Electronic Medication Administration Records and Barcode Medication Administration to Support Safe Medication Practices in Long-term Care Facilities

by

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Abstract

Medication incidents are common in long-term care facilities (LTCF). While few contribute to permanent disability or death, a significant proportion lead to resident harm. Technology solutions have been proposed to improve medication safety in long-term care environments, with electronic medication administration records (eMAR) and barcode assisted medication administration (BCMA) being a main focus of adoption. However, the impacts of eMAR-BCMA on medication incidents and medication administration incidents (MAIs) within LTCF have not been well defined. The overall objective of this research project was to explore the influence of stand-alone eMAR-BCMA systems on safe medication practices in LTCF.

In the first study of this thesis, we conducted a scoping review to map the extent, range and nature of research on the effectiveness, level of use, and perceptions of eMAR-BCMA in LTCF. We identified limited direct evidence linking eMAR-BCMA use and reduction in medication incidents and MAIs; in addition to, evidence of new types of medication incidents resulting from nursing staff workarounds, inconsistent influence on nursing time spent during medication administration and an array of perceived benefits and challenges.

In our second study, we conducted a retrospective review of medication incident reports submitted voluntarily by nursing staff within a single LTCF two years post adoption of eMAR-BCMA, in order to explore the frequency, type and severity of medication incidents; as well as, the characteristics of residents who experience them. We determined that despite eMAR-BCMA implementation, medication incidents and MAIs continued to be reported. The majority of medication incidents were related to improper medication administration practices, communication issues, and pharmacy dispensing errors.

Our results suggest that more rigorous, prospective research in LTCF and community pharmacies is required to demonstrate the impact that stand-alone eMAR-BCMA systems have on medication safety in LTCF. It also highlights that opportunities remain to optimize use of eMAR-BCMA and improve medication incident reporting in the LTCF setting.

PREFACE

This thesis is an original work by Andrew Fuller. Chapter 3 of this research project, of which this thesis is a part, received ethics approval from the University of Alberta Ethics Board, "Electronic Medication Administration Records in Long-term Care Facilities," No. Pro0007992, April 30, 2018.

Chapter 2 of this thesis has been published as AEC Fuller, LM Guirguis, CA Sadowski, MJ Makowsky, "Electronic Medication Administration Records in Long-Term Care Facilities: A Scoping Review," *Journal of the American Geriatrics Society.* 2018;66(7):1428-1436. I was responsible for concept, design, data analysis and interpretation and manuscript compostion. LM Guirguis contributed to the concept and design, data interpretation and manuscript composition. CA Sadowski contributed to data interpretation and manuscript composition. MJ Makowsky was the supervisory author and assisted with concept and design, data analysis and interpretation, and manuscript composition.

DEDICATION

I would like to dedicate this Thesis to my beautiful wife *Michele Fuller* whose love and support throughout my pharmacy career inspired me to take this journey and helped make this work possible.

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INTRODUCTION

1.1 Introduction

1.1.1 Background:

Medication incidents are a concern in long-term care facilities (LTCF) and occur at any stage of the medication use process, such as the prescribing, transcribing, dispensing, administration, communication/documentation and monitoring of a medication.[1-3] A recent systematic review suggests they impact up to 27% of LTCF residents and can lead to significant resident harm.[4] A medication incident, also referred to as a medication error, is any preventable event that may cause or lead to inappropriate medication use or resident harm while the medication is in the control of the health care professional, resident, or consumer.[1, 5] With over 300,000 Canadians [6, 7] and 2.2 million Americans[8] residing in LTCF in 2011-2014, upholding medication safety in these facilities is a key priority.

Residents of LTCF require a higher level of care due to chronic illness, injury, functional and cognitive impairments, disability, and other health related conditions[8] which may prevent maintaining the activities of daily living, such as personal self-care and health-related responsibilities. In Canada, the majority of LTCF residents are seniors, where the average age is 86, 70% are female, 98% have a cognitive and/or functional impairment and 67% have a diagnosis of dementia.[9] LTCF may contain secure units for individuals with moderate to severe dementia, who may have a high risk of wandering and unpredictable behaviors.[10] In Alberta, long-term care is available depending on the level of services and support that is required,[11]

where the majority is provided within long-term care and other assisted living facilities that include on-site supervised care, 24 hours a day, 7 days a week.[12]

Due to the complexities of the healthcare needs and medical conditions of LTCF residents, polypharmacy is a concern as almost half of LTCF residents are prescribed nine or more medications daily[13] increasing the risk of medication incidents[14, 15] and adverse drug events (ADE).[16] An ADE is an injury from a medicine or lack of an intended medicine and also includes adverse drug reactions and harm from medication incidents.[17] ADEs can occur when medications are managed safely and appropriately but can be amplified due to age-related changes to the metabolism and response to medications[18] or when the medication is used in error.

1.1.2 Medication Safety

Several approaches have been adopted to reduce the risk of ADEs and medication incidents. Deprescribing strategies address potentially inappropriate medications (PIM);[19, 20] however, up to 75% of LTCF residents are still prescribed at least one PIM.[21] Guidance for prescribing medications in individuals with multiple medical conditions, including dementia has been endorsed[22, 23] even though there is little research on how to appropriately treat co-morbidities in those living with dementia.[24] Strategies have been used to reduce medication incidents due to misinterpreted medication orders[25] and to increase healthcare provider awareness to medications known to instigate significant ADEs and harm to LTCF residents if used in error [26, 27] Other approaches to improving patient safety focus on building a culture of safety, teamwork, quality improvement strategies, education and training.[28]

1.1.3 Medication Incidents

While there are different approaches to improve medication safety, medication incidents still occur within LTCF. The majority of medication incidents are medication administration

incidents (MAI; also known as medication administration errors [MAE]) and order communication issues which account for up to 53% [3, 13, 29-34] and 51%[2, 4, 35-38] of medication incidents respectively. In a 2017 systematic review of the prevalence of medication incidents in LTCF residents by Ferrah et al., medication administration was involved in up to 53% of medication incidents.[4] Similarly, an evaluation of web-based medication incident reporting data from 25 LTCF within North Carolina, found that 47% of medication incidents involved administration.[32] The most common medication error type associated with MAIs include medication administration at an incorrect time, the medication was missed, or the wrong dose or wrong medication was adminsiterd.[2, 29, 31, 32, 39]

Inappropriate medication management can lead to negative outcomes. For example, 12.6% of medication incidents have been reported to lead to resident harm.[2, 32, 36, 38] Typically medication administration was the most common medication-use phase in which an incident led to harm in LTCF.[32, 36, 38] For example, using retrospective web-based medication incident reporting data from 393 LTCF, Greene et al. found that over 56% of medication incidents that caused serious harm was due to medication administration. Resident harm can range from temporary harm requiring intervention to permanent disability or death.[40] Even though harm can occur, the systematic review by Ferrah et al. found that a small proportion of medication incidents actually led to permanent disability or death within LTCF.[4]

1.1.4 Medication Incident Reporting

Effective medication incident reporting and analysis is a key element in establishing a safe medication use system.[41] These systems depend on the willingness of individual providers to report incidents and therefore health care organizations strive to facilitate a just culture where providers, feel safe, encouraged, and enabled to discuss quality and safety concerns.[42] It is

well recognized that disciplining employees for honest mistakes does little to improve overall system safety, while mishaps accompanied by malicious behavior present valid objections to calls for blame-free error reporting.[42] When incidents occur, the system approach concentrates on the conditions under which individuals work, rather than focusing on the failings on the part of the individuals providers.[43] Rather than focus on punishment or remediation, the systems approach seeks to identify situations or factors likely to give risk to human error and change the underlying systems of care to reduce the occurrence of errors or minimize their impact on patients.[44]

The majority of data that is used to assess medication incident and MAI frequency, medication error type and resident harm in hospital and LTCF are based on the voluntary submission of medication incident reports by nursing staff. Medication incident reports are used for LTCF quality improvement and assurance initiatives; as well as, as a requirement by governing bodies.[45] However, despite efforts to create a culture of patient safety medication incidents are under-reported and are not considered to reflect the actual number of medication incidents that may have occurred in a particular facility.[46-52] Previous studies examined the perception of medication incident report submissions by nursing staff and under-reporting can be related to nursing staff interpreting the medication incident as not serious enough to report[46, 47] or a fear of disciplinary action when a medication incident occurs.[49, 51] In addition, the process of completing an medication incident report may be too complicated or time consuming.[52] Furthermore to under-reporting, medication incident reports are known to be incomplete, missing relevant information.[53] Additional methods can be used to evaluate medication incidents including manual chart reviews,[54] direct observation of the nursing staff

administering medications,[55] or utilizing reporting data available from health information technologies designed to prevent medication incidents from occurring, such as barcode assisted medication administration (BCMA).[56, 57]

