USE OF AN AUDIT WITH FEEDBACK IMPLEMENTATION STRATEGY TO PROMOTE MEDICATION ERROR REPORTING BY NURSES

Short title: Medication Error Reporting by Nurses

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Authors' Contributions

AMH, TKB and AES conceived of and obtained funding for the study. AMH, TKB, AES, and VB designed the study protocol. VB coordinated the data collection and data cleaning. AC, VB and MM planned and conducted the statistical analysis of the data and AC, AMH, & MM drafted the manuscript. All the authors participated in the interpretation of the data and in the critical revision of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims and objectives

To outline the development and effect of an audit with feedback implementation strategy that intended to increase the rate of voluntary medication error reporting by nurses.

Background

Medication errors are a serious global health issue. Audit with feedback is a widely-used implementation strategy that has potential to modify nurses' reporting behaviour and improve medication error reporting rates.

Design

Quasi-experimental implementation study (fulfilling the TIDieR checklist) with two pairs of matched wards at a private hospital in Australia was conducted from March 2015-September 2016. One ward from each pair was randomised to either the intervention or control group.

Method

Nurses within intervention wards received audit with feedback on a quarterly basis over a 12-month implementation period. Control wards underwent quarterly audits only (without feedback). Feedback consisted of a one-page infographic poster, with content based on medication error data obtained from audits and the hospitals' risk management system (RiskMan). The primary outcome - rate of medication errors reported per month - was determined in both groups at pre-implementation, implementation, and post-implementation phases. Differences between groups were compared using generalised linear mixed models with Poisson distribution and log link.

Results

A non-significant intervention effect was found for rate of medication errors reported per month. Interestingly, when combining data from both groups, a significant increasing time trend was observed for medication errors reported per month across pre-implementation and implementation phases (80% increase).

Conclusions

The audit with feedback strategy developed in the present study did not effectively influence the voluntary reporting of medication errors by nurses.

Relevance to clinical practice

Despite the lack of intervention effects, the use of a published checklist to optimise the reporting quality of this study will contribute to the field by furthering the understanding of how to enhance audit with feedback implementation strategies for nurses.

KEYWORDS

Nurses; Medical Audit; Medication Errors; Implementation Science; Patient Safety; Quality Assurance, Health Care; Feedback, Psychological

INTRODUCTION

Patient safety and quality improvement initiatives are key considerations within increasingly complex healthcare environments (Leape & Berwick, 2005). The reporting, analysis, and prevention of medical errors that may result in adverse outcomes for patients are particularly salient issues for the acute healthcare sector (Wolf & Hughes, 2008). While incidence rates vary considerably between countries and settings, a substantial body of evidence indicates that medical errors are a leading cause of mortality and injury worldwide (Institute of Medicine (US) Committee on Quality of Health Care in America, 2000). Estimates have placed medical errors as the third most common cause of death in the US (Makary & Daniel, 2016). The resultant impact of medical errors on patients, healthcare professionals, and acute care organisations is therefore significant at the human, societal and economic levels.

Medication errors are a chief contributor to overall medical error rates, with global total healthcare expenditure in response to medication errors estimated to be USD$42 billion annually (Aitken & Gorokhovich, 2012). The medication administration process is particularly vulnerable to errors (Keers et al., 2013). Errors associated with medication administration in Australian hospitals are reported to occur in ~9% of all administrations (excluding timing errors) (Roughead et al., 2016). While medication errors do not always result in serious harm to patients, the majority of such errors are preventable. Fundamental to the prevention of medication errors in the acute care setting is the reporting of errors as they occur. In the majority of acute care organisations, healthcare professionals are responsible for voluntarily entering medical errors into a secure risk management software system. Reporting allows for circumstances surrounding errors to be understood, future prevention efforts to be tailored and prioritised, and a culture of safety to be encouraged (Elden & Ismail, 2016). Despite such clinical importance, widespread under-reporting of medication errors is a well-recognised problem that reduces data quality and impedes the generation of strategies to enhance patient safety (Wolf & Hughes, 2008).

The under-reporting of medication errors can be attributed to a multitude of health system, organisational, and individual factors that influence healthcare professional behaviour. Given that nurses spend up to 40% of their time administering medications (Armitage & Knapman, 2003), and are responsible for checking prescribed medications and monitoring the effect of administered medications, they have a key role in the reporting of medication errors. Implementation strategies that focus on positively influencing the voluntary reporting behaviours of nurses are therefore vital for the improvement of medication error reporting rates in acute healthcare settings.

BACKGROUND

The field of implementation science has an important role in improving the quality and effectiveness of healthcare, via the scientific study of methods that promote the systematic uptake of evidence-based practices into routine clinical care (Eccles & Mittman, 2006). The scope of implementation science is broader than traditional clinical research, with factors such as healthcare professional behaviour and organisational context considered key to the sustainable uptake, adoption and implementation of evidence in practice. Within the discipline, an implementation strategy is defined as "an integrated set, bundle, or package of discreet implementation interventions ideally selected to address specific identified barriers to implementation success" (Bauer et al., 2015, p.4). Common examples of implementation strategies include reminders, academic detailing, as well as audit with feedback (Proctor, Powell, & McMillen, 2013).

Audit with feedback is a widely used implementation strategy that has potential to modify nurses' reporting behaviour and improve medication error reporting rates. Feedback has been defined in the literature as "a summary of the clinical performance of healthcare provider(s) over a specified period of time" (Ivers et al., 2012, p.1). More practically, feedback strategies based on audit data involve individuals or groups of healthcare professionals who receive feedback on their clinical performance, by reflecting on audit data derived from their routine practice. The intention of audit with feedback is to enhance professional performance through increasing awareness and motivation to change behaviour and/or improve outcomes, and in turn, maximise quality of care and safety of patients. The effect of audit with feedback has been evaluated in three Cochrane reviews and updates since 2003 (Ivers et al., 2012, Jamtvedt et al., 2006, Jamtvedt et al., 2003). The most recent review in 2012 observed a positive increase in desired practice (median adjusted absolute risk difference 4.3%), although results were highly variable (IQR 0.5% to 16%) (Ivers et al., 2012). This review also indicated that audit with feedback may be more effective when baseline performance is low; when feedback is provided both verbally and in writing; when feedback is delivered by a supervisor or colleague; when the process is performed more than once; and when feedback includes clear targets and an action plan (Ivers et al., 2012). Other research has additionally observed that audit with feedback requires a supportive organisational context that encompasses a constructive approach to continuous quality improvement, as well as factors related to staffing, resource and leadership (Jamtvedt et al., 2019). While knowledge of these supportive design elements and organisational factors are valuable, the heterogeneity of previous research and the inconsistent reporting of primary studies has meant there remains a lack of evidence regarding which aspects of this complex, multidimensional strategy work best. Additionally, the majority of studies undertaken to date have involved the use of audit with feedback among doctors (Ivers et al., 2012). Only 11% (n=16) of the 140 studies included within the most recent Cochrane review explicitly tested audit with feedback among nurses (Ivers et al., 2012).

