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Pilot of a National Inpatient Medication Chart in Australia: improving prescribing safety and enabling prescribing training

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WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

- Prescribing errors are common and are caused by multiple factors. Standard medication charts have been recommended by British and Australian Health services. A study of a standard medication chart in five hospitals in one state of Australia significantly reduced prescribing errors.

WHAT THIS STUDY ADDS

- A standard medication chart developed in one area can be adopted through a collaborative process and successfully implemented across a diverse country resulting in similar reductions in prescribing errors. Three of the four stages of the prescribing process (information gathering, decision making and communication of instructions) can be improved by the use of an improved standard medication chart. The introduction of a standard medication chart has enabled development of standard prescribing education programmes.

AIMS

To establish whether a standard national inpatient medication chart (NIMC) could be implemented across a range of sites in Australia and reduce frequency of prescribing errors and improve the completion of adverse drug reaction (ADR) and warfarin documentation.

METHODS

A medication chart, which had previously been implemented in one state, was piloted in 22 public hospitals across Australia. Prospective before and after observational audits of prescribing errors were undertaken by trained nurse and pharmacist teams. The introduction of the chart was accompanied by local education of prescribers and presentation of baseline audit findings.

RESULTS

After the introduction of the NIMC, prescribing errors decreased by almost one-third, from 6383 errors in 15 557 orders, a median (range) of 3 (0–48) per patient to 4293 in 15 416 orders, 2 (0–45) per patient (Wilcoxon Rank Sum test, $P < 0.001$). The documentation of drugs causing previous ADRs increased significantly from 81.9% to 88.9% of drugs (χ^2 test, $P < 0.001$). The documentation of the indication for warfarin increased from 12.1 to 34.3% (χ^2 test, $P = 0.001$) and the documentation of target INR increased from 10.8 to 70.0% (χ^2 test, $P < 0.001$) after implementation of the chart.

CONCLUSIONS

National implementation of a standard medication chart is possible. Similar reduction in the rate of prescribing errors can be achieved in multiple sites across one country. The consequent benefits for patient care and training of staff could be significant.

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Introduction

Medication errors are among the most common incidents reported in public hospitals [1, 2]. Prescribing errors are potentially the most serious of all medication errors [3]. A study commissioned by the General Medical Council UK (GMC) found that 5.9% of consultants and 10.3% of trainee doctors in UK hospitals made prescribing errors in 1 week [4]. Approximately 50% of medication errors and adverse drug events (ADEs) are deemed preventable suggesting improvement in current systems possible [5–8].

The causes of prescribing errors and ADEs are multifactorial. Some are knowledge based errors such as not considering previous adverse drug reactions (ADRs), or not knowing a dose of a drug, others are due to slips and lapses due to unfamiliarity with non standard systems [5, 6, 9]. Multiple interventions are therefore required to reduce errors, at the level of the individual, team, system, environment and culture [6, 10]. Further research into why prescribing errors occur identified that a culture exists where drug selection is seen as the critical component of prescribing, and that the processes of selecting forms, routes and doses of drugs and physically documenting or communicating those decisions by completing a medication chart is seen as a low risk chore, frequently delegated to inexperienced junior doctors [6, 9, 11].

Prescribing can be considered as a four stage process, with each stage impacting on the next: (i) gathering patient and drug information including medication history, previous ADRs and an accurate diagnosis, (ii) making a clinical decision to select the correct drug, form, route, dose and duration of treatment depending on the patient's characteristics and other concomitant diseases and drug therapy, (iii) communicating those decisions by generating instructions for the supply and administration of these drugs and (iv) reviewing the outcome and revising the prescribing decisions [12] (Figure 1).

Electronic prescribing with clinical decision support (EP-CDS) offers a partial solution to reducing prescribing errors [13], but such systems are currently not widely available and have also been associated with introducing errors not seen in paper systems [13, 14]. The medication chart remains a critical form of communication of prescribing decisions and instructions between doctors, pharmacists and nurses, and acts as a record of medication administration and supply instructions. Prior to the introduction of the National Inpatient Medication Chart (NIMC), multiple different medication charts existed within and across Australian hospitals. Changes to the layout of medication charts have been shown to reduce the frequency of prescribing errors [15]. When a standard chart was introduced to five sites in south east Queensland, one of eight jurisdictions in Australia with 20.1% of the Australian population, a significant reduction in the frequency of prescribing errors was observed, 20.0% to 15.8% of orders per patient ($P = 0.03$) [16].

There have been calls for a standard chart in the UK and Australia [4, 17]. The GMC report considered that a lack of standardization in prescribing charts contributed to some of the prescribing errors [18]. The process of standardization could reduce the opportunity for errors due to a lack of familiarity and therefore having to learn multiple