1.1.5 Health Information Technology

To address resident safety issues, health care systems have adopted various health information technologies to decrease medication incidents and improve the accuracy of medication administration. This includes electronic heath records (EHR), electronic medical records (EMR), computer physician order entry (CPOE), drug distribution/dispensing systems, smart (computerized) intravenous infusion pumps, electronic medication administration records (eMAR) and BCMA.[58] An eMAR is a software program that provides access to a resident's profile, including the residents' photo, medical conditions, allergies, vitals and the most current medication list and administration directions. Nursing staff refer to the eMAR to confirm the medications required to be administered and then electronically sign off the medication as administered once completed. An eMAR can be used as a stand-alone program for medication administration or it can be integrated with a BCMA system. BCMA utilizes a handheld device which scans resident specific packaged medications and presents the residents profile on the eMAR. Barcode scanning adds an additional safety check prior to administration confirming appropriateness. When a medication is scanned in error (i.e. wrong time or wrong medication), a safety alert or a warning prompt is generated in order to correct the error prior to administration. Again, once medication administration is complete, the medications are signed off on the eMAR. A 2014 national survey suggested that eMAR-BCMA systems are found in over 93% of hospital settings in the U.S.[59] Information on uptake in LTCF is more sparse with a 2008 survey of nursing homes in the state of Minnesota suggesting that 50% of LTCF in this jurisdiction utilize this technology.[60]

The majority of evidence regarding the effectiveness of eMAR-BCMA systems in medication administration and safety comes from hospital environments. In a systematic review to determine whether implementation of the eMAR-BCMA is associated with declines in MAI rate in acute care settings by Young et al., eMAR-BCMA inconsistently decreased the overall incidence of MAIs.[61] For example, Franklin et al. documented a 39% reduction in MAIs reported post implementation,[62] while Morriss et al. found an increase in medication error rates of 69.5 medication incidents per 1000 doses pre-implementation to 79.7 per 1000 doses post implementation ($p<0.001$).[63] More recently, an integrative review to understand the effect of barcode medication administration technology on medication incidents, by Strudwick et al. concluded that most of the 11 studies reviewed had significant decreases in medication incidents after eMAR-BCMA implementation.[64] For example, in the study by Poon et al.,[65] there was a decrease in non-timing MAIs from 11.5% to 6.8% ($p<0.001$), in the study by DeYoung et al. the medication incident rate decreased from 19.7% pre- implementation to 8.7% post implementation ($p<0.001$),[66] while Ching et al. found a reduction from 5.9 errors/100 doses pre-implementation to 3.0 errors/100 doses post implementation, an absolute risk reduction of 2.9 errors per 100 doses (95%CI: 2.2, 3.6, $p<0.001$).[67] In addition, an eMAR-BCMA pretest-posttest direct observation non-equivalent comparison group study within several hospital settings found the accuracy rate of medication administration increased and the number of medication incidents consistently declined.[58]

Typically, hospitals have implemented integrated eMAR-BCMA systems in the context of other health information solutions (i.e. EHR, EMR, CPOE), whereas in LTCF, the use of health

technology lags, and stand-alone eMAR or eMAR-BCMA are more common. eMAR-BCMA systems designed for use in LTCF are commercially available and are promoted as being more efficient and accurate than paper-based processes and capable of improving the safety of medication administration.[68, 69] As a manager and clinical pharmacist with a practice in a LTCF environment, I was directly involved in the implementation of eMAR-BCMA systems in LTCF across Alberta and the assessment and interventions around medication incidents in individual residents. This involvement sparked my interest in how eMAR-BMCA systems influence medication safety for the residents I directly or indirectly cared for. However, the existing literature exploring effects of eMAR-BCMA on medication administration and MAIs within LTCF had not been summarized and it is unknown if these systems can deliver similar gains in medication safety to those seen in hospital environments. Further, while studies completed within acute care settings and LTCF have used medication incident report data to establish the frequency, type and outcome of medication incidents, limited research has been found reviewing medication incident reports in LTCF that utilize eMAR-BCMA.

1.2 Objectives:

The overall objective of this thesis is to explore the influence of stand-alone eMAR-BCMA systems on safe medication practices in LTCF. Two projects were conducted. The first project was a scoping literature review to map the extent, range, and nature of research on the effectiveness, level of use, and perceptions of eMAR and BCMA in LTCF, to identify gaps in current knowledge and prioritize areas for future research. Utilizing methodologies described by Arksey and O'Malley,[70] relevant peer-reviewed literature and grey literature was identified using a two-phase approach search strategy. The second project was a retrospective review of

voluntarily submitted medication incident reports within a single 239-bed designated assisted living facility which implemented eMAR-BCMA to support medication administration approximately two years prior to the review. In addition to characterizing the frequency, type and severity of reported medication incidents and MAIs, we evaluated if medication incidents were more commonly reported on secure or non-secure units, investigated characteristics of residents that experienced multiple medication incidents, and explored factors that influence medication incident severity.

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CHAPTER 2

Electronic Medication Administration Records in Long-Term Care Facilities: A Scoping Review

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ABSTRACT

Objectives: To map the extent, range, and nature of research on the effectiveness, level of use, and perceptions about electronic medication administration records (eMAR) in long-term care facilities (LTCF), and identify gaps in current knowledge and priority areas for future research.

Design: Scoping review of quantitative and qualitative literature.

Setting: Literature Review

Participants: Original research relating to eMAR in LTCF was eligible for inclusion.

Measurements: We systematically searched MEDLINE, CINAHL, Scopus, ProQuest, and the Cochrane Library, and performed general and advanced searches of Google to identify grey literature. Two authors independently screened for eligibility of studies. Independent reviewers extracted data regarding country of origin, design, study methods, outcomes studied, and main results.

Results: We identified 694 articles of which 34 met inclusion criteria. Studies were published between 2007 and 2016 and were mostly from the United States (n=25). Twenty studies (59%) used quantitative methods including surveys or analysis of eMAR data; seven (21%) used qualitative methods including interviews/focus groups, document review, and observation, and seven (21%) used mixed methods. Three major research areas were explored: medication error/medication administration error rates (n=11); eMAR benefits and challenges (n=19); and eMAR prevalence and uptake (n=15). Evidence linking eMAR use and reductions in medication errors is weak because of suboptimal study design and reporting. The majority of studies were descriptive and documented inconsistent benefits and challenges and low levels of eMAR implementation.

Conclusion: Further investigation is required to rigorously evaluate the effect of standalone eMAR systems on medication administration errors and patient safety, the extent of eMAR implementation, pharmacists' perceptions, and cost effectiveness of eMAR systems in LTCF.