This paper reports the findings of a study testing the effect of a feedback strategy (the Safe Medication Audit Reporting Translation [SMART] intervention) on nurses' medication error reporting. In an effort to reduce known gaps and variation in reporting of primary studies of audit with feedback strategies, this paper reports against a checklist of modifiable audit with feedback design elements that has been produced through a consensus-based approach in a secondary review of audit with feedback strategies (Colquhoun et al., 2017).

METHODS

Design

A quasi-experimental implementation study, with two pairs of matched wards at an acute care hospital, was conducted from March 2015 to September 2016. The utilisation of a quasi-experimental design was primarily chosen for its capacity to establish intervention effects in 'real-world' settings – with consequently high external validity (Bärnighausen et al., 2017). Wards (two surgical and two medical) were selected for inclusion and matched based on similarities in average length of stay, number of occupied beds (28-30) and geographical layout. One ward from each pair was randomised to the intervention group, while the other was randomised to the control group. Wards were coded and randomisation was performed blind, using computerised random allocation software. Intervention wards received the audit with feedback strategy, while control wards underwent audit only (without feedback). Key information related to the methods utilised in this study is provided in this paper. The Template for Intervention Description and Replication (TIDieR) checklist (Hoffmann et al., 2014) was used to ensure the reporting of the implementation strategy was complete (Supplementary File 1).

A more detailed explanation of the methods can be obtained from the published protocol paper (Hutchinson et al., 2015).

Research aims and objectives

The aim of this study was to develop and test the effect of an audit with feedback implementation strategy that was intended to increase the rate of voluntary medication error reporting by nurses. The primary research question was therefore: "Does audit with feedback promote voluntary medication error reporting by nurses"? Based on the findings of pilot and feasibility work (Hutchinson et al., 2015), a directional hypothesis was established; that the audit with feedback implementation strategy delivered to nurses in the intervention wards would result in an increase in the rate of reported medication errors by nurses.

Theoretical underpinnings

Two distinct but complementary theories informed this study; the Promoting Action on Research Implementation in Health Services (PARIHS) Framework (Kitson, Harvey & McCormack, 1998; Rycroft-Malone, 2004) and the Theory of Planned Behaviour (TPB) (Ajzen, 1985). According to the PARIHS framework evidence, facilitation and context are key ingredients in the success of efforts to implement practice change (Kitson, Harvey & McCormack, 1998; Rycroft-Malone, 2004). In the present study, medication error and reporting rate data provide the evidence; facilitation refers to the roles and strategies used to promote increased medication error reporting; and the context constitutes the culture, leadership and evaluation/feedback process within the respective wards. The TPB addresses an individual's intention to act in a certain way (Ajzen, 1985). Accordingly, behavioural intention is theorised to be a precursor to actual behaviour. Intention is derived from attitudes (e.g., attitudes towards medication error reporting), subjective norms (e.g., perceptions, as influenced by peers, about expectations to undertake medication error reporting), and perceived behavioural control (e.g., perceived ease or difficulty associated with reporting of medication errors).

Outcome definition

The standard definition of a medication error was adopted as specified by National Coordinating Council for Medication Error Reporting, which states: *"A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer"* (National Coordinating Council for Medication Error Reporting and Prevention, 2017).

Setting and sample selection

The study was undertaken at one large, private, not-for-profit hospital in Melbourne, Australia. This hospital was selected for convenience; the associated pilot research was conducted at this hospital (Hutchinson et al., 2015), and the organisation had expressed a continued desire to advance this work. Sampling of wards was purposive, with ward selection and matching guided by an initial assessment of the clinical case-mix (diagnostic group, average length of stay, occupied beds) of all acute care wards at the participating hospital. This process was performed in collaboration with the Executive Director of Nursing. The medical wards included a neurology/stroke ward and a general medical/aged care assessment ward; the surgical wards included a cardiothoracic ward and a plastics/general surgery ward. These wards were not involved in the pilot research. All participating wards were located in close proximity to each other, and comprised teams of medical doctors that worked across multiple wards. All managers (n=4) and full/part-time nurses (both registered and enrolled nurses; n=162) working in the participating wards were considered eligible for inclusion. Casual nurse bank/agency nurses and nursing students were excluded due to their inconsistent presence on wards.

Implementation strategy development

A key stakeholder group was established to determine the preferred methods and mechanism for feedback. This group comprised of 17 representatives, including ward nurses (n=4), nurse unit managers (n=2), pharmacists (n=3), clinical governance/change management personnel (n=2), nurse directors (n=2), researchers (n=3) and a senior medical doctor (n=1). The feedback component of the implementation strategy was informed by individual meetings and email communication with key stakeholders. Specifically, advice was sought regarding content (prioritisation of variables, content comprehension, content relevance), frequency, presentation (written/verbal, use of illustrations/graphical elements, visual appeal, layout), delivery (mode of delivery), and supportive processes (information sessions). Prior to the first round of feedback, members of the stakeholder group were asked to evaluate a feedback prototype, primarily with regard to the understandability, usefulness, and usability of feedback. Evaluation of the feedback prototype was obtained from stakeholders via both email and individual face-to-face meetings. Modifications to the feedback prototype were performed prior to the implementation of each round of feedback.

