hospitals in Australia arose from the Medication Safety Breakthrough Collaborative. This National Inpatient Medication Chart (NIMC) was adopted for national roll-out following an agreement of the Australian Health Ministers Council in 2004 that the chart be used in all Australian public hospitals by June 2006⁸². The recommendation for a process of pharmaceutical review of all aspects of medication management in the hospital was also part of this reform⁸².

The chart along with education on safe prescribing and administration were piloted in 31 sites in 2004⁸³. This included public and private hospitals in metropolitan, regional and rural areas. Hospitals conducted baseline audits of medication charts before implementation of the NIMC and a post-implementation audit after 3 months. The post implementation audit was completed by 28 of the sites. Some of the improvements seen in the combined results for the various sites included:

- increased documentation of adverse drug reactions (21% to 50%);
- decreased prescription of drugs to which patient had an allergy (9% to 6%);
- increased entry of actual administration times by the prescriber (18% to 68%);
- increased frequency of providing the actual indication for a 'prn' medication (13% to 26%)
- increased documentation of the maximum dose for a 'prn' medication (24% to 36%);
- increased frequency of the prescriber name being identifiable (41% to 79%)
- increased frequency of target INR documentation for warfarin therapy (9% to 71%).

It is acknowledged in the study report⁸³ that the pilot study used surrogate measures of patient harm, rather than direct measures. It was recommended that further evaluation of the NIMC and supporting educational programs should be considered in the future, including measurement of impacts on patient harm.

A description of the implementation of the NIMC and medication safety guideline in three acute care Victorian hospitals has been published⁸⁴. Initiatives used to implement the chart

and guideline included an interdisciplinary steering group to support the integration across the whole organization. This group met monthly for a six month period to ensure that emerging issues could be responded to and plans and directions set. A dedicated project officer acted as a facilitator and coordinator. Four interdisciplinary working groups, each led by a champion from the steering group were used to progress the strategies in the specific areas of supply, communication, education and evaluation. The supply group worked with stakeholders to ensure that any features added to the NIMC to suit the individual organization were in accordance with government requirements. The communication group managed the dissemination of information about the chart and guidelines amongst the various disciplines in the hospital. The education group developed and implemented a multiple stage education program starting with lectures and workshops and changing to more personalized communication after use of the chart had started. The evaluation group developed clinical indicators for areas of practice where medication error was most likely to occur and conducted pre- and post-implementation audits of medication chart documentation. The audits provided data to feedback to staff through the communication and education strategies. Problem areas for documentation were identified and where necessary policies were developed to address these.

A critical audit of the chart's design and performance has been published from the Royal Perth Hospital (RPH)⁸⁵. This audit included three aspects. Firstly an assessment of the design of the chart was performed by the study team by comparing it with the previously used chart at the hospital, four other WA hospital charts and nine charts from teaching hospitals in other states and territories. The charts were compared on 15 design features. Secondly, a non-comparative audit of compliance of completion of the individual fields of the chart, using the criteria as required by the Office of Safety and Quality in Health Care (WA). Thirdly, an audit of charts from six medical and surgical wards of the hospital was performed to examine compliance after introduction of the NIMC compared to the RPH chart before introduction. Some aspects of the design of the NIMC were assessed by the authors to be likely to improve medication safety (including 1. a section to complete medication history; 2. allowing recording of sustained-release dose forms; 3. a mechanism to circle inpatient drugs intended for provision at discharge; 4. provision for documenting the indication of each medicine; 5. direction to record intended administration times of each medicine. However, the authors found that four of these five advantages were actually poorly complied with in practice. Overall compliance with the chart was found to be 56% [95% CI 43-67%], however there was variable compliance with different sections of the chart, with only 2.3% of charts with the medication history completed. There was a modest, but non-significant increase in overall compliance after the introduction of the NIMC compared to the previous chart (6% [95% CI -0.2 to 13%]). The authors raised concerns about some of the features of the chart including the cramped design, lack of colour, lack of provision for variable dosing and the need for an average of twice as many charts per admission (and hence increased requirements for rewriting charts and possible transcription errors)⁸⁵.

There is a need for an ongoing national approach to the optimisation and implementation of the NIMC which incorporates feedback from institutions across Australia.

Education and training for prescribers

A survey study conducted at two teaching hospitals in Brisbane with 101 medical students prior to their intern year examined perceptions around prescribing⁸⁶. The study sought to assess the student's perceptions about their readiness to prescribe six weeks before beginning

their internship, expectations of the support they would have in prescribing, awareness of the types and frequencies of medication errors and the possible outcomes associated with errors. A factor analysis identified that while most students felt able to prescribe post-operative electrolytes and medications for simple conditions, they felt less confident in prescribing for specific high-risk situations such as prescribing of warfarin. While students showed awareness of medication errors in the healthcare system, most of them believed the medicines they prescribed would be safely administered. Most students perceived there was a culture of blame for doctors that made prescribing errors in the hospital setting.

Education for medical students in the form of “safe medication practice tutorials” has been studied in the Australian setting by the Safe Medication Practice Unit in Queensland⁸⁷. A series of eight interactive case-based tutorials have been developed based on findings from focus groups and interviews with junior doctors and doctors who have made prescribing errors. The tutorials cover a broad range of topics associated with safe medication management. These include medication history taking, safe and effective use of the standardized medication chart (National Inpatient Medication Chart), discharge medication and information transfer to other healthcare professionals and prescribing for specific drug classes including anticoagulants, analgesics, insulin and hypoglycaemics and intravenous fluids and electrolytes. The sessions were facilitated by a senior doctor, pharmacist and clinical nurse. The tutorials were evaluated in a controlled study in which a group of 81 final year medical students who had been allocated to the intervention group and who voluntarily attended at least 75% of the tutorials offered were compared to students allocated to a control group. Knowledge and ability to prescribe safely in commonly encountered situations were examined at the end of the final year. Comparison of the scores in the examination showed statistically significant higher scores for each of the four questions for the intervention group, with the total mean score of 26.3/38 for the control group and 29.5/38 for the intervention ($p < 0.05$). The course was subsequently adopted for all students at the Queensland Medical School, with updates annually.