Key Words: Electronic medication administration records; Long-term care; Medication Safety; Scoping review

2.1 Background

Long-term care includes a broad range of health, personal care, and supportive services that meet the needs of individuals whose capacity for self-care is limited due to chronic illness, injury, disabilities, or other health-related conditions.[1] While individuals may receive long-term care in a variety of settings, most receive care in nursing homes or other assisted living facilities. An estimated 300,000 Canadians and 2.2 million Americans resided in nursing homes or other assisted living facilities in 2013/2014.[1,2]

Because of the complexity of medication regimens and physical, functional, or cognitive impairments, residents of long-term care facilities (LTCF) require nursing assistance for medication management and administration. Almost half of residents are prescribed nine or more medication therapies daily,[3] which increases the risk for medication errors[4,5] and adverse drug events (ADE).[6] Medication errors, which are any preventable event that may cause or lead to inappropriate medication use or patient harm,[7] can occur at any stage in the medication-use process including prescribing, dispensing, documentation, monitoring and administration.[8,9] A recent systematic review found that medication errors occur in 16-27% of nursing home residents. In five of the reviewed studies, the majority of errors (between 20-60%) occurred in the administration and order communication phase.[10] Other studies in LTCF have reported medication administration error (MAE) rates between 3% and 50%.[3,9,11-16] Wrong time errors (71%), wrong dose (13%), and omitted doses (11%) are most commonly documented.[13] Extensive medication regimens put increased pressure on nursing staff and increase the risk of errors as approximately one-third of nursing time in LTCF is spent on medication administration.[17]

Standalone eMAR systems targeted to LTCF are available and are promoted as having the ability to improve the efficiency and safety of medication administration.[28,29] While facilities implementing these systems strive to achieve safer medication administration, it is not known whether LTCF can expect similar benefits as hospitals. Typically, hospitals have implemented integrated systems in the context of other health information solutions, while LTCF are generally understaffed and the majority of care is provided by unregulated healthcare or nursing staff.[30] These factors, in addition to differences in levels of patient acuity and private and public funding models may further complicate translation of these findings to LTCF. To our knowledge, the literature exploring the outcomes associated with eMAR implementation in LTCF has not been comprehensively summarized. Therefore, our objective was to map the extent, range and nature of research on the effectiveness, level of use, and perceptions about eMAR and BCMA in LTCF in order to identify gaps in current knowledge and prioritize areas for future research.

2.2 Methods

Relevant literature was identified using a 2-phase search strategy. First MEDLINE, CINAHL, Cochrane Library, Scopus, ProQuest Dissertations, and Theses Global databases were searched from 2000 to July 2016. Terms used included "electronic medication administration record," "bar-code medication administration," "medication management information technology," "health information technology," "medical informatics," "nursing informatics," "electronic health records," and "medication therapy management." Second, to identify relevant grey literature, we conducted advanced and basic searches of Google. Four search terms were used: "electronic medication administration records," "eMAR," "health information technology," and "bar-code medication administration." Each search term was combined with "long-term care,

nursing home, supportive living, assisted living, and skilled nursing facility." All searches were conducted with the assistance of a medical librarian. The full set of search terms is shown in Appendix 2.1. Reference lists of all relevant articles were manually searched.

2.2.1 Inclusion and Exclusion Criteria

We included English-language original literature, regardless of design, related to eMARs and BCMA in LTCF. We defined eMAR systems as electronic point-of-care systems that allow an electronic version of the resident's medication administration record to be displayed on a digital device and on which the nursing staff or pharmacist updates records using a web interface and nursing staff document when medications are administered. We defined BCMA systems as electronic point-of-care systems designed to scan resident-specific barcodes using a hand-held device to confirm resident identification and medication administration. We defined LTCFs as nursing homes, residential aged-care facilities, assisted living facilities, and care homes. Long-term care wards located in hospitals were not considered to be LTCFs. We defined grey literature as literature that government, academics, business, and industry produce in print and electronic formats (e.g., theses, conference proceedings, technical reports) and not controlled by commercial publishers.[31] We excluded systematic reviews or other narrative reviews of the literature, but when these were found, the original studies were located. News reports, news article interviews, personal opinion pieces, unstructured interviews, and advertisements from eMAR vendors and community pharmacies were excluded.

2.2.2 Screening and Data Abstraction

Two reviewers (AF, MM) independently screened titles and abstracts of all literature identified in the Phase 1 search, obtaining full articles to assess relevance when necessary. Given the large number of results in the general Google-based grey literature search (n=450,940), both reviewers independently completed a review of the website title for the top 50 results for each of the 4

searches and actual website content when necessary. The two reviewers reviewed the reference lists of included studies from both searches. Disagreements were resolved by consensus. Three authors were contacted (two to provide more information to determine eligibility, one to determine year of publication), but none responded to our requests.

Quantitative and qualitative data were extracted using a standardized template and included author, publication year, country of origin, design, study methods, study environment, population, technology studied, main outcomes studied, main results, and conclusion. Study designs were categorized as analytic or descriptive, with analytical studies further categorized as experimental or observational according to a previously published classification system.[32] The method of data collection was characterized as survey, qualitative, observation, document review, analysis of eMAR administrative data, or mixed methods. We documented whether an eMAR or BCMA was implemented in isolation or in the context of other health information solutions (e.g., electronic medical record, computerized physician order entry (CPOE), electronic health record (EHR)). Studies were grouped according to the main outcomes reported. Given that this review did not directly use health information, approval from the health research ethics board was not sought.

2.3 Results

The initial search yielded 771 abstracts, of which 34 articles were included in this review (Figure 2.1). Of the included studies, eleven were identified through the medical database search,[15,25,33–41] eight from reference lists of included studies,[42–49] and 15 from the grey literature search.[50–64] Fifty percent (n=17) of articles were published in the peer-reviewed literature (Table 2.1). Included studies were published between 2006 and 2016, 74% (n=25) were completed in the

United States and 88% in nursing homes or residential aged care facilities (n=30). We found 28 descriptive reports and six analytical studies. Of the descriptive reports, 14 (50%) were surveys, 12 were qualitative investigations, and one each was implementation and document review. All of the analytical studies were observational (two cohort, four cross-sectional). Overall, 20 used quantitative methodology, seven used qualitative methodology, and seven used mixed methods. Qualitative data collection methods included individual interviews, focus groups, document review, direct observation, process mapping, nominal group technique, and informal conversations. Participants in included studies were primarily nursing home staff or administrators, but some were pharmacists and physicians. Standalone eMAR systems were evaluated in six studies, and combinations of eMAR with BCMA, electronic medical records, EHR, or CPOE were studied in 13 studies.

2.3.1 Main Outcomes

The outcomes investigated in the included studies fell into three main categories: medication and medication administration error rates (11 studies),[25,36–39,41,50,52,56,58,59] benefits and challenges (19 studies),[15,34,36–41,44,45,50,51,54,56,58–60,62,63] and eMAR prevalence and uptake (15 studies) [33,35,41–43,45–49,53,55,57,61,64] (Figure 2.2.) Studies that included multiple outcomes were counted in each respective category; detailed summaries may be found in Supplementary Tables S2.1 and S2.2.

2.3.2 Medication and Administration Error Rates

Four articles reported medication error rates in relation to eMAR implementation.[25,52,58,59] Two studies were grey literature descriptive case reports that reported error rates before and after implementation of an eMAR.[58,59] After implementation of an eMAR, one study noted that the incidence of medication errors dropped from 192 to 31 per year[59] and another that the rate dropped from 212 per year before implementation to 20 and 17 in the two years after implementation.[58] Neither described the type of medication errors that decreased. The other two

reports were from a cohort study that used a BCMA system to measure the incidence of MAEs after implementation only and found that 1.2% of all medications administered (2,289/188,249 administration attempts over 3 months) were potential MAEs that the BCMA averted.[25,52] Of these, 86% were administering medications at an incorrect time, 10% were attempts to give a medication to the wrong resident, and 4% were attempts to give a discontinued medication. Neither the clinical significance or severity of MAEs was adjudicated in these reports.

Nine reports (six peer-reviewed,[25,37–39,41,50] three grey literature[36,52,56)] described other outcomes related to medication errors. Three studies used questionnaires of nursing staff to assess perceptions of stress and risk of medication errors,[38] awareness of medication errors or near misses,[50] and awareness of MAEs.[25,52] (Supplementary Tables S2.1 and S2.2). One reported statistically significantly lower perceived risk of MAEs with implementation of an eMAR than with paper records.[38] In the grey literature, a questionnaire to understand the costs and benefits of eMAR noted a perceived medication error rate of zero after eMAR implementation.[56] Other studies used qualitative or mixed methods to explore the medication administration process and errors. Specifically, these studies reported outcomes related to eMAR prevention of MAEs,[37] identification of medication order discrepancies ordered through an eMAR that led to a MAE,[39] and perceptions and concerns regarding medication administration and MAEs.[36] Nursing staff with access to an eMAR reported lower stress levels about making MAEs, a positive perception of medication administration,[50] and the perception that the eMAR decreased medication errors.[36] Lastly, registered nurses felt that, when physicians used an eMAR system that integrated CPOE, medication errors were avoided.[41]

2.3.3 Benefits and Challenges

Twelve studies reported benefits of eMAR beyond MAEs.[15,36,37,41,44,54,56,58– 60,62,63]