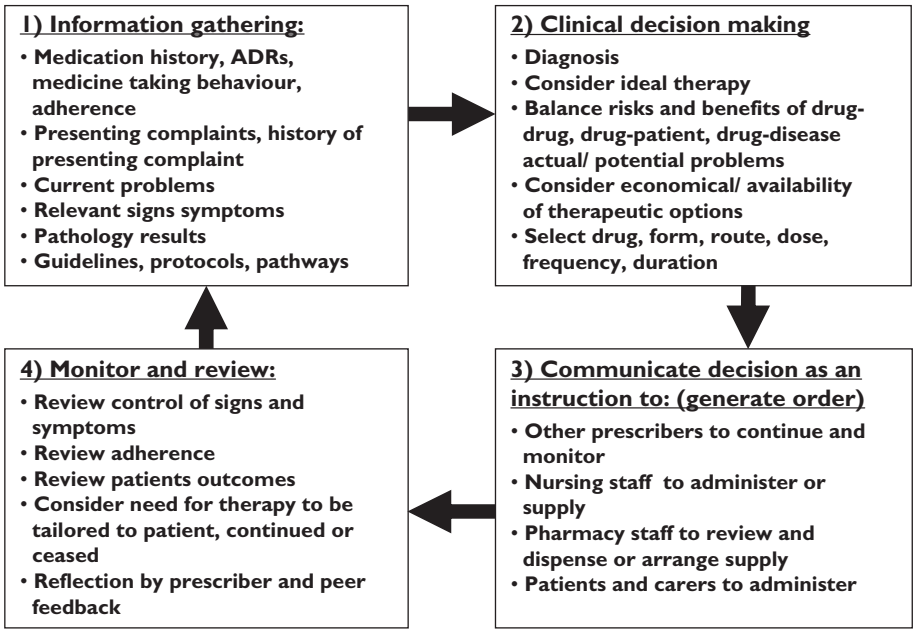

Figure 1
The four stage model of prescribing

systems as clinicians move between clinical units and hospitals [19, 20]. Standard systems also provide an opportunity to uniformly train both students and clinicians in their use. In 2004, all Australian jurisdictional health ministers endorsed the introduction of a standardized NIMC as a national patient safety initiative. In this paper, we describe the pilot of the Australian NIMC and evaluate its effect on the frequency of prescribing errors.

The aim of this study was to take a chart previously trialled at five sites in one state and determine if the benefits in reducing prescribing errors, including documentation of previous ADR and warfarin prescribing details could be replicated if it was applied nationally [16]. The national chart could then enable the development of practical prescribing training and the lessons learned from the pilot study might be applicable to other countries [8].

Methods

The NIMC Working Group (NIMCWG) was convened with doctors, nurses and pharmacists drawn from all jurisdictions. The first objective of the group was to review the evidence supporting any existing charts and it was agreed to use a modification of the state wide chart used in Queensland [16]. The Queensland chart was developed from observational studies, work practice mapping, human factor engineering and a rigorous approach to incident analysis [6]. The process of developing the Queensland chart and its impact on prescribing errors has been described previously [16]. The chart was further enhanced by a Delphi process of piloting, evaluating error rates and seeking feedback from clinicians from medication safety bodies in each jurisdiction as part of the process. In 2005, following consultation with state-wide medication safety and therapeutics committees and within NIMCWG, a pilot version of the NIMC was agreed upon based on the Queensland chart. The current 2009 version of the NIMC is shown in Appendix 1.

Prescribing error study design

The study involved a prospective, before and after chart audit of stat, variable dose, regular and as required (prn) prescribing errors on the general inpatient medication charts. Continuous infusions, insulin, chemotherapy, acute and chronic parenteral analgesia, intensive care, discharge and electronically generated charts were not included in the scope of this study. The definition of prescribing error was adapted from that of Dean *et al.* *'A prescribing decision or prescription writing process that results in an unintentional, significant reduction in the probability of treatment being timely and effective or increases the risk of harm, when compared with generally accepted practice'* [21]. Agreed definitions and examples of types of prescribing errors aligned with the stages of prescribing are shown in Table 1. Lack of documentation of previous ADRs or indication and target International Normalized Ratio (INR) range for warfarin therapy were examples of information gathering errors, unintentional duplication or re-exposing patients to drugs which had caused previous ADRs, although clinically inappropriate, were included as clinical decision errors. The clinical appropriateness of drug, route, dose or form selection was not otherwise examined.

Ethics approval was obtained at sites in accordance with local requirements. A series of workshops in major capital cities across Australia introduced attending doctors, pharmacists and nurses from pilot sites to the background and rationale of the chart. Teams of pharmacists and nurses were trained to systematically undertake the observational audit using a standard tool and to use training packages to assist in local implementation of the chart. Teams undertook direct observational audits, of all available charts on medical, surgical, paediatric and mental health wards to identify and document prescribing errors, using established definitions [21]. All available medication orders including those cancelled or previously changed were reviewed. Inter-rater reliability was not determined, as both trained observers had to agree on errors. Where disagreement occurred a third auditor was involved. The same pairs of auditors undertook pre and post audits where possible.

All outcome measures were collected in November 2004 as a baseline prior to the introduction of the NIMC. The pilot was planned to coincide with the commencement of the new intake of junior medical staff in January 2005. Post implementation data were collected in June 2005, 6 months after introduction of the chart. Data were collected on the numbers of patients; orders, prescribing errors (see Table 1), ADRs documented and warfarin prescribing details. Data on the number of patients and orders were collected from the same wards before and after implementation. Data were entered locally into Excel® spreadsheets and collated centrally.