A pre-intervention, post-intervention comparison study in a Melbourne teaching hospital examined whether an educational intervention could reduce the use of “error-prone prescribing abbreviations” in an emergency department (ED) setting⁸⁸. The intervention, that formed part of the orientation program for ED registrars and postgraduate course nurses, involved small group and one-to-one tutorials about abbreviations commonly causing medication errors or confusion and the use of summary cards and posters to reinforce this information. The intervention ran for a six month period. All medication and fluid charts in the ED department were assessed for error-prone abbreviations at a randomly selected time each day for one week before the intervention and one week following it. The error-prone abbreviations were classified as major, moderate or minor significance by two independent pharmacists. Error-prone abbreviations were defined as those on lists from the Institute for Safe Medication Practices, the Joint Commission on Accreditation of Healthcare Organizations or the health service’s internal policy documents. Charts for 166 patients were included in the two assessment phases. The error-prone abbreviation rate per 100 prescriptions decreased from 31.8 pre-intervention to 18.7 post-intervention ($P < 0.001$). The rates of abbreviations classified as of major significance decreased from 5.8 per 100 prescriptions pre-intervention to 2.3 post-intervention ($P < 0.001$).

The previous medication safety report did not include analysis of the evidence for education and training and its impact on medication errors. The studies reported above may not be the only Australian studies on this topic.

Academic detailing

One study was located which examined whether an academic detailing service could reduce prescription errors for drugs of addiction (DOA) in the hospital setting in New South Wales⁸⁹. The types of errors were devised from categories based on state laws but did not include any assessment of the appropriateness of the drug prescribed or patient outcomes.

The types of errors included:

- the quantity not being written in both words and numbers;
- the DOA not written on a separate script;
- alterations to the script not initialled;
- details of the preparation or form of the drug omitted;
- liquid preparations without a milligram dose given;
- strength omitted or incorrect.

The intervention, conducted in 2001, involved a one-on-one interview for all first and second year post-graduate practitioners in the intervention hospital where difficulties with DOA prescribing was discussed and a ten-point summary of prescription requirements and a sample correct prescription was provided. A second follow-up interview was conducted after two months and the assessment of error rates assessed two months after the end of the intervention. Error rates before and after the intervention period were compared with a control hospital where no intervention was given. The baseline levels of prescription errors at the intervention hospital (approximately 40%) were higher than those of the control hospital used for the study (25%), making comparison difficult. At the intervention hospital 41% of the 46 scripts assessed pre-intervention contained errors, compared to 24% of the 128 prescriptions assessed post-intervention ($p < 0.001$, chi square = 17.3). There was no change in the error rate at the control hospital.

Further adequately controlled studies are required to confirm whether academic detailing can reduce prescription error rates in the Australian hospital setting. These should include assessment of errors likely to impact on patient outcomes.

Systems ensuring better dissemination of knowledge about drugs

Clinical decision support systems: the evidence

In the previous review¹⁰ it was found that there was international evidence to support electronic prescribing in combination with clinical decision support systems as an effective strategy for reducing medication errors including errors with the potential to cause patient harm. Some research conducted in the Australian setting since the last review adds further insight into the implementation of this strategy.

The limitations of using electronic prescribing alone without other clinical information support is highlighted in the findings of a study of discharge prescriptions at a teaching hospital in Brisbane³⁸. A computer-generated discharge summary system was developed from which a discharge prescription was generated based on information entered by the medical officer into a database. An observational audit of 200 discharge prescriptions was conducted in 2001 which involved a review of 100 handwritten prescriptions (for a total of 605 medications) and 100 computer generated prescriptions (for a total of 700 medications). The same group of medical staff was responsible for both types of prescriptions. There were more

errors in the computer generated prescriptions. There were a total of 81 errors (11.6% of items) in the computer prescriptions and 30 (5.0% of items) for the handwritten ones ($p < 0.001$). While the errors judged to have the potential to result in patient harm were similar between the groups, it was noted that there were specific types of errors that occurred more frequently when a computer was used. It was found that 25 dosing errors were made with a computer prescription, compared with 5 dosing errors in the handwritten prescriptions. It was suggested that this may have resulted from copying of previous discharge information. Additionally errors in the duration of therapy were more frequent for the computer-generated prescriptions due to default settings in the computer. The authors concluded that electronic prescribing alone without decision support and alerting systems could actually increase the risk of patient harm.

There is recognition that electronic medication management systems can introduce machine-related errors. This led an Australian research group based at the University of New South Wales⁹⁰ to examine the development of a multilevel “accident model” to examine points in electronic prescribing systems where system failures may occur. This model uses a systematic approach to examine human-computer interaction processes as well as the context in which electronic prescribing systems are used (such as health professional cultures, organizational factors). It is hoped that this will aid the development electronic prescribing systems with features to improve patient safety. The validity of the model is to be further tested by the group in ongoing research.