2.3.3.1 Improved Efficiency Outcomes

Ten studies (four peer-reviewed,[15,37,41,44] six grey literature[36,56,58–60,62]) reported on efficiencies with eMARs, which were described as improving workflow, resulting in time savings for the medication administration pass,[44,56,58,62] whereas in two studies, no differences were reported.[36,37] Several studies addressed how eMARs provided easier access to complete, real-time resident information regarding active medication orders.[15,36,60] Two grey literature case studies[56,59] documented a reduction in monthly medication reconciliation time with eMAR. In the peer-reviewed literature, when an eMAR was combined with CPOE[41] or an EHR,[15] medication order processing was reported to be streamlined, reducing the numbers of steps and documentation points. One grey literature report identified monetary savings resulting from the ability to update the eMAR immediately with changed medications orders.[56] Lastly, adoption of an eMAR created a more complete EHR[59] and, when combined with a CPOE, gave physicians the ability to modify the eMAR remotely, avoiding delays or additional site visits.[41]

2.3.3.2 Safety and Quality

Nine studies (five peer-reviewed,[15,37,41,44,63] four grey literature [56,59,60,62]) reported on improvements to safety and quality of care as a result of eMAR. Some linked these improvements to medication administration, and others linked them to other features in the eMAR. For example, eMAR alerts and signaling functionalities were reported to have alerted staff to potential medication safety problems such as when a medication was due or past due, when a medication needed follow-up, or when a new medication was ordered.[15] Others reported that care was felt to be safer with an eMAR but provided no further elaboration.[44] One case study claimed improvements to patient safety and better health outcomes because of eMAR alerts, mandatory documentation of administration, and effectiveness of as-needed medications, and resident photographs for identification.[60] Kramer reported that built-in accountability

features in the eMAR contributed to a safer, more reliable workflow.[56] eMAR integrated decision support systems resulted in improvements in staff adherence to medication monitoring and reduced missed lab tests and other orders.[56] Finally, one report identified eMAR as a high priority for implementation to improve quality.[63]

2.3.3.3 Administrative Reporting Quality Improvement

Five studies[37,54,58–60] addressed the effect of eMARs on quality improvement and adherence to organizational and regulatory policies. The only peer-reviewed study acknowledged that eMAR eliminated documentation practices that did not adhere to organizational policy such as nursing staff administering medications before signing their charts.[37] eMARs also permitted ease in demonstrating that care was being provided in accordance with regulatory requirements set forth by state legislation[59] and improved the ability to monitor drug use and evaluate quality measures, which includes as needed medication frequency and documentation of effectiveness.[58] Other perceived administrative benefits included eMAR reporting functions, mitigation of drug diversion, and staff login with unique credentials.[59]

2.3.3.4 Challenges

Seven studies (five peer-reviewed,[15,34,37,40,41] two grey literature [36,51]) reported challenges with eMARs related to the design or instability of the Internet or eMAR system. Other examples included limited interactivity between facility and pharmacy, inadequate flexibility because profiles were "read only," minimal decision support tools, and poor resident information layout.[40] Physicians and nurses noted lack of training and information technology support.[41] Lastly, eMAR implementation could not resolve chronic structure and process problems that predated implementation and led to new safety concerns. For example, nursing staff would work around intentional blocks that prevented excessive medication ordering, dual documentation of medication administration, and documentation of assessment before administration.[15,34]

Workarounds were also noted with unintentional blocks resulting from ineffective technology design related to medication orders, Internet connectivity, and organizational processes.[15,34]

2.3.4 eMAR Prevalence and Uptake in LTCFs

Twelve cross-sectional surveys (five peer-reviewed,[33,42,43,49,57] seven grey literature reports[45–47,53,55,61,64]) between 2006 and 2015 evaluated the prevalence of eMAR uptake in U.S. LTCFs. Depending on the timeframe and location, 18% to 49% of facilities surveyed had implemented an eMAR. Two additional cross-sectional surveys of LTCF pharmacy providers reported that 18%[48] and 23.3%[35] of pharmacies used an eMAR. Three investigated predictors of adoption of eMARs in LTCFs using multivariate regression analysis.[33,42,53] Census region; level of administrator experience, education, and accreditation; and overall number of services delivered were independent predictors of electronic information systems for medication administration records,[33] whereas profit status did not influence eMAR uptake.[42] Lastly, one study explored physician uptake of an eMAR system with CPOE functionality.[41]

2.4 Discussion

In this scoping review, we identified 34 reports related to the use of eMARs in LTCFs. The most studied outcomes were the benefits and challenges of eMARs, mainly explored using qualitative or mixed methods. eMAR prevalence and uptake were determined using cross-sectional surveys, and MAEs were determined according to objective review of eMAR data, staff surveys, or focus groups regarding perceptions of risk of medication errors. Although most studies were descriptive and provided consistent data that nursing staff act on warnings that eMAR systems generate, we did not find any robust experimental trials evaluating the effect of eMARs on MAEs in the peer-reviewed literature, although we identified two case reports that compared medication error rates before and after eMAR implementation which showed a substantial decrease in medication errors. Unfortunately, these provided weak evidence of benefit because

of weaknesses in study design and reporting. Small published studies suggest that eMARs can increase nursing staff awareness and decrease anxiety associated with medication administration. Other benefits identified in qualitative studies included greater efficiency, safety, and administrative processes, and problems with eMAR design, reliability, information technology, and staff workarounds were the main challenges. The influence of eMARs on nursing time spent during medication administration rounds was inconsistent. Finally, surveys suggest that up to 49% of LTCFs in certain U.S. jurisdictions have implemented eMAR.

2.4.1 Comparison with Other Research

In contrast to the long-term care literature, many studies have addressed the effect of eMARs and BCMA on MAEs in the hospital setting. A 2010 systematic review[27] concluded that BCMA systems, which incorporate eMAR technology, had varied influence on the 5 rights of medication administration (i.e., right drug, right time, right patient, right dose, right route) and did not consistently decrease overall incidence of MAEs but were able to identify additional MAE categories beyond the five rights. Since this review, additional well-designed hospital-based comparative studies have demonstrated significant reductions in MAE rates with eMARs and BCMA ranging from 41.4% to 80.7%.[65–69] Similarly, other studies have shown that medication error rates decreased after BCMA[70,71] and eMAR implementation,[72] although the most recent study[73] illustrates the inconsistent effect of BCMA and eMARs on MAEs, finding no significant change in MAE rates. The major methodological differences between the studies we identified and those exploring eMARs in institutional settings make further comparisons regarding MAE rates challenging.

There are several similarities in the benefits and challenges of implementing eMARs in LTCFs and hospital settings, including improved communication between team members;

interdisciplinary relationships; immediate access to resident-specific information and medication orders; and positive nursing perceptions about ease of documentation, drug information accuracy, and patient safety.[65,74–76] Hospital pharmacists had positive perceptions in terms of ability to interpret prescription orders through eMARs with CPOE functionality.[76] As for challenges, hospital nursing staff perceived that communication between nursing staff and pharmacy did not improve,[75] the medication administration process was slower,[72] nursing staff workload increased, and eMARs were inflexible and user-unfriendly and was slow to reflect updated medication information.[74] Pharmacists perceived medication dispensing to be slower and inefficient in the dispensary and difficult to use and not useful for improving patient care and reported low satisfaction with the system.[76] At a system level, the high financial cost associated with implementing and operating this technology has been perceived as a significant barrier.[77] Several hospital based studies have also documented workarounds, whereby nursing staff bypass the safety alerts of eMAR or rely on the technology too much, possibly increasing the risk of errors not seen before implementation of eMARs.[66,78,79] Finally, rates of eMAR implementation in LTCFs seem to lag those in hospital settings, which had an uptake in U.S. hospitals in 2014 of 93.3% for eMAR and 88.4% for BCMA.[24]

2.4.2 Main Gaps and Priority Areas for Future Research in LTCFs

Evaluation of the existing literature in LTCFs revealed several research gaps. First, there has been no rigorous MAE prevention study, and a trial similar to two previous trials[66,72] is important, because eMAR systems typically implemented in LTCFs are vastly different from the large integrated health information systems implemented in hospital settings. Second, although a large proportion of articles included in our review investigated uptake of eMARs in LTCFs, these studies were outdated and do not reflect uptake in Canada. Third, there was little research on the effect of eMARs on pharmacy practice, given community pharmacists' role in the

processing, assessing, dispensing, and distributing of medications for LTCFs and in altering the medication profile in the eMAR. The studies that included pharmacist or pharmacy views consisted of the perceptions of two pharmacists,[41] one pharmacist's experience with eMAR,[40] prevalence of eMAR uptake by LTCF pharmacy providers,[35,48] and the pharmacist perspective of how eMARs could improve current care processes.[63] Further study is required on the effect of eMARs from the community pharmacist perspective. Finally, there are no data evaluating the economic effect of eMARs in LTCFs. It is unclear whether providing more efficient delivery of resident care or preventing emergency department visits or hospitalizations because of a reduction in MAEs and the adverse drug reactions associated with them offset the financial costs of implementation, training, and maintenance of the system.