Implementation strategy delivery

A feedback report (that incorporated a brief educational component) was presented in a one-page infographic poster and provided to intervention wards on a quarterly basis (i.e. four times in total) throughout the 12-month implementation phase. All members of the stakeholder group were emailed the feedback poster one week prior to feedback being delivered to intervention wards. Stakeholders were invited to comment on the content in general, and were also asked to comment on specific aspects of the content. When appropriate, revisions were made to the poster based on the comments received. The feedback poster was then printed in colour and placed in the intervention wards by a member of the research team (a nurse and PhD student). Poster locations, as deemed appropriate by the stakeholder group and nurse unit managers of participating wards, included: medication rooms, the mirror next to hand basin in staff bathrooms, on the back of toilet doors and on the walls above toilet roll holders, on tables in tea rooms, in staff communication books, and on the wall near staff lockers. Feedback posters were also sent electronically via email by the senior nurse/s to nurses in the intervention wards.

The feedback report was unique to each intervention ward and specifically related to processes of care. The content of the posters drew on data generated from two main sources:

1) Point-*prevalence audits of medication documentation in patients' medical records*
   Audit cycles occurred every three months over the 12-month implementation phase (i.e. four times). Each cycle comprised of an audit performed two weeks prior to the delivery of feedback, and again two weeks post feedback. Each audit typically commenced on a Tuesday and involved an audit of the medication charts/medical records of all patients from two days prior (to allow for any documentation lag). Data obtained therefore represented all patients in a given ward on a consistent day of the week between 1pm and 10pm. The audits of patient medical records detected errors evidenced in the documentation related to, for example, missed medications without a documented reason for omission, wrong timing and/or frequency of administration, medications administered when the patient had a record of a previous adverse drug reaction, medications administered when the medication record did not include sufficient patient identifiers, when the prescription was not signed by a medical officer, or when the prescription medication name, dose, frequency and/or route were not clearly documented. A member of the research team (a nurse and PhD student) and a research assistant who were not blinded to ward allocation, conducted all point-prevalence audits. Data from this source that was presented in the feedback to intervention wards included: the number of medication errors observed, the number of patients affected by a medication error, a breakdown of the types of medication errors observed, and the number of charts appropriately documenting patient allergy status, weight and Identification (ID).
2) Medication error reports and medicine-related adverse events reported in the risk management and reporting system (RiskMan.Net©)
   Routinely-reported RiskMan medication errors/adverse event data extracted for the individual intervention wards for the timeframe corresponding to the specific time period of the point-prevalence audits were included in the feedback posters.

Feedback posters presented data from the above-mentioned sources, aggregated at the ward level. At no point did feedback posters reflect the performance of individual nurses or provide data for individual patients. The posters included both text and graphical depictions of the data, namely pie charts and bar charts. Intervention wards were not compared to each other in the feedback posters, instead, comparisons were made that depicted within-ward differences between previous audit cycles. Feedback posters included 'did you know…?' information sections related to medication safety, organisational policy and medication error reporting. The content of these sections was the same for both intervention wards at each cycle, but differed at each of the four feedback cycles. The selection of content for the "did you know…?" sections was based on information obtained from the post-feedback survey (as described within outcome assessment section). The colour palette of the feedback posters was also slightly modified at each feedback cycle to assist nurses in differentiating between feedback posters. The bottom section of each feedback poster specified a target that nurses were expected to meet – 100% reporting of medication errors in RiskMan. Located next to this target, the number of medication errors reported in RiskMan for the current feedback cycle was specified and compared to the previous feedback cycle. The feedback report did not explicitly ask nurses to consider the implications of the feedback for their clinical practice. Similarly, nurses were not required to complete an action plan based on feedback received. An example feedback poster can be found in Supplementary File 2. Posters were removed from the intervention wards approximately three weeks after the initial posting.

Control

Wards randomised to the control condition underwent point-prevalence audits of medication documentation in patients' medical records (as outlined above). No feedback was provided to nurses or nurse unit managers in the control wards following the point-prevalence audits. As with the intervention wards, weekly RiskMan data were retrospectively obtained for the control wards for the entire study period.

Outcome assessment

In line with the directional hypothesis of the present study, the primary outcome was the number of medication errors/medication-related adverse events reported in RiskMan per month. All medication-related RiskMan data were retrospectively extracted for all four wards by a staff member of the Clinical Governance Unit at the participating hospital, who was blinded to ward allocation. Relevant RiskMan data were extracted for the following periods: a 12-month period prior to the implementation phase (pre-implementation); the 12-month period of the implementation phase (implementation); and a 6-month period following the implementation phase (post-implementation). The purpose of extracting data over the three specified periods was to establish a trend in medication error reporting over pre-implementation, implementation, and post-implementation periods. Figure 1 details the outcome assessment cycle for the entire study period.

Secondary outcomes for the present study included dimensions of organisational context and nurse perceptions about the useability, usefulness, and understandability of the feedback posters. These data were obtained using the following instruments:

1) The Alberta Context Tool

The Alberta Context Tool (ACT), informed by the PARIHS framework (Kitson, Harvey & McCormack, 1998; Rycroft-Malone, 2004) and other literature, assesses individual healthcare professionals' perceptions of modifiable aspects of the work environment (Estabrooks et al., 2009). Individual data can then be aggregated to produce ward/group level estimates of organisational context. This information was sought to determine if differences in organisational context existed between wards. The acute care version of the ACT was administered on two occasions to nurses in all four wards: at baseline of the implementation phase (prior to the introduction of feedback); and again at the completion of the 12-month implementation phase. The ACT consists of 56 items that assess eight dimensions of organisational context: culture, leadership, evaluation, social capital, informal interactions, formal interactions, structural and electronic resources, and organisational slack. The eighth dimension, organisational slack, is subdivided into three categories (staff, space, and time). Together, these dimensions and sub-dimensions comprise ten modifiable concepts (Box 1). All 56 items are scored on a 5-point Likert scale. A variety of methods are used to obtain final scores for each dimension/sub-dimension; however, higher scores reflect a more positive perception of a given dimension (e.g. leadership) within the care unit. The ACT has previously been shown to have adequate internal consistency reliability; Cronbach's alpha exceeded 0.70 for nine out of ten ACT dimensions (Squires et al. 2015). Demographic items (e.g. age, education, role) were also added to the ACT survey. These demographic items were selected to describe the sample of nurses participating in the present study.