A study of the implementation of an inpatient electronic prescribing and clinical decision support system in a metropolitan and rural hospital in Victoria was described by Ribbons et al.⁹¹. The system studied allowed a ‘point and click’ method of prescribing for physicians prescribing inpatient and discharge medications, integration with the hospital’s pharmacy ordering system and use of clinical decision support tool. The clinical decision support allowed checking of interactions, allergies and duplicate ordering and access the AusDI drug and therapeutics database and MIMS. Pilot projects to test the system were undertaken in one acute and one sub-acute ward of each of the hospitals independently. These were 30-bed wards in which two clinical computers were available in addition to a wireless laptop as a point-of-care computer. Intensive training was provided to medical officers and nursing staff in the wards. The use of the system in the acute ward setting had to be discontinued after six weeks in the rural hospital and eight weeks in the metropolitan hospital. The barriers to effective implementation in the acute ward setting were found to be perceptions of increased clinical risk; workload issues; lack of medical staff commitment; insufficient computer access and technical and software limitations (including inadequate interaction and allergy checking, and problems with version control). The experience in the sub-acute ward setting in both hospitals was different, with its use becoming accepted practice and the system being rolled out to other sub-acute wards. Medication error rates were not assessed in the study. The study highlighted the need for an electronic administration system for document control issues (such as version control). It was also identified that clinical workflow issues are understood in implementing any new system, and there needs to be a commitment through the whole organization to ensure that adequate resources are allocated. In areas where patient medication charts are frequently reviewed (such as acute ward settings), if handwritten alterations to charts are prohibited, this can result in the need to re-print a large number of charts. Provision of training in the system away from the clinical areas was also considered important. A committed clinical champion for the system was also suggested as a means of improving staff commitment to the technology. The authors concluded that implementation of electronic prescribing and clinical decision support systems requires a highly organised approach at all

levels of the institution, giving consideration to the technical issues as well as the culture and environment in which it is to be used.

Another qualitative feasibility study for an electronic prescribing decision support (EPDS) system was undertaken in a public hospital in New South Wales⁹². This study used the Sauer's Triangle of Dependencies model to examine the organisational context in which an information system is placed. The research was a case-study evaluation using face-to-face interviews as well as focus groups with hospital staff. Questions were used to examine the limitations of the present paper-based prescribing system; technical requirements for an electronic prescribing and decision support system; the environment in which the system would be used; the political setting, the type of ward structure suited to electronic prescribing; perceived barriers to implementation of an electronic system in the past and mechanisms for consulting with medical staff in the design and implementation of an information system. Interviews and focus groups were held with medical staff, pharmacists, nurse managers and clinical information technology experts. However there was a low level of participation in the study by both medical staff (9%) and nurse managers (20%). The qualitative data indicated that while nearly all participating clinicians indicated they would be willing to adopt electronic prescribing and alert systems, the implementation of an EPDS system in the particular hospital would be hampered by significant existing barriers. Barriers identified included a lack of confidence in some of the security aspects of the system (e.g. use of electronic signatures, failing to log-out of a system), lack of funding and resources to implement a system successfully, concern about the time taken to complete and check an electronic prescription (e.g. excessive drug-drug interaction checking by some decision support/alerting systems), lack of compatibility with the existing patient administration system in the hospital, legislative barriers (such as legal requirement for handwritten signatures). The majority of clinicians favoured the idea of a state-wide EPDS system which would mean staff changing between institutions would not need to re-learn a system and communication and transfer of patient information between different institutions would be facilitated. Clinicians stated the need for an integrated patient-centred system that would overcome the need to log into different systems for different types of results.

A project involving a review of electronic medication management (EMM) systems in the Australian setting was published in 2007⁹³. The author defined EMM systems as "systems which manage each phase of the medication management process: decision support; physician order entry; pharmacist review; pharmacist dispensing; and nurse administration". The project involved the use of a multidisciplinary reference group including medical, pharmacy and nursing representation and clinical information technology experts. The team formulated what they considered to be the "key principles and core features" for assessing the suitability of an EMM systems. Additionally, a literature review was undertaken to assess the current state of implementation of EMM systems in Australia. This included obtaining information from Commonwealth and state/territory government departments. Various available EMM systems were assessed according to the criteria developed by the multidisciplinary team as well as the findings of the literature review. Through the review, it was found that Australian governments recognized the value of EMM, and have approached implementation in various different ways and to varying degrees. States such as Victoria, South Australia, Queensland and New South Wales have considered EMM as part of moves towards integrated electronic health records. Some EMM systems have also been trialled in South Australia and the Northern Territory. Tasmania and Western Australia had developed business cases around possible initiatives for EMM. The Commonwealth was seen to play a role in standardizing the processes for EMM and use of terminology through strategies

including the HealthConnect initiative. EMM systems from 11 companies were evaluated as part of the study with all those assessed found to have majority of the required core functions seen as important by the study reference group, although systems were not ranked relative to each other. It was concluded that a number of systems now available were suitable for use in Australian hospitals, but that a number of change management issues needed to be addressed for implementation to occur more widely.

Since the previous medication safety review a number of studies have examined the implementation of electronic prescribing in combination with clinical decision support systems in Australian hospitals. The potential value of these strategies now appears to be more widely recognised by government, hospitals and health professionals. However, published studies provide useful insights into some of the barriers to the introduction of this strategy in the acute care setting in Australia that need to be overcome before wider implementation can occur. There is still a lack of published research on the impact of electronic prescribing in combination with clinical decision support systems on medication errors or adverse drug events in the acute care setting in Australia.

Clinical guidelines

Clinical guidelines are another potential strategy to improve prescriber decision-making. An Australian study conducted in a regional area of Victoria examined the implementation of guidelines for thrombolytic therapy in management of acute myocardial infarction (AMI)⁹⁴. The region is serviced by four hospitals that manage AMI. A resource folder (“Guidelines for the Early Management of Acute Myocardial Infarction”) was developed by a multidisciplinary team from the centres managing AMI in the region. The resource included information on AMI diagnosis, criteria and protocols for administering thrombolytic medications and a summary of evidence supporting the recommendations. Distribution of the guidelines was also accompanied by education sessions for medical staff in three of the four hospitals. The impact of the guidelines was examined in a retrospective before and after audit of medical records for AMI patients for a period of 12 weeks before and 12 weeks after guideline implementation. Compliance with the guidelines was measured as 1) the proportion of AMI who were eligible for thrombolytic therapy who received it; 2) the time taken to administer the thrombolytic after patient presentation. Data were collected for 170 confirmed AMI patients during the study period, of which 75 were eligible for thrombolytic medication. There was no significant difference in the proportion of eligible patients receiving thrombolytic medication before and after the guideline implementation (74.2% before versus 62.5%, after, $p=0.0275$). The time to administer the medication was also not significantly different (67.7 min versus 60.5 min, $p=0.759$). The study therefore suggested the guideline resource and education strategy used in this region had little effect on the use of thrombolytic medications in the management of AMI.