Statistical methods

The primary outcome measures of the study were the frequency of prescribing errors per patient, the rate of errors per order per patient, the documentation of ADRs and warfarin details, pre and post the introduction of the NIMC. Errors are expressed as actual numbers and percentages. Absolute and relative risk changes were calculated. Categorical data were compared using the χ^2 test, and odds ratios with 95% confidence intervals presented. Continuous data not normally distributed were compared using the Wilcoxon rank-sum test. Tests of continuous data were calculated as two-tailed, and $P < 0.05$ predetermined to represent statistical significance. All statistical analyses were carried out with Stata V10.0. (StataCorp, College Station, TX USA).

Table 1

Common prescribing errors by component of the prescribing process

Error type	Definition and examples
Information gathering	
Documentation of previous ADR or allergy status	If a patient has had either a previous ADR or allergy or if there are no known previous ADR/allergies documented on their medication chart
Details of previous ADR	Patient with previous allergy to penicillin did not have any documentation of actual reaction experienced
Warfarin details	Documentation of indication and target INR range required
Clinical decision making	
Need for drug treatment (duplication)	Patient already prescribed Tritace (ramipril) 10 mg each morning, had lisinopril added
Select specific drug (re-expose patient to drug which caused previous ADR)	Patient allergic to penicillin (hives, rash) started on dicloxacillin
Select drug formulation	Verapamil oral 240 mg each morning prescribed for hypertension, without specifying that sustained release formulation was required.
Communication of clinical decision as an instruction to other prescribers, nurses or pharmacists	
Drug name	Metoprolol oral 50 mg bd was prescribed; patient had received 50 mg of haloperidol as name was unclear and the nurse had misinterpreted the drug name
Drug route	Digoxin 125 µg stat dose prescribed without specifying route
Drug dose	Enalapril oral 1 tablet each morning prescribed without specifying the strength. **Unacceptable ambiguous dosing instructions included:** no leading or unnecessary trailing zeros (.1 g or 5.0 mg), U (for units) *ug* for mcg or micrograms.
Regular dosing frequency	Ceftriaxone IV 1G *od* prescribed. The *od* looked like qd and a nurse had entered administration times of 06.00, 12.00, 18.00 and 22.00 instead of 08.00 only. **Unacceptable ambiguous regular frequency instructions included:** *od which could be interpreted as once, twice or four times each day. 6h, 6/24 or 6°⁻* all of which are used for 6 hourly but can be misinterpreted.
As required (PRN) dosing frequency	**Missing PRN frequencies:** Morphine iv or im 2.5–5.0 mg prn. There was no indication of minimum time interval between doses or maximum dose in a set period of time. **Unclear PRN frequencies:** for drugs which could be administered more than once a day ordered as tds. This could be interpreted as three doses in 24 h or every 8 h. Multiple doses per day PRN per 24 h period were required to be documented hourly on standard chart.

Table 2

Number of patients and medication orders reviewed pre and post implementation of the NIMC in 22 sites

	Pre NIMC (median[range])	Post NIMC (median[range])	RRR (%)	ARR (%)	*P* value, OR (95% CI)
Patients	1 328	1 234			$P > 0.05$
Stat or once only	2 329 [1 (0–26)]	2 600 [1 (0–22)]			$P < 0.001$
Regular orders	9 578 [7 (0–46)]	9 250 [7 (0–85)]			$P = 0.32$
PRN orders	3 650 [2 (0–19)]	3 566 [3 (0–15)]			$P = 0.07$
Total orders written for all patients	15 557 [11 (0–59)]	15 416 [11 (0–112)]			$P = 0.018$
Prescribing errors					
All prescribing errors identified	6 383 [3 (0–48)]	4 293 [2 (0–45)]			$P < 0.001$
Number of patients with ≥1 error	1 130 [85.1]	913 [74.0]	13.0	11.1	$P < 0.001$, 0.5 (0.41, 0.61)
Percentage of errors per order per patient*	33.3% (0–550%)	16.7% (0–300%)	50.0	16.6	$P < 0.001$

ARR, absolute risk reduction; OR, odds ratio; RRR, relative risk reduction, *Calculated from total number of errors per patient divided by total number of orders multiplied by 100.

Results

Thirty sites were recruited in the pre-implementation study and 31 sites provided post implementation data. However, only 22 hospitals provided data for individual patients from the same wards before and after implementation and were included in further analysis. Similar numbers of patients, numbers of orders and numbers of orders per patient were observed pre and post the intervention. There were no statistically significant differences in the numbers of regular or p.r.n. medications ordered per patient before and after the intervention. There were more stat orders and therefore total orders per patient after the intervention as a factor of the standard chart allowing more stat orders. Table 2 presents the different types of orders from the 22 matched sites.