2) Post-Feedback Survey

An anonymous post-feedback survey was developed to elicit nurses' perceptions about the feedback, specifically the use, understandability, usefulness, and relevance of feedback. Informed by the TPB, a series of questions related to intention to change behaviour in response to the feedback. Survey items were drawn from a post-feedback survey previously designed and implemented by a member of the research team (Squires et al., 2014). Modifications to the wording of some survey items were necessary to account for contextual differences between studies (e.g. variation in country, setting, and groups of health professionals being surveyed). Overall, the survey comprised seven forced choice items related to the perceptions of the feedback reports, and five open-ended questions that invited suggestions to improve future feedback posters. The survey also included eight forced choice items that examined demographics and the clinical role of the nurse.

Ethical issues and approval

Prior to commencement of data collection, a member of the research team individually met with all intervention and control group nurses to explain the study purpose and procedure, to respond to any questions, and to provide them with an explanatory statement. Surveys were hand-delivered to nurses by the researcher or the nurse-in-charge. Completion and return of instruments implied consent to participate in the study. Operational approval was provided by the Executive Director of Nursing at the participating hospital. Ethics approval was obtained from the university's human research ethics committee, and the participating hospital's human research ethics committee.

Power Calculation

In the post-implementation period, total mean number of occupied beds in the intervention and control groups were 5673 and 5506 respectively, and monthly medication error report rates were 10.17 in the intervention and 6.57 in the control. This information was used to perform a post-hoc power calculation for between-group comparison (i.e. intervention vs control) at the post-implementation period. Using the above information, the study had more than 80% (81.3%) power to detect a 75% relative increase in medication error proportion, this was equivalent to 5% absolute increase (i.e. from 0.007 to 0.012) in the intervention group. A significance level of 0.05 was assumed for this calculation.

Statistical analysis

Descriptive statistics, primarily frequencies, were used to summarise characteristics of ward nurses at baseline and completion of the 12-month implementation phase. With regard to the primary outcome (rate of reported medication errors per month), error rate per month was reported in intervention and control groups at pre-implementation, implementation and post-implementation phases. The primary analysis was the comparison of reported error rates between intervention and control groups using generalised linear mixed models with Poisson distribution and log link. For this analysis, the rate of medication errors (rather than percentage of errors) was compared to account for the longitudinal nature of the outcome. The models considered number of reported medication errors in study wards as the outcome, offset by the average number of occupied beds in the wards per month (i.e. modelling rate of medication errors per ward per month). The Poisson model to evaluate the intervention impact on the main outcome had a fixed effect factor intervention group, a nominal study phase factor and intervention group by study phase two-way interaction terms. The intervention group by study phase interaction term is the intervention impact, which enables between group comparison of reported errors at implementation and post-implementation phases while adjusting for baseline error rates. Generalised estimation equation (GEE) technique was used to account for within-ward autocorrelations implementing a first order autoregressive (AR(1)) correlation structure. Risk ratio (RR) and 95% confidence interval (CI) from the Poisson models were reported as effect size. With regard to the analysis of secondary outcomes, independent samples t-tests were performed to evaluate the within- and between-group differences in ACT dimension scores. Patterns of change in post-feedback survey data were analysed using descriptive statistics, namely frequencies and Chi-squared tests for independence. IBM SPSS Statistics (version 24) software was used for data analyses, and a Type I error level of 0.05 was used to evaluate statistical significance of all outcomes. All p-values reported were two-sided.

RESULTS

Nurse characteristics

Presented in Table 1 are the characteristics of participating nurses in all wards on completion of the ACT at baseline of the implementation phase and again at completion of the implementation phase at 12-months. Overall, the response rate at the baseline of the implementation phase was 65.4% (106/162 surveys returned), and the response rate at completion of the implementation phase was 60.9% (95/156 surveys returned). The majority of nurses (intervention/control) were aged 30-59 years, had completed a Bachelor and/or Honours degree, and were employed in the role of Grade 2 Registered Nurse (general practice nurses who had completed at least one year of practice following registration). Additionally, nursing experience of participants was similar across both intervention and control wards, with mean nursing duration in both ward types being approximately 16 years at baseline of implementation, and 14 years at completion of the implementation phase.

Medication error reporting

The total number of medications reported per month during the 12-month pre-implementation phase was relatively similar for both intervention and control groups (~7 errors/month). During the 12-month implementation phase, the rate of reported medication errors improved among both groups (intervention: 13.54 errors/month; control: 12.08 errors/month). The rate of reported medication errors per month during the 6-month post-implementation phase then decreased in both groups from that observed in the implementation phase (intervention: 10.17 errors/month; control: 6.67 errors/month). Despite this decrease, the rate of reported medication errors per month in the intervention group remained higher than pre-intervention rate (pre-intervention: 7.67; post-intervention: 10.17). Table 2 provides a summary of medication errors reported per month for each phase.

Table 2, Model 1 illustrates Poisson regression results, comparing medication error rate comparisons between intervention and control groups at implementation and post-implementation phases. No significant intervention effect, as measured by two-way study phase by intervention group interactions, were observed at implementation ($p = 0.63$) and post-implementation phase ($p = 0.19$), accounting for pre-implementation error rate. When combining all data from intervention and control wards in a Poisson model (Model 2), a significant time trend across pooled intervention and control data was observed. There was an 80% increase in the rate of medication errors reported from pre-implementation to implementation phase; RR= 1.80, 95% CI (1.49, 2.16), $p<0.0001$. There was also an 18% increase in reported medication errors from pre-implementation to post-implementation phase, but the trend was not statistically significant (RR= 1.18, 95% CI (0.92, 1.51), $p=0.14$).

Alberta Context Tool

For the majority of ACT dimensions, the perceptions of the intervention and control groups were similar across both time points - baseline of implementation and completion of implementation (Table 3). Statistically significant between-group differences were observed at baseline only for the ACT dimensions of Social Capital (intervention: 3.79 ± 0.50, control: 4.03 ± 0.42, $p = 0.01$), and Organisational Slack – Staff (intervention: 2.63 ± 0.96, control: 3.24 ± 1.23, $p = 0.01$). Further, a significant within-group decrease in the mean was observed over time for the dimension of Organisational Slack – Staff among the control group only (baseline: 3.24 ± 1.23, completion: 2.68 ± 1.11, $p = 0.02$).