The previous medication safety report did not include analysis of the evidence for guidelines, nor drug usage evaluation and their impact on medication errors. The study reported above is not the only Australian study on this topic.

Systems providing clinical pharmacy services

Clinical pharmacists participate in a number of medication processes including medication review, ordering, dispensing, monitoring and education.

Some studies undertaken in the Australian setting have used an uncontrolled, pre-test, post-test design study to assess the impact of clinical pharmacist services. One study examined the impact of clinical pharmacist and clinical pharmacologist activities on the rate of prescription errors in the children's ward of a Sydney hospital. Medication charts were audited for one month to establish a baseline rate of prescription errors in the ward. This chart audit was followed by a twelve month intervention strategy involving in-service education on prescribing conducted by a clinical pharmacologist and regular medication chart reviews conducted by a clinical pharmacist who indicated errors in writing and discussed them with the prescribing doctor. In the baseline audit there were 52 major errors in the 212 charts audited (24.5%). In the audit following the intervention strategy there were 35 major errors in the 325 charts audited (10.8%)⁴⁷.

Another more recent study examined the impact of an emergency department (ED) clinical pharmacist on prescribing errors⁴⁰. The study, conducted in a single Victorian metropolitan teaching hospital, examined prescription error rates for patients during a control period of 5 days and compared this with error rates in the following week when a pharmacist ED service was provided. Standard care provided during the control period involved the admitting doctor completing the initial medication history and medication chart with the pharmacist for the ward the patient was admitted to completing a check of the medication history and medication reconciliation. In the intervention period a dedicated ED pharmacist interviewed patients admitted through the ED department using a structured medication reconciliation form to obtain a medication history which could be used by the admitting doctor to prepare the medication chart. The ED pharmacist also reconciled the history with the ED medication chart where possible or passed information to the ward pharmacist. At approximately 24 hours post-admission a senior clinical pharmacist reviewed the medication history and medication chart to record and resolve any prescribing errors. Error types were classified using an in-house classification system and the risk rating was assessed by a blinded, independent physician using standard risk assessment criteria. There were 56 patients in the control period group and 55 in the intervention period group with patient characteristics and the number of drugs ordered per patient similar between the groups. There were 88 prescription errors detected at 24 hours post-admission in the control period (1.6 errors/patient) and 25 errors detected in the intervention period (0.5/patient). The difference between the number of errors per patient was significant ($P < 0.0001$). There was a relative reduction of errors rated as high extreme (64% reduction), moderate (71% reduction) and minor (90% reduction). The most common types of errors were drug omissions. This study supports the role of an ED pharmacist in reducing prescription errors.

Less rigorous evidence for the effectiveness of clinical pharmacy interventions is provided by studies in which interventions undertaken by clinical pharmacists have been independently reviewed in order to assess their clinical significance. The evidence obtained from these types of studies is not as strong as that obtained from controlled studies as there is no comparison group, nor pre-test, post test design, however, studies of this type were the most commonly undertaken in the Australian setting. Studies were included that had documented clinical pharmacists interventions, the interventions were reviewed by an independent panel or reviewer and the clinical significance of the intervention was rated using pre-defined criteria or their impact on patient outcomes or medication error rate was determined. Nine Australian studies assessing the effectiveness of clinical pharmacist interventions for reducing adverse drug events meeting the inclusion criteria were located in the previous review¹⁰. A summary of these studies appears in Table 7.

Table 7: Studies of interventions by clinical pharmacists in Australia*

Reference	No. of patients or charts reviewed	No. of interventions	Major findings
Interventions in acute care public hospitals reviewed			
Dooley et al., 2004 ⁹⁵	24 866 patient separations during study	1 399 pharmacist-initiated changes to drug therapy or patient management	There were 96 (7%) interventions deemed to have reduced the length of hospital for a patient, and 156 (11%) interventions which reduced the potential for the patient to be readmitted to hospital.
Hall et al., 2001 ⁹⁶	Number not given – interventions collected for one week per month for 6 months	2342 interventions analysed, 7.4% were administrative 92.6% were clinical	A potential for sequelae if the intervention did not occur was described as either “severe” or “catastrophic” in significance in 28 cases and “possible” to “almost certain” to have occurred without the intervention.
Tenni, 1996 ⁹⁷	115 408 chart reviews	62 132 clinical pharmacist services	Interventions associated with review of biochemistry results were classified as clinically significant in 92% of cases, therapeutic drug monitoring interventions were significant in 90% of cases, and patient counselling interventions were clinically significant in 74% of cases. Sixty nine percent of the significant interventions involved dose changes.
Simioni and Brien, 1996 ⁹⁸	80 patients involved in a baseline phase, 77 patients involved in a trial phase involving the implementation of pharmaceutical care plans on a medical ward	253 interventions (99 in baseline phase, 154 in study phase)	During the baseline phase (current clinical pharmacy practice at the hospital) there were 69 interventions (70%) that were accepted by medical staff and resulted in a positive patient outcome. In the trial phase (using pharmaceutical care plans) there were 113 interventions (73%) accepted by medical staff and which resulted in a positive patient outcome. There were 15 interventions (15%) in the baseline phase and 20 interventions (13%) in the trial phase that prevented drug toxicity or exacerbation of an existing medical problem. One intervention in the baseline phase was ranked as “potentially life saving”.
Spencer et al., 1994 ⁹⁹	Number not given – interventions over a 6 month period recorded	611 interventions analysed	372 interventions were classified as being of “appreciable” or “major” clinical significance according to a published rating system.