All prescribing errors decreased after introduction of the NIMC; from 6383 errors in 15 557 medication orders in 1328 patients to 4293 in 15 416 orders in 1234 patients (Table 2). Prescribing errors decreased by almost one-third,

Table 3

Prescribing errors according to the stage of the drug use process

	Pre NIMC Number of errors (% of total orders)	Post NIMC Number of errors (% of total orders)	RRR (%)	ARR (%)	*P* value, OR (95% CI)
Total orders	15 557	15 416			
Prescribing decision errors					
Duplication	176 (1.13)	146 (0.94)	16.8	0.19	*P* = 0.10, 0.83 (0.66, 1.04)
Previous ADR same class re-prescribed	59 (1.08) (*n* = 5 467)	29 (0.58) (*n* = 5 011)	46.4	0.50	*P* = 0.005, 0.53 (0.33, 0.85)
Number Sustained Release orders*	NA	400	–	–	–
All prescribing decision errors	235	175	25.2	0.38	*P* = 0.003, 0.75 (0.61, 0.91)
Prescribing communication errors					
Drug name (all orders	782 (5.03)	459 (2.96)	41.15	2.07	*P* < 0.001, 0.56 (0.51, 0.65)
Route (all orders)	1 279 (8.22)	1 012 (6.52)	20.68	1.70	*P* < 0.001, 0.78 (0.71, 0.85)
Sustained Release form not specified	NA	249 (62.3)†	–	–	–
Dose (all orders)	1 412 (9.08)	667 (4.30)	52.64	4.78	*P* < 0.001, 0.45 (0.41, 0.50)
Use of 'od'	480 (3.09)	296 (1.91)	38.19	1.18	*P* < 0.001, 0.61 (0.53, 0.71)
Frequency (regular) excludind od	809 (8.45)	537 (5.74)	32.00	2.71	*P* < 0.001, 0.66 (0.59, 0.74)
Frequency (regular) all errors	1 289 (13.46) (9 578 orders)	833 (9.00) (9 250 orders)	35.21	2.92	*P* < 0.001, 0.63 (0.57, 0.69)
Frequency (PRN) missing	464 (12.71) (3 650 orders)	434 (12.17) (3 566 orders)	4.26	0.54	*P* = 0.49, 0.95 (0.83, 1.10)
Frequency (PRN) unclear	922 (25.26) (3 650 orders)	713 (20.00) (3 566 orders)	48.18	13.09	*P* < 0.001, 0.77 (0.69, 0.86)
Frequency (PRN) all errors	1 386 (37.97) (3 650 orders)	1 147 (32.16) (3 566 orders)	15.29	5.81	*P* < 0.001, 0.77 (0.70, 0.86)
All prescribing communication errors	6 147	4 118†			
All prescribing errors	6 383	4 293†			

*Denominator is the number of sustained release orders, NA, not available. †sr error not included in total errors. ARR, absolute risk reduction; OR, odds ration; RRR, relative risk reduction.

from a median (range) of 3 (0–48) per patient to 2 (0–45) per patient ($P < 0.001$). Data were collected for all orders (including those cancelled) per patient. The percentage of errors per order per patient (errors per patient divided by the total number of orders per patient × 100) could exceed 100% as there could be more than one error per order. The proportion of patients with no error increased significantly from 14.9% to 26.0% ($P < 0.001$). The percentage of errors per order per patient also decreased significantly from a median (range) of 33.3% (0–550%) before to 16.7% (0–300%) after, representing an absolute error reduction of 16.6% ($P < 0.001$).

As shown in Table 3, errors in communication of clinical decisions decreased significantly for drug name, dose, route and frequency. On the pilot NIMC prescribers were prompted to enter both a prescribing frequency and the dosing administration times according to agreed administration times printed on the chart. Twelve of the 22 sites recorded whether the administration times appeared to be entered by the prescriber and whether or not the dosing times correlated with the dosing frequency. Before the intervention, 1019 (18.2%) of 5611 regular orders appeared to have been entered by the prescriber compared with 3647 (67.9%) of 5370 after the implementation of the pilot NIMC ($P < 0.0001$). Consequently, the number of times the administration times did not correlate with dosing frequency dropped from 211 (3.8% of 5611 orders) to 104 (1.9%) ($P < 0.0001$). The total number of communication errors decreased from 6147 to 4118.

Documentation of adverse drug reactions

The patients' medication charts were used as the primary reference source of ADR history information. Patients were asked to confirm information if available. The majority of previous medication charts only displayed ADR details on the front page of either two or four page charts. The NIMC was redesigned so that the ADR details only needed to be entered once (on the top of page 3) and a cut out section at the top of pages one and two meant that the single entry of ADR details was now visible when prescribing on any of three pages (see Appendix 1). The results of

Table 4

Adverse drug reaction documentation

	Pre NIMC (%)	Post NIMC (%)	RRR (%)	ARR (%)	*P* value, OR (95% CI)
Number of patients with ≥1 ADR	403 (30.35)	363 (29.42)	–	–	–
Number of ADR recorded	706 (1 [1–12])*	560 (1 [1–7])*	–	–	$P = 0.41$
Medication name documented	578 (81.87)	498 (88.93)	8.62	7.06	$P < 0.001$, 1.78 (1.27, 2.51)
Reaction documented	212 (30.03)	297 (53.04)	105.34	31.63	$P < 0.001$, 2.63 (2.07, 3.34)
Patients with all names documented	302 (74.94)	315 (86.76)	15.77	11.82	$P < 0.001$, 2.19 (1.48, 3.27)
Patients with previous ADR same class re-prescribed	57 (14.14)	28 (7.71)	45.47	6.43	$P = 0.005$, 0.53 (0.33, 0.85)
Number of patients without ADR	925 (69.65)	871 (70.58)	–	–	–
Patient with nil known ticked or written if no ADR	668 (72.21)	560 (64.29)	10.97	±7.92	$P < 0.001$, 0.69 (0.56, 0.85)
Patients with nil known documented or all medication names documented	970 (73.04)	875 (70.91)	±2.92	±2.13	$P = 0.23$, 0.90 (0.75, 1.07)

ARR, absolute risk reduction; OR, odds ration; RRR, relative risk reduction; *median (range).