Post-feedback survey

Table 4 outlines the responses to the post-feedback survey for each of the intervention wards at all four survey rounds. At all rounds, the majority of nurses in both wards reported that they had read more than half of the feedback poster (Intervention Ward 1: range 68.8% to 83.3%; Intervention Ward 2: range 82.1% to 94.3%); understood more than half of the feedback poster (Intervention Ward 1: range 73.9% to 88.9%; Intervention Ward 2: range 84.6% to 91.7%); and perceived the feedback as being either useful or very useful (Intervention Ward 1: range 72.7% to 81.3%; Intervention Ward 2: range 81.5% to 91.7%). The discussion of feedback posters with other staff members varied between wards and within survey rounds. However, nurses from both wards in all survey rounds indicated the primary reason for any discussion was to determine what others thought about the feedback.

The majority of nurses in both wards across all survey rounds did not feel that the feedback posters generated an interest in receiving other types of data (except Intervention Ward 2 at Round 1 [Yes: Round 1 - 56.3%]). In Round 1, the majority of nurses in both wards felt that after reading the report, they would be interested in knowing other information from the report (Yes: Round 1 Intervention Ward 1 - 68.7%, Intervention Ward 2 - 82.9%). This interest decreased over time, such that by Round 4, the majority of nurses in both wards indicated they were not interested in knowing other information from the report (No: Round 4 Intervention Ward 1 - 68.7%, Intervention Ward 2 - 63.0%). When nurses did indicate interest in other information types, information about how other units have addressed medication error reporting problems, information about best-practice medication error reporting, and information about the reasons for the results in the report were perceived to be of most interest.

Nurses from both wards at all survey rounds indicated that the report provided them with information that could be used to make changes in the way they approach medication error reporting. When asked to specify what changes they would like to make, methods to assess medication errors, and medication administration methods were perceived to be areas where change was most highly sought.

DISCUSSION

This paper reports the development and conduct of an audit with feedback implementation strategy that aimed to improve medication error reporting by nurses in a private acute care setting in Australia. No significant intervention effect was found for the primary outcome measure – rate of medication errors reported per month. As such, the study hypothesis was not supported; indicating the feedback implementation strategy did not effectively influence the voluntary reporting behaviours of nurses with regard to medication errors. Interestingly, when data from both groups were aggregated, an increasing significant time trend was observed for medication errors reported per month across pre-implementation and implementation phases. This highlights the possibility that other organisational factors may have influenced medication error reporting rates across both wards. Notably, the organisation was preparing for the implementation of an electronic medication ordering system and conceivably the preparation for this initiative may have raised awareness of medication management and error reporting. Additionally, the significant, increasing time trend observed in this study may have, in part, been due to the auditing that was performed in all intervention and control wards. The phenomenon, referred to as the 'Hawthorne Effect', is typically described as the human tendency to improve performance because of the awareness of being studied (McCarney et al., 2007). Therefore, it is possible that nurses altered their 'usual' behaviour or performance during the implementation phase in response to their awareness of being audited by external researchers. Finally, while every attempt was made to avoid contamination between wards, the close proximity of matched wards, and the presence of medical doctor teams and casual nurse bank/agency nurses and students that worked across multiple wards may have contributed to some contamination.

The lack of intervention effects observed in the present study fits within the spectrum of findings reported in previous Cochrane reviews of audit with feedback implementation strategies (Ivers et al., 2012, Jamtvedt et al., 2006). Such reviews have found a variable effect of audit with feedback strategies on professional behaviour, ranging from little to no effect through to substantial effect (Ivers et al., 2012). Intervention effects have also been suggested to be greater when baseline performance is low, when feedback is delivered both verbally and in written form, when feedback is delivered by a supervisor or colleague, when feedback is provided more than once, and when feedback includes clear targets and an action plan (Ivers et al., 2012). The feedback mechanism in the present study was developed through extensive consultation with a key stakeholder reference group. In line with recommendations outlined in the previous reviews (Ivers et al., 2012, Jamtvedt et al., 2006), the feedback was delivered more than once (four times in total), and the performance of nurses with regard to medication error reporting was low at baseline. However, the feedback approach, co-designed with the stakeholder group, involved feedback being delivered in written format only (rather than in verbal and written forms). Additionally, the feedback was delivered via a member of the research team (rather than a supervisor/colleague). Further, the feedback included a clear behaviour target but did not include a specific action plan. While recommendations outlined in previous reviews were considered in development of feedback, the mechanism and method of feedback was ultimately guided by members of the stakeholder group. Had this study adopted the feedback design recommendations from systematic review evidence, it is possible the observed intervention effect may have been larger.

The directional hypothesis formed in the present study was primarily based on findings obtained from the associated pilot research, in which an 80% increase in the reporting of medication errors was observed between pre- and post-implementation of the pilot feedback strategy (Hutchinson et al., 2015). While the overall study design, research questions, and outcome measures were consistent across both studies, a senior staff member at the participating hospital (internal facilitator) led the pilot research and delivered the feedback to nurses. In contrast, these roles in the present study were performed by a researcher external to the organisation (external facilitator). The PARIHS framework recognises the roles of internal and external facilitators in facilitating practice change (Kitson, Harvey & McCormack, 1998; Rycroft-Malone, 2004). Knox et al (2011) identify advantages and disadvantages of internal and external facilitators. Internal facilitators are well positioned to facilitate implementation efforts because they understand the culture, processes and personalities within the setting, and are more likely to assume ownership of an initiative. However, they are typically bound by a top-down approach, more likely to be influenced by internal politics, pressures and interpersonal forces, and to have their attention diverted by competing priorities related to clinical demand. The external facilitator, on the other hand, is more likely to facilitate and support staff, have clear role boundaries, and be less subject to organisational pressures. However, the external facilitator requires more time to establish with staff a rapport, trust, goals and expectations, and staff can become reliant on external facilitators, necessitating a withdrawal process and the establishment of a sustainability plan. In the present study, because the feedback was intermittent and of short duration, the researcher (external facilitator) possibly required more time to develop credibility, trust and a strong rapport with the staff in order to effect behaviour change.