Table 7: Studies of interventions by clinical pharmacists in Australia* (cont.)

Interventions in a repatriation hospital reviewed			
Alderman and Farmer, 2001 ¹⁰⁰	Number not given - all interventions considered to be of potential major significance over a 30 day period	67 interventions considered to be of potential major clinical significance	A total of 39 interventions were considered to be of major clinical significance. Most common category of drug-related problem addressed by the interventions was an inappropriately high dose of medication, which occurred in 17 (44%) of interventions
Interventions in metropolitan and country hospitals assessed			
Donnelly et al., 1991 ¹⁰¹ .	4328 charts reviewed	334 interventions recorded	Interventions were classified as potentially life-saving in 17 cases (5% of interventions), preventing major toxicity or organ damage in 44 cases (13% of interventions), optimising drug therapy in 189 cases (57% of interventions) and minor in 84 cases (25% of interventions).
Interventions in an oncology hospital reviewed			
McLennan et al. 1999a & 1999b ^{102, 103}	Number not given – interventions associated with inpatient care collected over a 2 month period	674 interventions documented (corresponding to 295 episodes of inpatient care)	Activities were classified according to <i>International Diseases Classification – 10 (Australian modification)</i> (ICD-10-AM) taxonomy. Outcomes could be assessed for 10% of the interventions reported. In 90% of the assessed interventions clinical benefit was documented.

*Studies included if interventions were independently reviewed and clinical significance, impact on patient outcomes or medication error rate was determined.

Systems improving information transfer

Information transfer at the hospital-community interface: the evidence

Controlled studies undertaken in Australia to assess the impact of discharge medication management services implemented by pharmacists or by pharmacists and nurses have shown this service improves patient outcomes and reduces undesirable medication events.

Two controlled studies conducted in South Australia evaluated the impact of discharge liaison services on the outcomes for patients discharged from an acute care hospital^{104, 105}. This intervention involved counselling before discharge from hospital, followed by a pharmacist and nurse visiting a patient's home a week after discharge from hospital to optimise the management of the patient's medication, identify any early deterioration in the patient's condition and facilitate medical follow-up if required. The outcomes measured included the frequency of unplanned readmissions to hospital and death within 6 months of discharge from hospital. The intervention was associated with a reduced frequency of hospital readmission and death for patients with congestive heart failure and patients discharged from medical and surgical wards.

A randomised controlled study of a discharge medication liaison service for patients discharged from medical and orthopaedic wards was undertaken in two hospitals, one in Queensland and one in New South Wales^{106, 107}. On the patient's discharge from hospital the medication liaison officer provided information to the patient's primary health care providers

(general practitioner and community pharmacist). Patients in the control group received the normal discharge processing. Outcomes measured included readmission to hospital within 30 days of discharge, mortality, and functional status. There was a 20% reduction in the total number of readmissions to hospital within 30 days of discharge from hospital for the intervention group over the control group, however, this did not reach statistical significance. Change in functional status was measured, using the SF-36 model, at admission to hospital and 30 days after discharge from hospital. There were significant improvements in scores for bodily pain and physical functioning in the control group, while there were significant improvements in bodily pain, physical functioning and mental health scores for the intervention group.

A study undertaken in South Australia evaluated the effectiveness of a medication liaison service to reduce the risk of undesirable medication events for patients making the transition between the hospital and community setting¹⁰⁸. A community pharmacist provided medication services for a group of patients discharged from an acute care hospital that were at risk of undesirable medication events. A control group received the standard discharge service from the hospital, while the intervention group received discharge counselling, home visits within 48 hours of discharge and the discharge summaries were forwarded to the patient's general practitioner and pharmacist. The number of medication-related problems six weeks after discharge from hospital was compared for the 2 groups of patients. The group receiving the medication liaison service had significantly fewer medication-related problems six weeks after discharge from hospital.

A randomized, single blind, controlled trial conducted in South Australia examined whether the addition of a pharmacist transition coordinator could impact on medication management and health outcomes in older people undergoing transition from a hospital to a long-term aged care facility¹⁰⁹. The study included 110 older adults who were discharged from three metropolitan hospitals to long-term care. The transition coordinator service focused on the transfer of medicines information to care providers in the long-term care facility and the patient's family physician and community pharmacist. This included a medication transfer summary (which supplemented normal discharge information), coordination of a medication review by the pharmacist contracted to the facility and a case conference including the pharmacist coordinator, family physician, community pharmacist and registered nurse from the facility. The main outcome measure (the Medication Appropriateness Index -MAI) was assessed at discharge (baseline) and at 8 weeks post-discharge by independent pharmacists blinded to patient group allocation. The MAI was not significantly different between the groups at baseline (intervention group 3.2 [95% CI 1.8-4.6]; control group 3.7 [95% CI 2.2-5.2]), while at 8 weeks the MAI was unchanged in the intervention group (2.5 [95% CI 1.4-3.7]), but significantly higher (worse) in the control group (6.5 [95% CI 3.9-9.1]). When patients who were alive at the 8 week follow-up were included in the analysis, there were significantly fewer hospital admissions and unplanned emergency department attendances in the intervention group (RR 0.38 [95% CI 0.15-0.99]), however there was no significant difference if all patients were included in the analysis. There was a significant difference in the outcome measure of "worsening pain" in favour of the intervention group compared to the control (RR 0.55 [95% CI 0.32-0.94]). There was no significant difference between the groups for the outcomes measure of adverse drug events (RR 1.05 [95% CI 0.66-1.68]). There were no significant differences for falls, worsening mobility, worsening behaviour or increased confusion. This study suggests a transition coordinator can improve some aspects of medication management during the transition from hospital to residential aged care, however no impact on adverse drug events was demonstrated in this study.