2.4.3 Strengths and Limitations

To our knowledge, this is the first scoping review of the topic, and it has several strengths. First, our search was comprehensive and included peer-reviewed and grey literature. Second, our methodology was robust, following the methodology of Arksey and O'Malley.[80] Nevertheless, this review has several limitations. First, results from the grey literature should be used with caution because the reporting, methodologies, and resulting claims are not as robust as those found in the peer-reviewed literature. This reinforces the need for more published literature on eMARs in LTCFs. Second, we may have missed important grey literature because of the large number of results from the general Google search and Google's search algorithms, which incorporate an individual user's previous search history. Third, only a small number of identified studies focused on standalone eMAR implementation.

2.5 Conclusion

We mapped the available evidence related to eMAR and BCMA technology in LTCFs. The research on eMARs in LTCFs was focused on medication errors, benefits, challenges, and

eMAR uptake. The majority of studies were descriptive, and there is a lack of rigorously designed research to inform administrators and clinicians about the effect of eMARs and BCMA on medication errors in LTCFs. Further investigation is required to evaluate the effect of contemporary eMAR and BCMA systems on MAEs and patient safety, levels of uptake of eMARs in LTCFs, the factors influencing uptake of these technologies, clinical pharmacists' perceptions of eMAR systems, and the cost effectiveness of eMAR implementation.

Figure 2.1. Search decision flow chart for Scoping Review of eMAR in LTCF

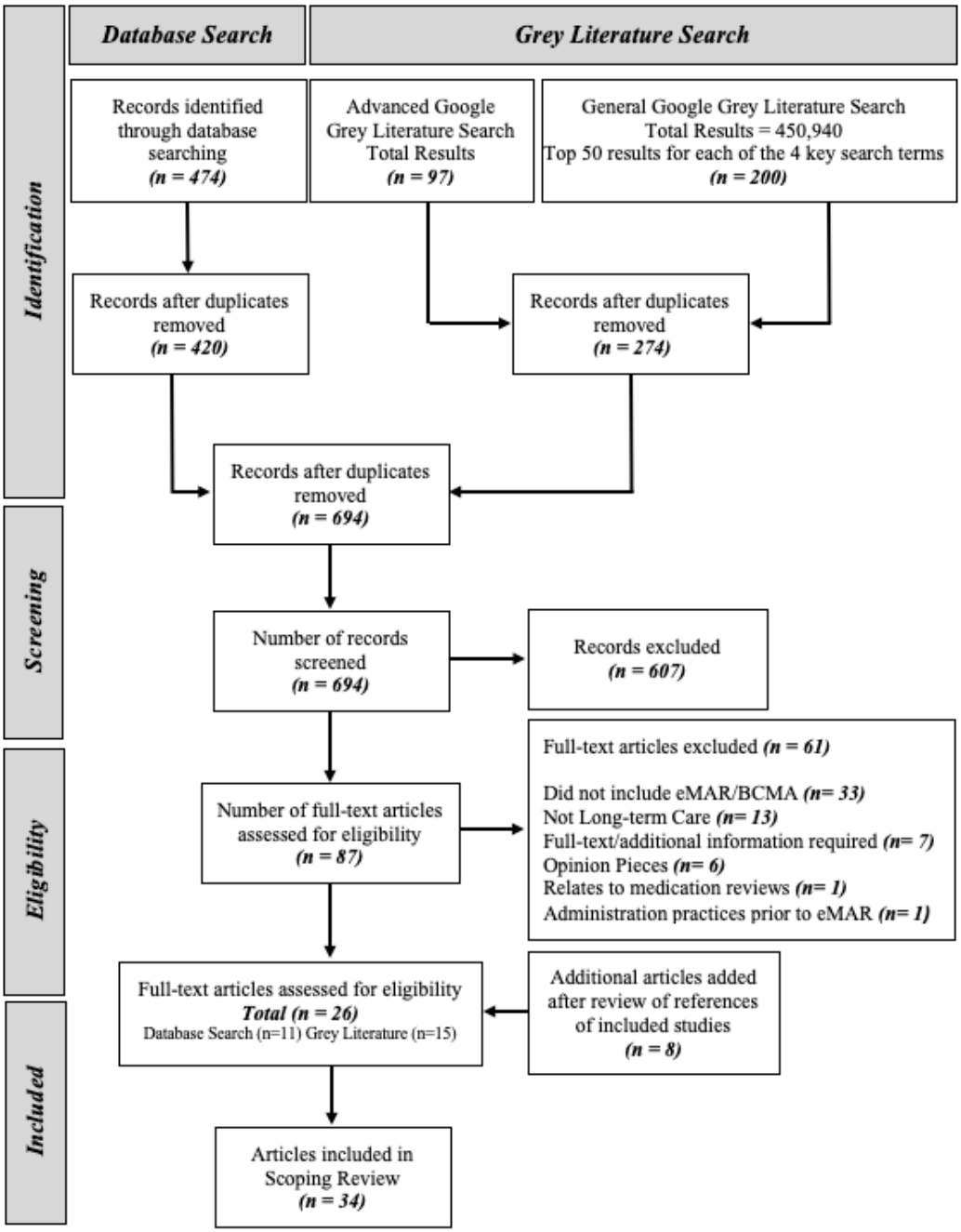
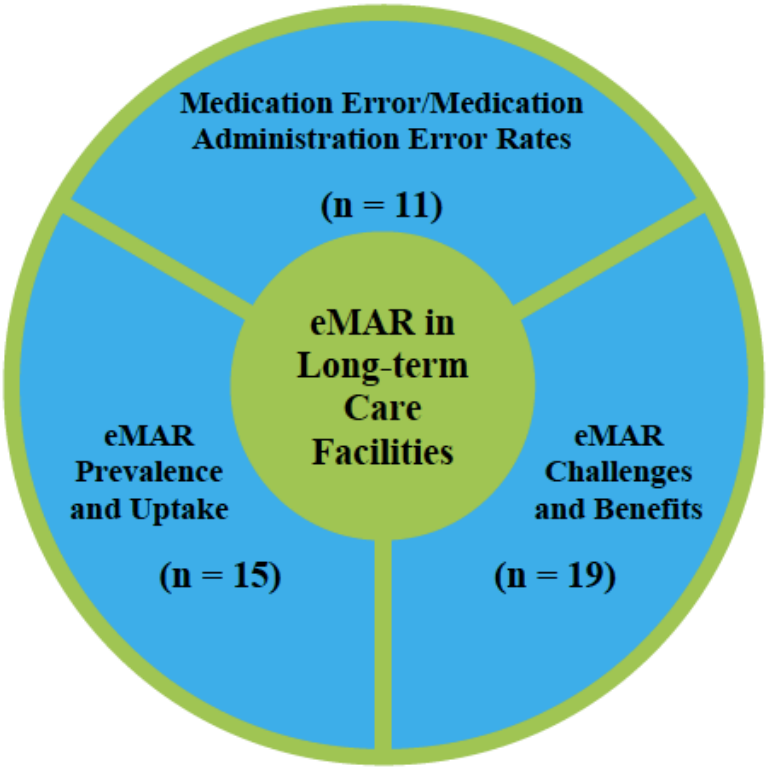


Figure 2.2. Map of main outcomes measured by number of studies in Scoping Review of eMAR.