The absence of significant between-group differences in organisational context was an unexpected finding of the present study. The influence of organisational context on the successful implementation of research evidence has been noted as being potentially greater when compared to individual healthcare professional factors (Kaplan et al., 2010, Yamada et al., 2017). The use of wards from the same acute care site may have contributed to this result, as all wards would have operated under the same organisational policies, shared the same senior management teams, and would have received equivalent training in RiskMan software use. The lack of significant intervention effects for monthly rate of reported medication errors, combined with the absence of significant between-group differences in the ACT dimension scores at the completion of implementation phase or a time trend in the ACT dimension scores, meant that the planned analysis to investigate the mechanisms for the intervention effects were not possible in the present study.

Strengths and limitations

A key strength of this study was the adoption of a quasi-experimental design, specifically implemented in a real-world acute care setting, hence maximising external validity. The involvement of the key stakeholder reference group also ensured the audit with feedback implementation strategy was appropriately tailored to the study setting. The generalisability of these findings is limited due the study being implemented in a single acute care hospital, with a relatively small sample size. Furthermore, the present findings reflect the reporting behaviours of nurses working within a private acute care setting in Australia. Private and public acute care settings in Australia differ with regard to their structure, funding models, and patient mix (Shmueli & Savage, 2014), and it is likely that an audit with feedback strategy implemented within a public acute care setting would produce different findings. Future research efforts should aim to minimise the potential confounding factors noted in the present study. In particular, the introduction of electronic medical records within an increasing number of hospitals in developed countries creates an opportunity for future research to conduct chart audits electronically. By removing the obvious presence of researchers in wards, it is possible the audit data would more accurately reflect routine care by eliminating the potential for altered behaviour resulting from healthcare professionals' awareness of being monitored. Further refinement of the feedback strategy to incorporate the completion of an action plan by nurses at each feedback cycle may result in better outcomes. Researchers could also consider: the utilisation of multiple hospital sites in a cluster design to avoid possible between-ward contamination; the use of an internal facilitator/champion to deliver feedback in both a face-to-face and written format; an increase in the duration of data collection time periods/phases; and the inclusion of audit with feedback into a multifaceted intervention that involves other implementation strategies such as reminder systems, or opinion leaders.

CONCLUSION

Nurses are key to the reporting of medication errors in the acute care setting. Implementation strategies that aim to positively influence the voluntary reporting behaviours of nurses are essential for the improvement of medication error reporting rates. The audit and feedback strategy developed in the present study did not effectively influence the voluntary reporting behaviours of nurses with regard to medication errors. Nevertheless, the results provide insights and recommendations that will guide future research in ways to improve audit with feedback implementation strategies among nurses.

RELEVANCE TO CLINICAL PRACTICE

This work makes a contribution to both nursing and implementation science fields, despite the lack of intervention effects observed. The use of a published checklist of modifiable audit with feedback elements (Colquhoun et al., 2017) to describe the audit with feedback implementation strategy developed in the present study has ensured standardised reporting quality, which will enable the study to be included in future reviews on the topic. Additionally, the majority of prior studies reporting audit with feedback strategies have targeted physicians (Ivers et al., 2012), therefore the focus on nurses in this study will contribute to much-needed evidence for the effect of audit with feedback within this important group of healthcare professionals. Lastly, the medication error reporting rates among nurses that were determined in this study are a valuable outcome that highlight the need for healthcare systems to have ongoing vigilance surrounding voluntary error reporting in an attempt to enhance patient safety.

WHAT DOES THIS PAPER CONTRIBUTE TO THE WIDER GLOBAL CLINICAL COMMUNITY?

- Nurses are key to the reporting of medication errors in the acute care setting.
- This study contributes to much-needed evidence for the effect of audit with feedback implementation strategies with nurses.
- This paper utilised of a published checklist of modifiable audit with feedback design elements, which has ensured standardised reporting quality.

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Box 1. Definitions of dimensions in the Alberta Context Tool.

Dimension	Definition (Squires et al., 2014)
Leadership	The actions of formal leaders in an organisation (unit) to influence change and excellence in practice; items generally reflect emotionally intelligent leadership
Culture	The way that "we do things" in our organisation and work units; items generally reflect a supportive work culture
Evaluation	The process of using data to assess group/team performances and to achieve outcomes in organisations or units (i.e. evaluation)
Social Capital	The stock of active connections among people. These connections are of three types: bonding, bridging, and linking
Informal Interactions	Information exchanges that occur between individuals working within an organisation (unit) that can promote the transfer of knowledge
Formal Interactions	Formal exchanges that occur between individuals working within an organisation (unit) through scheduled activities that can promote the transfer of knowledge
Structural / Electronic Resources	The structural and electronic elements of an organisation (unit) that facilitate the ability to assess and use knowledge
Organisational Slack (3 concepts: Staff, Space, Time)	The cushion of actual or potential resources which allows an organisation (unit) to adapt successfully to internal pressures for adjustments or to external pressures for changes.

Table 1. Demographic characteristics of participants completing the Alberta Context Tool at baseline and completion of implementation phase, by study group.

Demographic Characteristics	Baseline of Implementation Phase		Completion of Implementation Phase	
	Intervention	Control	Intervention	Control
Participants, n (%):	53/76 (69.7%)	53/86 (61.6%)	49/80 (61.3%)	46/76 (60.5%)
Years nursing duration, mean (SD)	16.63 (12.6)	16.42 (11.7)	14.07 (13.9)	13.22 (11.23)
Age, n (within-group %)				
Less than 30	10/52 (19.2%)	10/53 (18.9%)	16/47 (34.0%)	12/45 (26.7%)
30-44	16/52 (30.8%)	23/53 (43.4%)	14/47 (29.8%)	16/45 (35.6%)
45-59	17/52 (32.7%)	16/53 (30.2%)	10/47 (21.3%)	15/45 (33.3%)
60 and above	9/52 (17.3%)	4/53 (7.5%)	7/47 (14.9%)	2/45 (4.4%)
Education, n (within-group %)				
Certificate IV/Diploma of Nursing	6/53 (11.3%)	5/52 (9.6%)	2/49 (4.1%)	3/46 (6.5%)
Nursing Certificate (Hospital Training)	9/53 (17.0%)	8/52 (15.4%)	8/49 (16.3%)	9/46 (19.6%)
Bachelor or Bachelor with Honours	33/53 (62.3%)	28/52 (53.8%)	35/49 (71.4%)	29/46 (63.0%)
Postgraduate Certificate or Diploma	4/53 (7.5%)	8/52 (15.4%)	4/49 (8.2%)	4/46 (8.7%)
Masters or above	1/53 (1.9%)	3/52 (5.8%)	0/49 (0.0%)	1/46 (2.2%)
Role, n (within-group %)				
NUM/ANUM	6/53 (11.3%)	10/52 (19.2%)	6/49 (12.2%)	8/46 (17.4%)
Clinical Nurse Specialist	2/53 (3.8%)	1/52 (1.9%)	1/49 (2.0%)	2/46 (4.3%)
Grade 2 Registered Nurse	28/53 (52.8%)	32/52 (61.5%)	33/49 (67.3%)	27/46 (58.7%)
Graduate Registered Nurse	5/53 (9.4%)	3/52 (5.8%)	3/49 (6.1%)	5/46 (10.9%)