Qualitative research has also been published exploring the potential role of a liaison pharmacist between hospital and community health care settings in Australia¹¹⁰. This study involved the conduct of semi-structured interviews and a focus group examining the discharge process, liaison between hospital and community settings and the possible role of a community liaison pharmacist. Participants included medical practitioners, community nurses, community pharmacy, hospital pharmacy, consumers and hospital administrators from a division of general practice in Victoria. Most participants recognized that there were problems with the hospital discharge process, and that despite the implementation of programs to improve this process that problems still remain. In general, participants felt that a community liaison service could not be provided to everyone, but should be targeted at those most at risk of medication misadventure. The group agreed that if a medical practitioner could not visit a patient soon after their hospital discharge that a pharmacist was the most appropriate health professional to undertake this role. Potential roles for the community liaison service included providing advice and reassurance about medications, assessment of a patient's medication understanding and ability to manage their medicines at home, education and reinforcement of instructions about medicines and communicating patient progress and other issues with service providers. It was felt that the role needed to be well-defined and professional boundaries clearly specified. In general, it was considered that domiciliary visits were the most appropriate mechanism for the roles of the liaison pharmacist to be delivered, however other mechanisms such as telephone calls were also suggested. The logistics of providing the service included the need for domiciliary visits to be conducted within one week of discharge, but preferably within 24-48 hours.

Other models for development of medication liaison services between hospital and community settings have been examined in major hospitals in New South Wales and South Australia.

In New South Wales a 'Heartlink' medication management pathway for patients with chronic heart failure has been developed involving a community liaison pharmacist and medication management review facilitator¹¹¹. On patient admission to hospital consent is obtained for the hospital pharmacist to communicate with the patient's preferred community pharmacy to obtain a complete medication history. The community pharmacist also inserts an alert onto the patient's computer file which acts as a tag to ensure in future the community pharmacist is aware certain medications are contraindicated in the patient's condition, to monitor certain medications and to encourage the patient to carry a medication list and adhere to medications for their condition. On discharge from hospital the patient is given a medication list by the hospital pharmacist, and the community pharmacist is sent the discharge prescription, information about medication changes, any relevant information to assist long-term patient monitoring and any risk factors for medication misadventure identified. A community liaison pharmacist requests the patient's GP to refer the patient for a home medication review (HMR) following discharge home and also provides the GP with information about any specific medication risk factors or recommendations from the hospital team. The liaison pharmacist also accompanied the accredited pharmacist on the HMR visit to provide written resources and other information to the patient. An HMR facilitator worked to provide information to GPs and community pharmacists about the service, to act as a resource to the accredited pharmacist providing the HMR and provided continuing education opportunities for pharmacists and GPs together. The model has been evaluated through a retrospective survey of GPs, community and accredited pharmacists and patients. Most health professionals surveyed agreed that the service improved the link between the hospital and community setting. Time factors and lack of patient interest was identified as the major

barrier to the HMR process. Patients receiving the service who responded to the questionnaire (n=27) reported they were more confident taking medications regularly after the HMR and felt they learnt something from the HMR (24 respondents, 89%).

In South Australia an implementation pilot study examined a service to organize an HMR for patients at high risk of medication misadventure from within the hospital (before discharge home)¹¹². Standard care in the hospital involved mailing of a discharge summary, including a list to discharge medications, to the patient's GP. The added service involved a liaison pharmacist:

- sending a medication discharge summary to the patient's GP and community pharmacist;
- organising an appointment for the patient with their GP two days after discharge to order a HMR;
- requesting the community pharmacist to arrange an accredited pharmacist to undertake the HMR or ordering a hospital-funded review if the GP and community pharmacist could not be involved;
- sending the HMR report to the hospital outpatient clinic, the GP and community pharmacist.

There were 50 patients eligible for the study, of which 38 gave their consent to participate. A total of 21 patients received the full liaison service. The mean time for the HMR to take place was 18±7.4 days post-discharge. There were barriers identified in ensuring that an accredited pharmacist was engaged to perform the HMR in a timely manner. Barriers at the GP stage of the process included time constraints and unwillingness to learn how to make an HMR referral. Barriers at the community pharmacist stage included time constraints and a lack of remuneration for the community pharmacist making the referral.

Information transfer between hospitals and general practitioners:

Another Australian study to promote information transfer at the hospital community interface focused on the transfer of information between general practitioners and hospitals at both hospital admission and discharge. This study conducted by Mant et al.¹¹³ investigated the impact of a project to improve communication between general practitioners and hospital staff in an Area Health Service in New South Wales. Stage one of the project had indicated that compliance with the Australian Pharmaceutical Advisory Council (APAC) *National guidelines to achieve the continuum of quality use of medicines between hospital and community* was poor, and that a number of barriers to effective communication between hospitals and general practitioners existed¹¹⁴. Subsequently, a series of workshops were conducted to bring stakeholders together. At these meetings changes to systems that could be made to overcome these communication barriers were identified and participants agreed to commence implementation of these. In stage two of the project, surveys were conducted to review the progress using a series of specific indicators. Following this survey, a forum was held to review the results and to reassess action plans. Three months after the forum another survey was conducted. In comparison with stage one of the project, it was found that there were substantial and maintained improvements in faxing of discharge summaries from hospitals to GPs and provision of medication information to hospitals by GPs for patients at risk. Initiatives including updating of the directory of GP contact details by hospitals and provision of GP business cards to patients (to facilitate contact with the GP is a patient required an unplanned hospital visit) had been implemented at some sites. Some problems, however, had changed little including a poor rate of hospital notification to GPs of a patient's

admission to hospital. This study did not use adverse drug events or medication error as an outcome measure.