Table 5

Stratification of sites and error rates pre and post intervention by size of hospital in the matched 22 sites

Hospital size (total bed numbers)	Number of sites	Number of patients*		Total error per patient [median (range)]		Error rate per order per patient (%) [median (range)]	
		Pre	Post	Pre	Post	Pre	Post
<100	9	562	499	3 (0–37)	3 (0–55)	33.3 (0–500)	30.4 (0–300)
100–300	9	435	413	3 (0–47)	1 (0–27)	30.0 (0–300)	9.1 (0 –200)
>300	4	331	322	4 (0–46)	2 (0–28)	37.5 (0–550)	20.0 (0–155)
All	22	1328	1234	3 (0–46)	2 (0–55)	33.3 (0–550)	16.7 (0–300)
		Kruskal-Wallis test		$P = 0.001$	$P = 0.001$	$P = 0.004$	$P = 0.001$

*Not all beds were audited in all hospitals.

documentation of previous ADRs are shown in Table 4. In the pre-audit, 403 (30.4%) of patients had at least one previous ADR documented compared with 363 (29.4%) of patients in the post audit ($P > 0.005$). Documentation of the drug causing a previous ADR improved significantly from the pre audit (578 drugs were documented) for 81.9% of patients, to 88.9% completed (498 drug documented) for patients in the post audit (χ^2 test, $P < 0.001$). Similarly, the frequency of documentation of the details of the nature of ADR reaction almost doubled from 212 (30.0% of reaction types) to 297 (53.0%) (χ^2 test, $P < 0.001$).

The proportion of patients with at least one or more previous ADRs who were re-exposed to a similar class of drug was 57 of 403 (14.1%) of patients in the pre-audit and significantly less at 28 of 363 (7.7%) after the intervention (absolute risk reduction (ARR) 6.4%; χ^2 test, $P = 0.005$).

Warfarin prescribing

There were similar numbers of patients prescribed warfarin in both audits [83 (6.3%) before, and 70 (5.7%) after]. The indication for warfarin was documented on the medication chart in 10 (12.1%) patients before and in 24 (34.3%) patients on the NIMC (χ^2 test, $P = 0.001$). Documentation of the target INR range increased significantly from nine (10.8%) patients before to 49 (70.0%) after introduction of the NIMC (χ^2 test, $P < 0.001$).

Comparison of error rates between sites stratified by size and compared with the Queensland pilot

On stratifying the pilot hospitals by size, there were significantly higher baseline error rates in sites greater than 300 beds than in medium and smaller sites (Table 5). Post introduction of the pilot NIMC both medium and larger sites showed significantly greater reductions in the number and frequency of errors, with similar absolute reductions in error compared with smaller sites. When combined, the 22 sites post NIMC introduction showed an error rate per order per patient of 16.7%, which was similar to that shown in the Queensland pilot after introduction of the chart (15.8%).

Discussion

This study details the successful introduction of a standard medication chart informed by error analysis and supported by education and pre and post audit data in 22 hospitals across Australia. Results demonstrate that a chart developed in one state and shown to reduce significantly prescribing errors could be adopted nationally and implemented with the support of a programme of education.

The introduction of the NIMC pilot was associated with reductions in a range of types prescribing errors. Improvements were demonstrated in the documentation of information informing prescribing decisions such as previous ADRs with a consequential reduction in patients re-prescribed drugs to which they had had a previous ADR. Prescribers more frequently documented the dosing administration details for regular medications and as a result, the opportunity for inappropriate dosing administration was significantly reduced. Another improvement was the documentation of warfarin prescribing information, which has been shown to inform subsequent prescribing dosing decisions and reduce the occurrence of unsafe INR levels [16].

We have shown that the creation and implementation of a pilot of a national medication chart is possible following appropriate consultation. A strong body of evidence, based on careful analysis of individual, team and system errors, is required to demonstrate the potential benefits and risks of such initiatives prior to their introduction [6]. Prescribing practices, both the clinical reasoning behind the selection of medications, routes, dose and frequencies and the safety of the communication of those prescribing decisions can be modified through system changes such as those employed in this study. The existence of a standardized system allows prescribing education of all staff using the one common system that they will find in every hospital.

Other explanations for the observed reduction in error rate

The following sections outline the alternate hypothesis for the significant reduction seen in error rates associated with the NIMC intervention. The number of patients, regular and as required orders per patient did not differ before and after the intervention reflecting the similarity of wards and patients selected. Where possible, the use of the same clinicians collecting data in pre and post audits ensured a consistent approach. The audit tool was unlikely to have lead to a biased approach as strict protocols and definitions were used.

There are limited explanations for the observed reduction in error rates other than an effect of the chart itself. The interaction of humans with poorly designed systems is a common cause of human error [22]. The content, lack of decision support and layout of medication charts have previously been shown to contribute to prescribing errors [6]. Revision of the chart layout combined with feeding back the frequency of prescribing errors to prescribers has been demonstrated to change prescribing behaviour resulting in reduced frequency and seriousness of prescribing errors [15, 16].