*Some studies examined outcomes in more than one category

Table 2.1. Descriptive Characteristics of Included Studies

Characteristic	N=34
Publication Status	
Peer-Reviewed Literature	17 (50%)
Grey Literature	17 (50%)
Publication Year	
Unknown	1 (3%)
2005-2009	11 (32%)
2010-2014	14 (41%)
2015-2016	8 (24%)
Country	
USA	25 (74%)
Australia	4 (12%)
UK	3 (9%)
Sweden	1 (3%)
Canada	1 (3%)
Study Design	
Descriptive	28 (82%)
Survey	14 (41%)
Qualitative	12 (35%)
Implementation	1 (3%)
Document Review	1 (3%)
Analytic	6 (16%)
Experimental	0 (0%)
Observational Analytic	6 (16%)
Cohort	2 (6%)
Cross-sectional	4 (12%)
Case Control	0 (0%)
Study Design	
Quantitative	20 (59%)
Qualitative	7 (21%)
Mixed	7 (21%)
Method of Data Collection	
Survey	18 (53%)
Interview	12 (35%)
Document Review	9 (26%)
Direct Observation	7 (21%)
Focus Groups	7 (21%)
Analysis of eMAR Data	5 (15%)
Field notes	3 (9%)
Time motion-based observation	1 (3%)
Process mapping	1 (3%)
Nominal Group Technique	1 (3%)
Informal conversation	1 (3%)
Setting	

Long-term Care	30 (88%)
Assisted/Supportive Living	5 (15%)
Pharmacy	3 (9%)
Home Health Agencies	1 (3%)
Population/Participants	
Long-term Care Facilities	18 (53%)
Nursing Staff	15 (44%)
Pharmacists	5 (15%)
Physician	3 (9%)
Site Manager	4 (12%)
Health Information Technology Studied	
eMAR and EHR/EMR	7 (21%)
eMAR only	6 (18%)
eMAR and BCMA	3 (9%)
eMAR and CPOE	1 (3%)
eMAR, BCMA, and EHR	1 (3%)
eMAR, EMR and CPOE	1 (3%)
N/A	15 (44%)
Main Outcomes	
Medication Error/Medication Administration Errors	11 (32%)
Benefits/Challenges of eMAR	19 (56%)
Prevalence/Uptake of eMAR	15 (44%)

Legend: eMAR: Electronic Medication Administration Record, BCMA: Bar-code Medication Administration, EHR: Electronic Health Record, EMR: Electronic Medical Record, CPOE: Computer Physician Order Entry

Supplementary Table S2.1. Summary of Published Studies Included in Scoping Review (n=17)

Research Outcomes	Authors	Type of Study	Country	Setting	Purpose	Relevant Measured Outcomes	`Methods	Results/Relevant Findings	Source
Medication Administration Errors	Szczepura *et al.*[25] 2011	Cohort Study Cross-sectional Survey	United Kingdom	Nursing Homes and Residential Homes (BCMA)	To measure the incidence of MAEs in nursing and residential homes using a BCMA system *Comparison* *2 settings using BCMA (nursing home and residential home)*	• The incidence of potential MAEs using BCMA • Staff awareness of MAEs prior to BCMA implementation.	Disguised observation technique *Disguised observation of n=9 residential homes and n=4 nursing homes* Cross-sectional pre-study survey *Survey of n=45 staff members*	• 1.2% of all medication administrations were potential MAEs prevented by BCMA. • The frequency of averted MAEs with BCMA was significantly higher in NH vs. RH (p<0.01) • MAE risk was higher in the nursing homes (IR 1.43; 95% CI 1.32 to 1.56)	Medical Database Search
Medication Administration Errors; Benefits/ Challenges	Elliot *et al.*[39] 2016	Retrospective Cohort	Australia	RACF (eMMS)	To investigate the discrepancies between GP paper medication orders and pharmacy-prepared eMAR (eMMS) charts and delays between prescribing, charting and administration.	• Number and type of discrepancies between medication orders and eMAR (eMMS) • The number of discrepancies and delays that led to a MAE.	Cross-sectional audit of medication orders and medication charts *Audit of n = 88 resident medication records*	• 125 discrepancies noted where 47 (37.6%) led to MAE. • Of these, 42.6% (20) were due to discrepancies between GP-signed medication chart and eMAR (eMMS)	Medical Database Search
Perceived MAEs; Benefits/ Challenges	Qian *et al.*[37] 2015	Mixed Methods	Australia	RACF (eMAR)	To compare eMAR and paper MAR with the nursing time spent on various activities in a medication round and medication administration process. To identity the benefits and unintended adverse consequences of eMAR *Comparison* *2 units within an RACF (control/intervention)*	• The impact eMAR has on nursing time spent on activities • The benefits and consequences of eMAR	Time-motion observation *Direct observation of n=7 nursing staff members* Field notes Informal conversation Document review	• No difference in nursing time spent on medication administration or other various activities during the medication round. *eMAR Benefits:* • Improved nurses' compliance with documentation. • Freedom from the error of signing twice. • Reduces the possibility of forgetting medication administration or to sign medication charts. • Facilitates the time of medication administration. • Increase documentation space. *Challenges of eMAR:* • Inadequate information about residents. • Late addition of a new residents' provide in eMAR. • Nurses forgetting to medicate a resident due to power outage.	Medical Database Search
Perceived MAEs; Benefits/ Challenges	Alenius and Graf.[38] 2016	Prospective Case-control	Sweden	Nursing Home (MCSS)	To investigate the impact of eMAR on perceived stress among health personnel and the risk of MAEs in the Nursing Home setting. *Comparison* *2 nursing home settings (control/intervention)*	• Perceived stress among health personnel and perceived risk of MAEs before and after eMAR implementation.	Pre-post eMAR implementation questionnaire *Questionnaire of n=66 (pre) and n=59 (post) nursing personnel*	• Fewer personnel who were worried or anxious about MAEs in the intervention group at follow up (P<0.001) • Statistically significant reduction in perceived risk of making MAEs in the intervention group at follow up while the risk stayed the same or was increased in control group. • Perceived stress in general daily work was lower in the intervention group both at baseline (P=0.020) and follow up (P<0.001) • Perception of medication administration improved and more positive in intervention group • Perceived stress with the medication administration process decreased from baseline to follow-up in the intervention group while it was similar in the control group at both time points.(P=0.001). • The perception of the medication administration process improved in the intervention group at follow up (P=0.002), while there was no change in the control group.	Medical Database Search
Perceived MAEs; Benefits/ Challenges	Wild *et al.*[50] 2001	Qualitative	United Kingdom	Residential Homes and Nursing Homes (BCMA)	To evaluate the effects of a pharmacy led BCMA in care homes.	• Staff awareness of 'near misses'	Survey *n=49 pre, n=39 post nursing staff* Interview *n=unknown*	• Staff Awareness of near misses: • RH pre/post implementation~40%/74%. • NH pre/post implementation~0%/83% • Staff were more aware of 'near misses with BCMA. • Less and stress and pressure post-BCMA	Grey Literature Search
Perceived MAEs; Benefits/ Challenges; Prevalence/ Uptake	Elliot *et al.*[41] 2016	Mixed: Retrospective Audit and Qualitative	Australia	RACF (ePMMS)	Explore the uptake of the ePMMS by GPs and the experiences and perceptions of GPs, RACF Nurses and Pharmacists with the ePMMS.	• The uptake of ePMMS by GPs • Perceptions and the experiences of GPs, Nurses and Pharmacists with ePMMS	Interviews *n=2 pharmacists* Focus Groups *n=5 GPs, n=12 nurses* Retrospective audit of medication orders	• 3 of 7 GPs used the ePMMS. • 83% of medication orders through ePMMS were by 1 GP. *Benefits:* • Patient safety (updated MARs, avoided errors and delays and easier to interpret orders • Workforce efficiencies (quicker to modify MAR, decreased GP visits, time saved for new orders) *Limitations and Barriers:* • Inefficiencies • Poor uptake prevented full benefit of system being realized	Medical Database Search