Demographic Characteristics	Baseline of Implementation Phase		Completion of Implementation Phase	
	Intervention	**Control**	**Intervention**	**Control**
Qualified to Administer Medications	10/53 (18.9%)	4/52 (7.7%)	6/49 (12.2%)	2/46 (4.3%)
Other	2/53 (3.8%)	2/52 (3.8%)	0/49 (0.0%)	2/46 (4.3%)

Note: Differences in the n values for the demographic variables are due to missing/invalid data.

Abbreviations: NUM (Nurse Unit Manager); ANUM (Associate Nurse Unit Manager).

Table 2. Summary of the Poisson regression.

Models	Medication Errors Reported Per Month (n)			Poisson Regression		
	Pre-Implementation Phase	Implementation Phase	Post-Implementation Phase	RR	95% CI	p-value
Model 1						
Intervention[a]	7.67	13.54	10.17	Implementation[d]: 0.96	0.83 to 1.12	0.63
Control[b]	6.58	12.08	6.67	Post-Implementation[d]: 1.31	0.88 to 1.96	0.19
Model 2						
Groups combined[c]	14.25	25.62	16.83	Implementation[e]: 1.80	1.66 to 1.95	<0.0001
				Post-Implementation[e]: 1.18	0.95 to 1.46	0.14

Notes: [a]Average of mean number of occupied beds per night: 31.00, [b]Average of mean number of occupied beds per night: 30.09; [c]Average of mean number of occupied beds per night: 31.00; [d]Reference category was control group at Pre-Implementation Phase; [e]Reference category was Pre-Implementation Phase. Model 1 is a comparison between Pre-Implementation phase with combined Implementation and Post-Implementation phases as no between-group statistical differences were observed between Implementation and Post-Implementation phases.

Table 3: Alberta Context Tool dimension scores at baseline of implementation phase and completion of implementation phase (at 12 months) by study group (intervention/control).

Alberta Context Tool Dimensions	Intervention		Control		Independent samples t-test
	N	Mean ± SD	N	Mean ± SD	(t (df), p)
Leadership (score range 1-5)					
Baseline of implementation phase	52	4.01 ± 0.76	53	4.11 ± 0.50	t (103) = -0.80, p = 0.43
Completion of implementation phase	47	3.92 ± 0.75	45	4.03 ± 0.71	t (90) = -0.71, p = 0.48
Independent samples t-test (t (df), p)		t (97) = 0.58, p = 0.57		t (96) = 0.65, p = 0.52	
Culture (score range 1-5)					
Baseline of implementation phase	53	3.86 ± 0.60	53	3.93 ± 0.53	t (104) = -0.62, p = 0.54
Completion of implementation phase	49	3.82 ± 0.62	46	3.89 ± 0.59	t (93) = -0.52, p = 0.60
Independent samples t-test (t (df), p)		t (100) = 0.28, p = 0.78		t (97) = 0.33, p = 0.74	
Evaluation (Feedback) (score range 1-5)					
Baseline of implementation phase	52	3.48 ± 0.69	53	3.30 ± 0.53	t (103) = 1.21, p = 0.23
Completion of implementation phase	49	3.45 ± 0.63	46	3.49 ± 0.67	t (93) = -0.32, p = 0.75
Independent samples t-test (t (df), p)		t (99) = 0.29, p = 0.77		t (97) = -1.20, p = 0.23	
Formal Interactions (score range 0-4)					
Baseline of implementation phase	53	1.41 ± 1.08	53	1.57 ± 1.62	t (104) = -0.60, p = 0.55
Completion of implementation phase	49	1.78 ± 1.05	46	1.52 ± 1.03	t (93) = 1.19, p = 0.24
Independent samples t-test (t (df), p)		t (100) = -1.75, p = 0.08		t (97) = 0.16, p = 0.87	
Informal Interactions (score range 0-10)					
Baseline of implementation phase	53	4.28 ± 3.24	53	4.19 ± 1.88	t (104) = 0.18, p = 0.86
Completion of implementation phase	49	4.94 ± 3.28	45	4.39 ± 2.27	t (92) = 0.94, p = 0.35

Independent samples t-test (t (df), p)		t (100) = -1.02, p = 0.31		t (96) = -0.48, p = 0.63	
Social Capital (score range 1-5)					
Baseline of implementation phase	51	3.79 ± 0.50	52	4.03 ± 0.42	t (101) = -2.68, p = 0.01
Completion of implementation phase	49	3.81 ± 0.51	45	3.92 ± 0.48	t (92) = -1.11, p = 0.27
Independent samples t-test (t (df), p)		t (98) = -0.21, p = 0.83		t (95) = 1.21, p = 0.23	
Structural and Electronic Resources (score range 0-11)					
Baseline of implementation phase	52	6.18 ± 2.99	53	5.56 ± 2.40	t (103) = 1.18, p = 0.24
Completion of implementation phase	47	5.84 ± 2.00	46	5.49 ± 2.98	t (91) = 0.67, p = 0.51
Independent samples t-test (t (df), p)		t (97) = 0.66, p = 0.51		t (97) = 0.13, p = 0.90	
Organisational Slack					
Organisational Slack – Staff (score range 1-5)					
Baseline of implementation phase	52	2.63 ± 0.96	53	3.24 ± 1.23	t (103) = -2.83, p = 0.01
Completion of implementation phase	48	2.60 ± 1.10	44	2.68 ± 1.11	t (90) = -0.34, p = 0.74
Independent samples t-test (t (df), p)		t (98) = 0.10, p = 0.92		t (95) = 2.31, p = 0.02	
Organisational Slack – Space (score range 1-5)					
Baseline of implementation phase	52	2.78 ± 0.97	52	2.78 ± 0.92	t (102) = 0.00, p = 1.00
Completion of implementation phase	46	2.84 ± 1.06	44	3.14 ± 0.95	t (88) = -1.39, p = 0.17
Independent samples t-test (t (df), p)		t (96) = -0.32, p = 0.75		t (94) = -1.89, p = 0.06	
Organisational Slack – Time (score range 1-5)					
Baseline of implementation phase	53	2.76 ± 0.74	53	3.01 ± 0.74	t (104) = -1.75, p = 0.08
Completion of implementation phase	49	2.77 ± 0.60	46	2.76 ± 0.84	t (93) = 0.03, p = 0.98
Independent samples t-test (t (df), p)		t (100) = -0.06, p = 0.96		t (97) = 1.57, p = 0.25	