Shared electronic medication records

Initiatives to develop systems to improve the sharing medication information between patient's and various healthcare providers through a shared electronic medical record have been funded through the Australian Government. Since the last medication safety review¹⁰ a MediConnect program (formerly the Better Medication Management System) began development. This program aimed to develop a system to allow consumers to consent to various different healthcare professionals accessing and where necessary using and recording information in a shared medication record. This used a secure national electronic system which was trialled successfully in two sites in Victoria and Tasmania in 2003. In 2004 the MediConnect program was incorporated with the wider *HealthConnect* program. At present the Department of Health and Ageing is reviewing programs and priorities for the health and ageing portfolio¹¹⁵.

Medication record cards: the evidence

The previous medication safety review¹⁰ identified one randomised controlled study in the hospital outpatient setting which assessed the impact of using a medication card in conjunction with medication counselling for improving knowledge about medications and compliance^{116, 117}. The medication card contained written information about each of the patient's medications including generic and brand names, how the medication should be taken (including any special directions), the reason for taking the medication and any warnings. The intervention group received a medication card in addition to counselling from a pharmacist, while the control group received counselling only. At a second appointment three to four weeks later, there was a significant improvement in medication knowledge in the group using the medication card. There was an improvement in medication compliance in the group using the card, however, this did not reach statistical significance.

This study did not use adverse drug events or medication errors as an outcome measure. No further Australian studies examining the impact of a medication record card on medication safety were located in the literature review.

Systems promoting multidisciplinary care

Medication Management Review Services: the evidence

The only controlled Australian studies assessing medication management services have been undertaken as part of hospital-community discharge liaison studies^{104-106, 108, 109} described above. No further studies in the acute care setting in Australia were located in the literature review.

Systems to promote reporting of medication incidents and adverse drug reactions

As highlighted in the previous medication safety review¹⁰ routine data collection about undesirable medication events is important for understanding why they occur and how they might be prevented. While there are mechanisms to collect data on adverse drug reactions and medication incidents that are well established in Australia, it is recognized that medication incidents and adverse drug reactions are still under-recognised and under-reported. Continued and increased participation needs to be encouraged. Some strategies have been developed and investigated to promote participation in reporting and increase feedback from reporting systems back to healthcare providers.

The Australian Incident Monitoring System collects information on medication incidents. Information on incidents is routinely fed-back to participating hospitals. An expansion of this program was described by Wu et al.¹¹⁸. This involved a web-based system developed collaboratively between AIMS, the Australian Patient Safety Foundation and the Society of Critical Care Medicine. The published paper described the planned project - a medical incident reporting system for intensive care units (ICUs), including medication incidents and near-misses as well as other medical incident types. Thirty ICUs from hospitals in diverse geographical areas were recruited for the project. The planned project involved staff members of the participating units being encouraged to report (anonymously) incidents and especially near-misses to a project website. The project team planned to collate and review and analyse the reports. It was anticipated that the initial analysis would be primarily descriptive in summarising the types of incidents and the system factors leading to the incidents in order to identify common themes. It was envisaged that this analysis would provide information that would assist the development of risk-reduction strategies for the ICUs. Quarterly reports in electronic form were to be provided to each institution. With subsequent reports it was planned that comparisons of the types of incidents with previous reports would be provided, as well as comparisons with total data for all reporting ICUs. Feedback to staff was to be an essential component of the program to encourage incident reporting and to identify priority areas for action to improve patient safety. The literature review did not identify a subsequent published report on the outcomes of this project.

Another strategy to increase the reporting of adverse drug events in the Alfred Hospital in Melbourne involved introducing a process that would ensure medication errors identified via calls for the medical emergency team (MET) were included in hospital quality programs¹¹⁹. In the hospital the MET provides early intervention when a patient's condition deteriorates and causes of the deterioration are then recorded. However, there had been no process to ensure that deterioration that resulted from adverse drug event was recorded. A modification of the MET data management process involved including a category on the reporting form for "adverse medication effect" and a process to ensure that reports where medications were a contributing factor were communicated to the pharmacy department on a monthly basis. This allowed review by the hospital's Quality Use of Medicines manager and included in the hospital continuous quality improvement program. The intervention allowed the detection of adverse drug events that would have been missed in the existing system.

Other studies have examined factors that influence adverse drug reaction (ADR) reporting¹²⁰ and incident reporting¹²¹ in the acute care setting in Australia. In response to their findings these authors have suggested strategies to improve reporting. It was suggested that simple

interventions such as improving the accessibility of ADR report forms in hospitals and encouraging computer-based reporting would increase the number of reports. Additionally, educational initiatives for nurses and more junior medical staff were suggested¹²⁰. In response to barriers identified to incident reporting¹²¹ it was suggested that there was a need for the development of more time-efficient reporting systems as well as resources to provide feedback and action in relation to reported incidents and near-misses to ensure that healthcare providers see reporting as worthwhile and relevant. Personal digital assistants (PDAs) were successfully utilized by anaesthetists to facilitate incident reporting.³⁵ There is a need for further research in the Australian acute care setting to evaluate whether these suggested strategies could increase reporting rates.

The previous medication safety report did not include analysis of the evidence for improving adverse drug reaction reporting or incident reporting. The studies reported above may not be the only Australian studies on this topic.

Systems-based approaches to understanding and preventing medication errors

Systems to allow hospitals to assess medication systems and performance

The New South Wales Therapeutic Advisory Group (NSW TAG) and the Clinical Excellence Commission have adapted resources developed by the Institute for Safe Medication Practices (ISMP) in North America. The resources entitled “*Medication Safety Self Assessment for Australian Hospitals*” and “*Medication Safety Self Assessment for Antithrombotic Therapy in Australian Hospitals*” are available through the NSW Government Clinical Excellence Commission (CEC) website¹²². The completed assessments can be submitted to the CEC through a secure site which provides a confidential online report back to the hospital. The resources are designed to allow hospital administrators, in conjunction with a multidisciplinary team, to self assess their hospitals performance on key elements that have been shown to improve the safe use of medicines generally and anti-thrombotic agents more specifically. Rather than forming a minimum standard, in performing the assessment the resource considers innovative practices and system enhancements that are not yet widely implemented. It is hoped this resource will allow administrators to identify areas for improved medication practices, to examine progress over time and to compare results with other geographically or demographically similar hospitals. The system is currently being used, but has not yet been evaluated for its impact on improving medication safety in the Australian setting¹²³.