Research Outcomes	Authors	Type of Study	Country	Setting	Purpose	Relevant Measured Outcomes	`Methods	Results/Relevant Findings	Source
								• Low training/support	
Benefits/ Challenges	Scott-Cawiezell *et al.* [15] 2009	Implementation	United States	Nursing Home (eMAR)	To explore the impact of technology and a focused Quality Improvement team on medication safety practices and medication errors with an eMAR implementation.	• The impact of eMAR in the medication administration process and Quality Improvement.	Detailed Observation Focus Group *n=5 Midwestern nursing homes*	*eMAR Benefits:* • Provides new structures and processes to resolve challenges related to each individual medication, the medication pass and management of medications over time. • Provides real time information on active orders. • Allows the administrator to focus only on the medications that were due. • Provides alerts and signaling features to prompt staff of medication safety issues. • Streamlines medication order processing. • Provides critical safety issue reports. • Brings Nursing Home and Pharmacy staff together to solve problems. *eMAR Limitations:* • Did not provide an independent and sufficient solution to the challenges of medication safety • Safety practice concerns noted with staff workarounds • Could not solve chronic structure and process issues on site Could not resolve omitted and missing medication information between GP, Pharmacist and administration.	Medical Database Search
Benefits/ Challenges	Vogelsmeier *et al.* [34] 2008	Implementation	United States	Nursing Home (eMAR)	To explore the relationship of workarounds related to the implementation of eMAR and medication safety practices.	• To identify workarounds associated with the implementation of eMAR. • Identify the potential risks of workarounds on medication safety.	Direct observation *n=43 (pre) and n=45 (post) nursing staff* Key informant interviews *n=unknown* Process mapping Review of field notes	*Workarounds related to technology implementation:* • Intentional blocks designed to enhance resident safety • Unintentional blocks resulting from ineffective design Workarounds related to organizational processes not re-engineered to effectively integrate the new technology	Medical Database Search
Benefits/ Challenges	Tariq *et al.* [40] 2014	Formative Evaluation	Australia	RACF Pharmacy (eMAR)	To conduct an in-practice evaluation of eMAR being piloted in one RACF before its rollout to other sites, and to provide recommendations for system improvements	• The challenges associated with the design and use of the eMAR system. • Recommendations to improve the design before rollout.	Workflow observation *n=1 Pharmacy* *n=1 RACF* Semi-structured interviews *n=4 RACF staff, n=1 RACF manager and n=1 pharmacist*	*Design Challenges of eMAR system:* • Limited interactivity • Inadequate flexibility • Issues in information layout and semantics: • Minimal decision support System maintenance issues	Medical Database Search
Benefits/ Challenges	Rantz *et al.* [44] 2011	Qualitative	United States	Nursing Homes (eMAR)	To determine if quality of care provided is improved through the use of EMR and if care is improved, what elements improved?	• Quality of care with the use of eMAR • Benefits of eMAR	Observation *n=4 Nursing Homes* Interview *n=unknown* Focus Groups *n=22 focus groups*	*Benefits:* • Care was safer (no specifics provided) • Facilitated faster and safer medication pass.	Reference List
Benefits/ Challenges	Degenholtz *et al.* [63] 2016	Qualitative	United States	Nursing Homes (eMAR)	To develop an empirical framework for understanding the intersection between specific uses of HIT and clinical care processes	• Identify key care processes that domain areas that can benefit from health information technology.	Focus Groups (Nominal Group Technique)	Physicians and Pharmacists identified eMAR implementation among the top 3 care processes *Physicians:* • Nurses record when they have given medication using eMAR • Maximum dosing's should not have to be written explicitly. • There should be an automatic check for drug interactions *Pharmacists:* • Document when residents refuse medications and automatically transmit information to RN or Physician for drug • Identify ADR or side effects • Automate pain management protocol Capture actionable information not just "5 Rights"	Grey Literature Search
Prevalence/ Uptake	Chan[33] 2008	Cross-sectional Survey Retrospective Secondary Analysis	United States	Nursing Home (eMAR)	To test whether the percentage of occupancy and metropolitan location are associated with the likelihood of NH using EIS for clinical care support.	• Hypothesis 1: Higher occupancy rate in NH will lead to more medication administration EIS use. • Hypothesis 2: Being within a metropolitan area will lead to more medication administration EIS use.	Survey *n=1174 nursing homes*	*eMAR implementation in Nursing Homes* • Implemented: 38.1% • NHs in metropolitan areas are less likely than those in rural to have medication administration EIS. • NHs with occupancy rate of 70-79% are less likely than those with <70% to have medication administration EIS. • NHs with administrators <5years are less likely than those with at least 20 years to have medication administration EIS.	Medical Database Search

Research Outcomes	Authors	Type of Study	Country	Setting	Purpose	Relevant Measured Outcomes	`Methods	Results/Relevant Findings	Source
								NHs offering more services are more likely to have medication administration EIS.	
Prevalence/ Uptake	Martin[35] 2011	Cross-sectional Survey	United States	Pharmacy (eMAR)	To determine industry standards for LTCF pharmacy operations, consultant pharmacist practice, and the use of HIT in LTCF.	• Prevalence of eMAR in LTCF and AL Pharmacy providers	Survey *n=unknown Pharmacy providers*	*eMAR implementation in Pharmacy* • Implemented (LTCF/AL): 23.3%/19.5% • Pharmacies with larger staff numbers are more likely to have HIT.	Medical Database Search
Prevalence/ Uptake	Hamann *et al.*[42] 2013	Cross-sectional Survey	United States	Nursing Homes (eMAR)	To examine the ownership differences in the use of technology in NHs	• The mean percentage of adoption of eMAR in non-profit and for-profit Nursing Homes	Cross-sectional Survey *n=1174 Nursing Homes*	*Prevalence:* 38% for profit, 38% non-profit NHs have medication administration information via health IT	Reference List
Prevalence/ Uptake	Abramson *et al.*[57] 2014	Cross-sectional Survey	United States	Nursing Homes	To determine rates of electronic health record (EHR) adoption and health information exchange (HIE) among New York State (NYS) nursing homes	• The extent of eMAR uptake in those nursing homes with EHR.	Cross-sectional Survey *n=375 nursing homes*	• 45.5% of those nursing homes with full or partial EHRs had eMAR, • 8.1% of nursing homes without EHRs had eMAR	Grey Literature Search
Prevalence/ Uptake	Resnick *et al.*[49] 2009	Cross-sectional Survey	United States	Nursing Home (EIS/eMAR)	To define the extent of utilization of 12 types EIS function in U.S. Nursing homes. Relate EIS utilization to selected facility characteristics Contrast these findings to previous estimates of EIS use in NH	• Medication Administration EIS use in U.S. nursing homes	Survey *n=1174 nursing homes*	*eMAR implementation in Nursing Homes* • Implemented: 38.1% • Larger facilities and those that were part of a larger chain used more EIS.	Reference List
Prevalence/ Uptake	Abramson *et al.*[43] 2015	Cross-sectional Survey	United States	Nursing Homes (eMAR)	To assess the pace of EHR adoption, changes in computerized function adoption and participation in HIE by NY state nursing homes over time	• Prevalence of eMAR	Cross-sectional Survey *n=472 Nursing Homes*	***Prevalence:*** • 47.6% of NHs that are EHR adopters had eMAR (2012) • 51.0% of NHs that are EHR adopters had eMAR (2013)	Reference List

Legend: eMAR: Electronic Medication Administration Record, BCMA: Bar-code Medication Administration, eMMS: Electronic Medication Management System [This intervention includes electronic medication administration chart]; EIS: Electronic information systems [This term has 12 functional areas which includes Electronic Medication Administration information], ePMMS: Electronic Prescribing and Medication Management System [This intervention consists of electronic prescribing which directly populates Electronic Medication Administration Records], MCSS: Medication and Care Support System [This term is synonymous to eMAR], GP: General Practitioner, RN: Registered Nurse; MAE: Medication Administration Error, LTCF: Long-term Care Facility, HIT: Health Information Technology, AL: Assisted Living Facilities, SNF: Skilled Nursing Facilities, IT: Information Technology, RACF: Residential Aged Care Facility, NH: Nursing homes, HHA: Home Health Agencies, HIE: Health Information Exchange, EHR: Electronic Health Record

Supplementary Table S2.2. Summary of Grey Literature Included in Scoping Review (n=17)