Note: Score ranges for each outcome are provided to assist the interpretation of values. Dimension headings in italics are calculated as mean values, those in normal bold font as the mean of recoded items (0.0, 0.5, 1.0). Higher scores reflect a more positive perception of the given dimension (i.e. leadership) within the care unit. Within-ward differences in the n values for the Alberta Context Tool dimensions at same time points are due to missing/invalid data.

Table 4. Frequency of responses to the post-feedback survey at each of the four survey rounds by intervention ward.

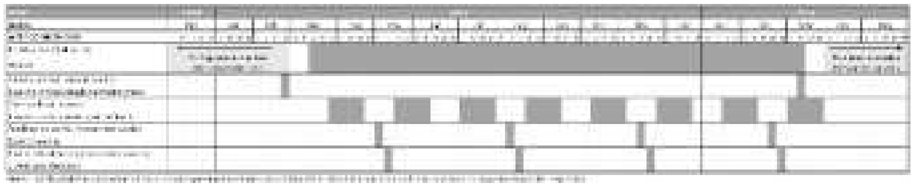
Question		Round 1 n (within ward %)	Round 2 n (within ward %)	Round 3 n (within ward %)	Round 4 n (within ward %)
How much of the report did you read?		**n=51**	**n=49**	**n=44**	**n=44**
Intervention Ward 1	Half or less	3 (18.8%)	3 (16.7%)	7 (30.4%)	5 (31.3%)
	More than half	13 (81.2%)	15 (83.3%)	16 (69.6%)	11 (68.8%)
Intervention Ward 2	Half or less	2 (5.7%)	2 (6.5%)	3 (14.3%)	5 (17.9%)
	More than half	33 (94.3%)	29 (93.5%)	18 (85.7%)	23 (82.1%)
How much of the report information do you feel you understood?		**n=52**	**n=49**	**n=43**	**n=42**
Intervention Ward 1	Half or less	4 (25.0%)	2 (11.1%)	6 (26.1%)	3 (18.8%)
	More than half	12 (75.0%)	16 (88.9%)	17 (73.9%)	13 (81.3%)
Intervention Ward 2	Half or less	3 (8.3%)	4 (12.9%)	2 (10.0%)	4 (15.4%)
	More than half	33 (91.7%)	27 (87.1%)	18 (90.0%)	22 (84.6%)
How useful did you find the report?		**n=52**	**n=49**	**n=43**	**n=43**
Intervention Ward 1	Not useful or Somewhat useful	4 (25.0%)	4 (22.2%)	6 (27.3%)	3 (18.8%)
	Useful or Very useful	12 (75.0%)	14 (77.8%)	16 (72.7%)	13 (81.3%)

Intervention Ward 2	Not useful or Somewhat useful	3 (8.3%)	5 (16.1%)	2 (9.5%)	5 (18.5%)
	Useful or Very useful	33 (91.7%)	26 (83.9%)	19 (90.5%)	22 (81.5%)
Did you discuss the report with another staff member?†		**n=51**	**n=49**	**n=43**	**n=43**
Intervention Ward 1	Yes	6 (40.0%)	13 (72.2%)	13 (56.5%)	3 (18.8%)
	No	9 (60.0%)	5 (27.8%)	10 (43.5%)	13 (81.2%)
Intervention Ward 2	Yes	29 (80.6%)	18 (58.1%)	7 (33.3%)	10 (35.7%)
	No	7 (19.4%)	13 (41.9%)	14 (66.7%)	18 (64.3%)
Does getting this feedback report make you more interested in other types of data?†		**n=47**	**n=47**	**n=44**	**n=44**
Intervention Ward 1	Yes	3 (20.0%)	5 (27.8%)	10 (43.5%)	5 (31.3%)
	No	12 (80.0%)	13 (72.2%)	13 (56.5%)	11 (68.8%)
Intervention Ward 2	Yes	18 (56.3%)	14 (48.3%)	7 (35.0%)	4 (14.8%)
	No	14 (43.8%)	15 (51.7%)	13 (65.0%)	23 (85.2%)
After reading the feedback report, would you like to know other information from the report?		**n=51**	**n=47**	**n=44**	**n=43**
Intervention Ward 1	Yes	11 (68.7%)	9 (50.0%)	14 (60.9%)	5 (31.3%)
	No	5 (31.3%)	9 (50.0%)	9 (39.1%)	11 (68.7%)

Intervention Ward 2	Yes	29 (82.9%)	21 (72.4%)	9 (42.9%)	10 (37.0%)
	No	6 (17.1%)	8 (27.6%)	12 (57.1%)	17 (63.0%)
Did the report give you information that you could use to make changes in the way you approach medication error reporting?		**n=52**	**n=49**	**n=44**	**n=44**
Intervention Ward 1	Yes	13 (81.3%)	12 (66.7%)	13 (56.5%)	12 (75.0%)
	No	3 (18.7%)	6 (33.3%)	10 (43.5%)	4 (25.0%)
Intervention Ward 2	Yes	32 (88.9%)	24 (77.4%)	11 (52.4%)	22 (78.6%)
	No	4 (11.1%)	7 (22.6%)	10 (47.6%)	6 (21.4%)

Note: Differences in the participant n values for each question are due to missing/invalid data.

†Chi-Square tests for independence indicated significant differences at the $p<0.05$ level between wards and response to the given question for Round 1 only.



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