The reduction of patients re-prescribed drugs to which they had had previous allergies was most likely due to the information being visible when generating the majority of orders, prompts for forms, doses, frequencies and indications for warfarin were all features introduced with the chart.

The individual prescribers may have had an impact on the prescribing errors observed. The junior medical staff would most likely have changed between the two audits. The different times of the year may have been expected to impact on the prescribing error rate observed as junior doctors may be expected to make a higher number of prescribing errors earlier in their first year. However in this study the pre audit period was November, 11 months into the intern year whilst the post audit was completed in June, 6 months into the intern year. This suggests that even with less experience of using the chart, a lower number of errors were made 6 months into their intern year, further supporting the possible impact of the chart design and layout.

A further explanation for a reduced error rate could have been the education, including a detailed explanation of the background and function of the chart, provided as part of new medical staff induction prior to introduction of the pilot chart. Educational material and other materials to support implementation has been available on the Commission's website for hospitals to use when educating new prescribers during induction/orientation.

The variation in scale of error reduction between small, medium and larger sites was surprising but could be due to multiple factors including smaller sites having more locum staff, less local graduates and fewer consultant and trainee staff, and often lower levels of clinical pharmacy service.

Limitations

The change in medical staff between pre and post audits which may have included varying numbers of locally trained staff could have impacted on the results. The study methodology did not include recording individual prescribers' experience which could have affected prescribing error rates in the two samples. Also, the fact that this was a relatively well marketed system change could have been expected to have raised prescribers' awareness of medication safety and changed their prescribing behaviour in addition to any benefit from the chart alone, i.e. a Hawthorn effect may well have been operating. Whilst training for local co-ordinators occurred centrally, using a standardized training package, the impact of multiple observers across 22 sites may well have limited inter-rater reliability.

Comparison with other studies

The baseline error rate identified in our study (33% orders per patient with an error) was higher than in the Queensland pilot of a similar chart (20.0%) although this lower rate in the Queensland pilot could be attributed to the use of a range of medication safety education programmes already in place in Queensland. The scale of reduction of error was greater in this study than in the Queensland pilot but the final error rate was similar, 16.7% of errors per order in this study and 15.8% in the Queensland study.

The baseline error rate identified in our study (33% per order per patient) was considerably higher than the 1.5 to 6.7% found in prospective UK studies [23], even though similar definitions of prescribing errors were used. Variation in prescribing error rates is known to be observer dependent. In a previous study undertaken with a pharmacologist and pharmacist observer, we identified an error rate of only 2.5% per order [24]. Part of the difference in rates between previous studies and this study may be attributable to the use of trained pharmacist and nurse teams [23]. Nurses may be more aware than pharmacists of issues relating to potential administration errors that may result from prescribing errors, in particular those associated with communication of clinical decisions. The use of nurse and pharmacy observers may have resulted in a broader range of errors than seen with doctor and pharmacist studies. In order to increase inter-rater reliability both observers had to agree on errors, and where possible the same teams undertook the before and after audits.

Effective change management

Key success factors included a multidisciplinary approach to redesigning a high risk system in which each stage is affected by and impacts on others. The outcomes achieved in this study underscore the importance of leadership, communication and team cohesion for the successful implementation at individual sites [25].

The study also demonstrates the importance of a combination of top down direction from national safety and quality bodies, agreement by all health ministers and clinical ownership, and bottom up 'buy-in'. The lessons learned from this study are not new [26, 27].

Each member of the NIMCWG was responsible for taking the issues and work in progress back to their state's medication safety bodies and subsequently reporting back local comments and issues. This liaison encouraged 'buy-in' and ownership at a state level.

There was the risk of individual hospitals not participating in the developmental process and feeling that they were not adequately involved in the system redesign. Some authors using different prescribing error definitions focused on the completeness of specific sections of the chart and suggested that the NIMC did not show significant benefits compared with their previous chart in one site [28]. The analysis in this study from over 15 000 orders before and after intervention in 22 sites would confirm that the chart with supporting education was powered appropriately to show improvement in safety when compared with a wide range of previous charts [8, 28].

National implications

This findings of this study are relevant to systems using paper-based orders (such as those widely used in the UK and Australia) and may help guide the development and introduction of any future electronic medication management systems [26]. The methods and outcomes discussed have implications for all medication systems. A standardized insulin monitoring, prescribing and administration is being developed following a similar methodology to the NIMC. Safe prescribing education is a core component of the Australian National Patient Safety Education Framework [29] and the Australian Curriculum Framework for Postgraduate Medical Staff [30]. The NIMC is now being used in standardized prescribing training for undergraduate medical students [31] and there is an online training programme that is used by all Australian medical schools [32].

This pilot study demonstrated that the creation and implementation of a national medication chart was possible following appropriate consultation. Following this study the pilot NIMC was endorsed by health ministers as a national standard and recommended for implementation in all public hospitals in Australia. This occurred during 2006 and 2007. This then allowed undergraduate courses to introduce the medication chart to students in training programmes prior to taking up employment.