System-based approaches to drug administration errors

A study conducted at a tertiary hospital in New South Wales examined the establishment of a systems-based approach to the reporting, review and feedback of data obtained on prescribing incidents in the hospital¹²⁴. A database of prevented prescribing incidents (near-miss incidents) detected by hospital pharmacists was developed that was securely interfaced with dispensing software in the pharmacy. The pharmacist assigned a classification score for the type of incident and a potential severity score, and also recorded other descriptive data and a brief narrative of the incident. The database allowed the generation of confidential reports to examine trends in incident types, severity and different specialty areas. The data were analysed to examine the systems failures resulting in the incidents, and were de-identified to

ensure a 'no blame' approach was taken. Data feedback involved reporting to specific clinical areas and specialist medical officers. Clinical pharmacists specialising in the particular clinical area were involved in multidisciplinary forums in which intervention reports were discussed. Both junior and senior medical officers were involved in the discussions. A survey was sent to 21 senior clinicians who received reports through the program, of which 10 (47%) responded. All respondents indicated that they found that feedback reports were of value in improving prescribing practice in their area, that reports were being incorporated into clinical quality programs in their area and wanted to continue receiving the reports. Most respondents (80%) indicated that they found the comparative data between different departments useful. Data from the incident system was also used in practice-based teaching programs for junior medical staff in the hospital. Additionally review and analysis of the incident data has informed the development of protocols and policies around prescribing in the hospital.

System-based approaches to drug administration errors

A program to reduce the potential for medication infusion-related error was undertaken at an acute care hospital in Melbourne¹²⁵. The approach involved an evaluation of current medication infusion administration practices and incident reports of errors in the intensive care unit of the hospital and the design of systems to improve safety. A multidisciplinary team directed the project and examined medication administration errors over a 29-month period to categorise them according to root cause and to examine systems failures that contributed to the errors. The under-reporting of "near-miss" incidents was also reflected upon. Systems failures identified included the use of design flaws for some technology used, deviations from safe practice that had become culturally accepted on the ward, complexity and variability in medication prescribing and administration practices which were not necessary, lack of accessible medication calculation resources and limited accessible drug information. Improvement initiatives following the review included a medication safety education program including medication calculations initiatives, a campaign to increase reporting of near-miss incidents, strategies to address unsafe practices that had become accepted in the hospital such as storing potassium chloride ampoules in bedside drawers with other medications and poor labelling of drug infusions, the implementation of an auditing program, changes to infusion pump equipment and methods to standardize the prescribing and administration of particular medications such as immunosuppressive therapies, insulin and heparin. However, the study did not report the impact of the program on medication infusion error rates in the hospital.

There is a need for further research in the Australian acute care setting examining the impact that systems-based approaches can have medication errors and adverse drug events.

Appendix 1

Methodology

The objective of the review was to provide an update on studies conducted in the acute health care setting in Australia since the time of publication of the former Australian Council for Safety and Quality in Health Care Second National Report on Patient Safety – Improving Medication Safety¹²⁶. The review was primarily based on searches undertaken by the NSW Medicines Information Centre.

Search strategy

The search strategy was designed to identify studies undertaken in Australia from 2002 to early 2008 on

1. The extent and causes of medication incidents and adverse drug events; and
2. Strategies for reducing medication errors.

Searches were conducted in March and April 2008 in Medline (1950 - March Week 1 2008), Embase (1980 - March Week 1 2008), Pre-Medline and CINAHL (1982 – April Week 2 2008) using criteria relevant to the general headings in the former Council's Second National Report on Patient Safety – Improving Medication Safety.

The following terms were used in the searches:

adverse drug event\$, adverse drug reaction\$, exp Adverse Drug Reaction Reporting Systems, exp Australia, australia\$, exp Drug Surveillance Program, exp Drug Therapy, exp Hospitals, exp Hospitalization, exp Medication Errors, exp Medication Systems, exp Patient Safety, exp Physician's Practice Patterns, exp Quality Assurance, exp Safety Management, healthcare, incident\$ medication\$, medicine\$, misadventure\$, mishap\$, mistake\$, problem\$

All searches were limited to 2002 – date of search, 2008.

Selection of studies for review

Medication related problems

Studies included:

- Adverse drug event monitoring studies
- Medication incident monitoring studies (including studies where medication incidents were reported on as a subset of medical incidents)
- Quantitative reports of medication incidents (including prescription errors, dispensing errors, administration errors)
- Qualitative studies that examined causes of medication incidents (prescribing, administration and medication management deficiencies)
- Case reports of medication errors leading to near misses or adverse drug events.

Studies reporting on drug use evaluation research and reports of adverse drug reactions that were considered non-preventable were excluded as were studies undertaken in the community setting.

Strategies and activities for improving medication safety

Letters, studies, reports, reviews selected included those reporting on:

- systems to promote improved prescriber decision-making
- systems to promote improved prescription writing
- systems used to promote accurate dispensing and/or distribution
- systems used to promote accurate administration
- systems to improve management of medicines
- information transfer between hospital and community settings
- medication management services and case conferencing
- drug-specific handling/management strategies
- use of bar coding in medicines management
- clinical pharmacy services

Studies undertaken in the community were excluded.

124 articles were selected for review.

Review

The selected articles were grouped into two major themes.

- The extent and causes of medication related problems in acute care
- Strategies for improving medication safety in acute care.

Tables from the former Council's Second National Report on Patient Safety – Improving Medication Safety were updated with information from new studies and included in the review.

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