Sustainability of a national medication chart is a critical factor for on-going patient safety. The ongoing evaluation and improvement of the national chart should continue to be from national input, supported by evidence including detailed incident analysis and audits. To this end, the Australian Commission for Safety and Quality in Healthcare has implemented an Oversight Committee for the Australian NIMC. This group with state and territory representation ensures ongoing governance of the NIMC. The current version of the NIMC was released in 2009 (Appendix 1).

The benefits identified from the NIMC process for chart re-design are now being extended to prescribing and administration processes for venous thrombo-embolic prophylaxis, insulin, anticoagulation and continuous infusions of medicines.

In conclusion, prescribing is a complex and high risk intervention. A collaborative, evidence-based approach, using error analysis to develop a standard national medication chart, can reduce errors in various stages of prescribing and the potential for harm to patients. The chart will facilitate effective training of staff and increase the familiarity of staff with medication systems when working in different sites. A strong evidence base, demonstrating the benefits of initiatives, is essential before interventions such as the NIMC are accepted widely. It is clear that work practices can be modified and prescribing safety improved

through medication chart redesign. The NIMC has now been rolled out across all public and private hospitals in Australia.

Competing Interests

IC, CR, DS and CM all received funding for travel to attend National Inpatient Medication Chart Working Group meetings from the Australian Commission of safety and quality in health care.

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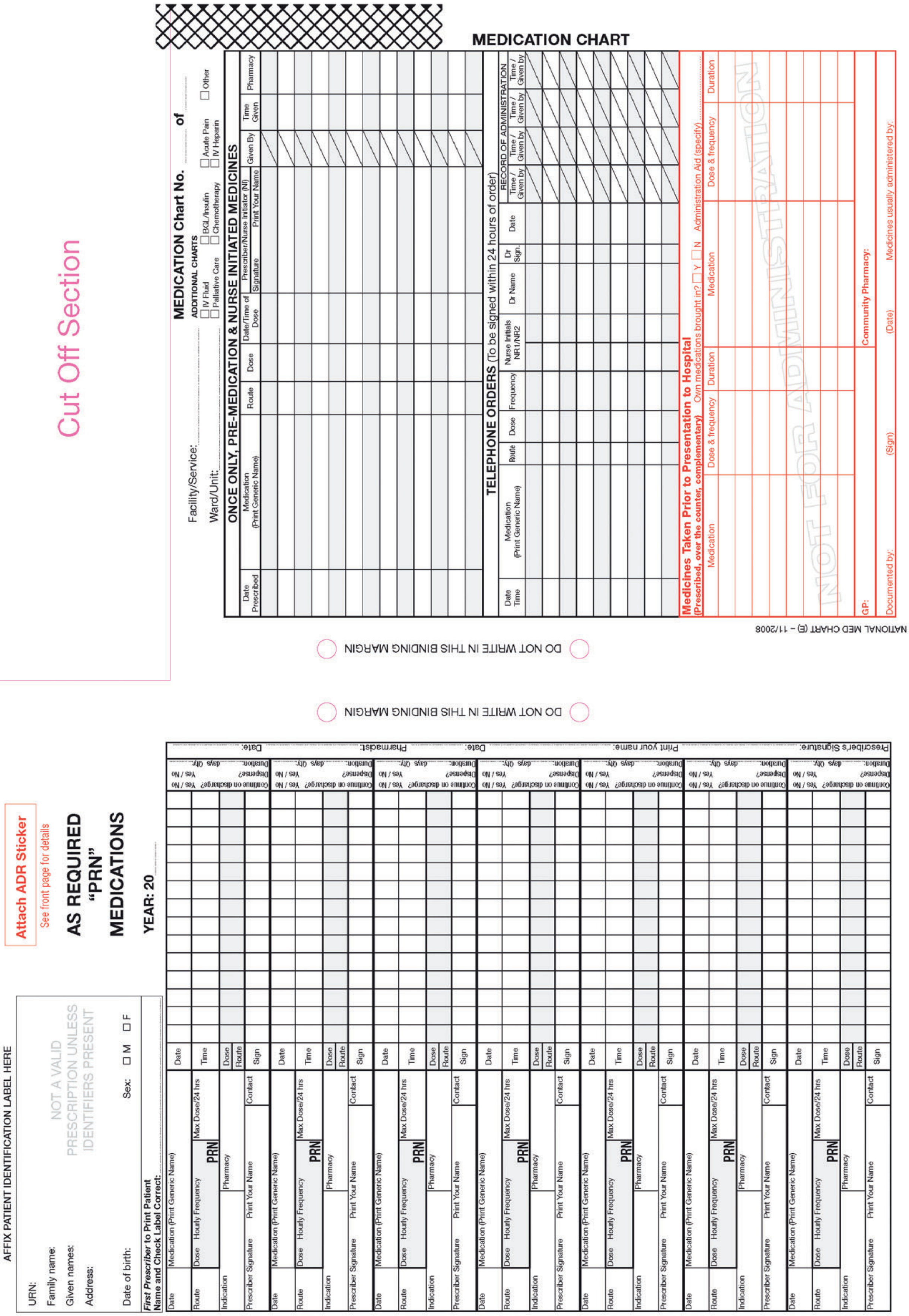
Appendix 1

The 2009 version of Australian National Inpatient Medication Chart


AFFIX PATIENT IDENTIFICATION LABEL HERE

URN:
Family name:
Given names:
Address:
Date of birth: Sex: ☐ M ☐ F

NOT A VALID PRESCRIPTION UNLESS IDENTIFIERS PRESENT

Attach ADR Sticker
See front page for details

AS REQUIRED "PRN" MEDICATIONS

YEAR: 20___

First Prescriber to Print Patient Name and Check Label Correct:

Date	Medication (Print Generic Name)		Date
Route	Dose	Hourly Frequency	Max Dose/24 hrs	Time
Indication		Pharmacy	PRN	Dose Route
Prescriber Signature	Print Your Name	Contact	Sign

Continue on discharge? Yes / No — Dispense? Yes / No — Duration: ___ days Qty: ___

Prescriber's Signature: ___ Print your name: ___ Date: ___ Pharmacist: ___ Date: ___

DO NOT WRITE IN THIS BINDING MARGIN

Cut Off Section

MEDICATION CHART

MEDICATION Chart No. ___ of ___

Facility/Service: ___
Ward/Unit: ___

ADDITIONAL CHARTS
☐ IV Fluid ☐ Palliative Care ☐ BGL/Insulin ☐ Chemotherapy ☐ Acute Pain ☐ IV Heparin ☐ Other

ONCE ONLY, PRE-MEDICATION & NURSE INITIATED MEDICINES

Date Prescribed	Medication (Print Generic Name)	Route	Dose	Date/Time of Dose	Prescriber/Nurse Initiator (NI) Signature	Print Your Name	Given By	Time Given	Pharmacy

TELEPHONE ORDERS (To be signed within 24 hours of order)

Date Time	Medication (Print Generic Name)	Route	Dose	Frequency	Nurse Initials NR1/NR2	Dr Name	Dr Sign.	Date	RECORD OF ADMINISTRATION Time / Given by	Time / Given by	Time / Given by	Time / Given by

Medicines Taken Prior to Presentation to Hospital
(Prescribed, over the counter, complementary) Own medications brought in? ☐ Y ☐ N Administration Aid (specify): ___

Medication	Dose & frequency	Duration	Medication	Dose & frequency	Duration

GP: ___ Community Pharmacy: ___
Documented by: ___ (Sign) ___ (Date) ___ Medicines usually administered by: ___

NOT FOR ADMINISTRATION

NATIONAL MED CHART (E) – 11/2008

Cut Off Section

Attach ADR Sticker

ALLERGIES & ADVERSE DRUG REACTIONS (ADR)
☐ Nil known ☐ Unknown (tick appropriate box or complete details below)

Drug (or other)	Reaction/Type/Date	Initials

Sign ..... Print ..... Date .....

AFFIX PATIENT IDENTIFICATION LABEL HERE AND OVERLEAF

URN:
Family name:
Given names:
Address:
Date of birth: Sex: ☐ M ☐ F

NOT A VALID PRESCRIPTION UNLESS IDENTIFIERS PRESENT

First Prescriber to Print Patient Name and Check Label Correct: Weight(kg):..... Height(cm):.....

REGULAR MEDICATIONS

YEAR 20..... DATE & MONTH →

VARIABLE DOSE MEDICATION

Date | Medication (Print Generic Name) | Drug level | Time level taken | Dose | Prescriber | Time to be given: ..... | Time given

Route | Frequency | Prescriber to enter dose times and individual dose

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | WARFARIN (Marevan/Coumadin) select brand | INR Result | Dose mg mg mg mg mg mg mg mg mg mg mg | Prescriber | 1600 (Nurse 1) | Nurse 2

Route | Prescriber to enter individual doses | Target INR Range

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

DOCTORS MUST ENTER administration times

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Pharmaceutical Review:

Date: Pharmacist: Print your name: Prescriber's Signature:

RECOMMENDED ADMINISTRATION TIMES
GUIDELINES ONLY

Morning	Mane	0800			
Night	Nocte			1800 or 2000	
Twice a day	BD	0800		2000	
Three times a day	TDS	0800	1400	2000	
Regular 6 hourly	6 hrly	0600	1200	1800	2400
Regular 8 hourly	8 hrly	0600	1400	2200	
Four times a day	QID	0600	1200	1800	2200

WARFARIN EDUCATION RECORD
Patient Educated by: .....
Sign: .....
Date: .....
Given Warfarin Book: .....
Sign: .....
Date: .....

Tick if Slow Release

SR = Sustained, modified or controlled release formulation.
If scored tablet, then half can be given.
Dose must be swallowed without crushing.

REASON FOR NURSE NOT ADMINISTERING
Codes MUST be circled

Absent	A
Fasting	F
Refused – notify Dr	R
Vomiting	V
On leave	L
Not available – obtain supply or contact Dr	N
Withheld – enter reason in clinical record	W
Self Administered	S

REGULAR MEDICATIONS

YEAR 20..... DATE & MONTH →

DOCTORS MUST ENTER administration times

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Date | Medication (Print Generic Name) | Tick if Slow Release

Route | Dose | Frequency & NOW Enter Times →

Indication | Pharmacy

Prescriber Signature | Print Your Name | Contact

Continue on discharge? Yes / No Dispense? Yes / No Duration: ..... days Qty: .....

Pharmaceutical Review:

Date: Pharmacist: Print your name: Prescriber's Signature:

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