Research Outcomes	Authors	Type of Study	Country	Setting	Purpose	Relevant Measured Outcomes	Methods	Results/Relevant Findings	Source
Medication Administration Errors	Szczepura *et al.*[52] 2013	Prospective Cohort	United Kingdom	Long-term Care and Assisted Living (BCMA)	To evaluate BCMA management system designed to improve drug administrations in residential and nursing homes, including comparison of error rates and staff awareness in both settings. *Comparison* *2 settings (nursing home and residential home)*	• MAE rates • Staff Awareness of MAEs	Cross-sectional pre-study survey *Survey of n=45 staff members* Chart Review	• 1.2% of medication administrations demonstrated a potential MAE error that was averted • Residential home staff were more aware of near misses compared to Nursing home staff.	Grey Literature Search
Medication Administration Errors; Benefits/ Challenges	Dibert *et al.*[58] 2012	Case Study	United States	Assisted Living (eMAR)	To demonstrate the implementation of eMAR and the reasons and implications of introducing the system	• The impact of eMAR in assisted living	Observation *n=11 Assisted Living Facilities*	• Medication error rates decreased 212/year pre-implementation (2010) to 20/year (2011) and 17/year (2012) post-implementation • Improved ability to track and monitor medication use • Improved quality measures: • PRN medication use and documentation of effectiveness • Timeliness of medication delivery at passes • Documentation of parameters.	Grey Literature Search
Medication Administration Errors; Benefits/ Challenges	Pratt[59] 2014	Case Study	United States	Assisted Living (eMAR)	To report on the goals established in an eMAR implementation project.	• Reduced medication error rate • Achievement of a more complete EHR • Workflow efficiencies • Regulatory compliance. • Caregiver accountability • Resident/workforce safety • Mitigation of drug diversion	Observation *n=1 Assisted Living Facility*	• Error rate decreased to 0.011% (2014) from 0.072% (2013) Med errors before eMAR 192/yr vs. 31/yr after eMAR • EHR is more complete with eMAR • 10 less nursing hours required per month for medication reconciliation at month end. • 1 hour less per day reviewing paper MARs not signed off or resolving paper MAR discrepancies. • Permits ease in demonstrating regulatory compliance. • Built in accountability feature increases patient safety. • eMAR can detect and mitigate diversion. • Staff login with unique credentials. Dashboard alerts that are outside required practice.	Grey Literature Search
Perceived MAEs; Benefits/ Challenges	*Potter*[36] 2014	Qualitative	United States	SNF (eMAR)	To explore perceptions and concerns of RNs regarding safe medication administration in SNFs Nurse satisfaction with current medication administration systems.	• Perceptions and concerns of RNs regarding safe medication administration in SNFs • RN satisfaction with current medication administration systems	Interviews *n=6 Registered Nurses (experience with eMAR)*	*eMAR Benefits:* • eMAR was safer than paper MAR • Provided better information regarding medications and administration times • Convenience • Decreased medication errors and improved residents' safety *Challenges:* • "Time management" was the same. • Difficulties adjusting to eMAR. • Lack of IT reliability	Medical Database Search
Perceived MAEs; Benefits/ Challenges;	Kramer *et al.*[56] 2009	Case Study	United States	Nursing Homes and Home Health Agencies (eMAR)	Understand how HIT tools are being used in NH and HHA. Identify the costs and benefits associated with HIT. Develop data collection and analysis plan to assess the costs and benefits.	• Benefits and negatives of eMAR	Interview *n=unknown*	*Benefits:* • Improved workflow resulting in time saving in medication administration. Reduced from 9 hours per 12 hour shift, to 6 hours per 12 hours shift • Monthly medication reconciliation time was reduced from several days per month, to less than an hour. • Updating the eMAR immediately saved money and improved safety by reducing discontinued medications being ordered or administered. • Improvements to error rates. • Improvement in staff compliance with medication monitoring and helped reduce missed labs and other orders. *Negatives:* • eMAR hard to navigate	Grey Literature Search
Benefits/ Challenges	Mohamoud *et al.*[51] 2009	Report	United States	Nursing Homes (eMAR)	A report summarizing the key challenges noted, solutions identified, and lessons learned by AHRQ funded projects implementing health IT in LTCF. Project InfoCare	• BCMA implementation barriers, lessons learned and best practices emerging from Project InfoCare	Unknown	*Barriers:* • Resident identification wristbands were an issue due to dignity and skin integrity. • Little incentive of pharmacies to participate.	Grey Literature Search

Research Outcomes	Authors	Type of Study	Country	Setting	Purpose	Relevant Measured Outcomes	Methods	Results/Relevant Findings	Source
Benefits/ Challenges	Klinger *et al.*[54] 2010	Case Study	United States	Nursing Homes (HIT/eMAR)	To establish the lessons learned from HIT demonstration in New York Nursing homes.	• On time administration of medications uptake of ePMMS by GPs	Survey *n=unknown* Interview *n=unknown*	• 99% of medication and treatments administered on time	Grey Literature Search
Benefits/ Challenges	Campbell *et al.*[60] Unknown Date	Case Study	Canada	Nursing Home (eMAR)	To demonstrate the implementation of eMAR	• Does eMAR minimize errors, improve documentation and enhance communication?	Observation *n=1 Nursing Home* Interview *n=unknown* Chart Review	*Benefits:* • User friendly; "Quick & easy to use" • Easier information access • Complete documentation • Enhanced communication • Error prevention and safe care: "Harder to make mistakes" "Easier to identify residents" Report functions	Grey Literature Search
Benefits/ Challenges	Ko *et al.*[62] 2016	Qualitative	United States	Nursing Homes (eMAR)	To characterize the effect of HIT on workforce perceptions and care processes, the training needs associated with HIT implementation and the infrastructure needed for the workforce to effectively use HIT.	• Benefits of eMAR	Interview n=15 nursing home staff where HIT was present Focus Groups *n=2 focus groups (6 nursing home staff)*	*Benefits:* • HIT Shortened the time to complete medication administration. (No specifics on type of HIT) • Easier to see medications and treatments (no specifics on type of HIT)	Grey Literature Search
Benefits/ Challenges; Prevalence/ Uptake	Hudak *et al.*[45] 2007	Mixed Methods	United States	SNF and AL (eMAR)	To determine the current state of HIT planning and adoption in LTCF in California. What are the perceived benefits and barriers? What should providers, policymakers, and community stakeholders know and do to support HIT adoption and successful se in LTCF?	• Prevalence of eMAR in LTCF • Barriers of HIT implementation • Drivers of HIT adoption	Literature Review Focus Groups/Interviews *n=unknown* Survey *n=80 SNF, n=18 AL*	*eMAR implementation within SNF/AF:* • Implemented: 18%/ 22% *Barriers to HIT implementation* • Lack of capital resources, difficulty in finding HIT that meet their need, lack of evidence of HIT and quality of care and operational efficiencies, risk of new state/federal requirements, lack of hardware and IT staff.	Reference List
Prevalence/ Uptake	Maestro[46] 2007	Cross-sectional Survey	United States	Nursing Home (eMAR)	To cover information technologies' impact on organizational strategy, address how LTCF organizations are planning for and managing IT, define level of capital and operating budgets dedicated to IT, and explore various operating models of IT	• Prevalence of eMAR in LTCF	Survey *n=36 AHCA multi-facility members*	*eMAR implementation in Nursing Homes* • Implemented: ~22%	Reference List
Prevalence/ Uptake	Stratis Health[47] 2008	Cross-sectional Survey	United States	Nursing Home (eMAR)	To determine the level of HIT use in Minnesota nursing homes	• Prevalence of eMAR in LTCF	Survey *n=297 nursing homes*	*eMAR implementation in Nursing Homes* • Implemented: 49% • Rural homes: 55.9% • Urban homes: 41.7% • Not for profit: 53.4%, for profit: 36% Part of a chain: 59%	Reference List
Prevalence/ Uptake	ASCP[48] 2009	Cross-sectional Survey	United States	Pharmacy (eMAR)	To provide insight into the senior care pharmacy marketplace	• Prevalence of eMAR in LTCF Pharmacy providers	Survey *n=unknown Pharmacy providers*	*eMAR implementation within Pharmacy providers*: Implemented: 18%	Reference List
Prevalence/ Uptake	Murray[53] 2015	Correlational	United States	Nursing Homes (eMAR) (BCMA)	To examine the relationship between NH quality of care as measured by CMS Quality Rating Scores and adoption of HIT in Minnesota NHs	• Prevalence of eMAR and BCMA	Cross-sectional Survey *n=217 Nursing Homes which have EHR*	*Prevalence:* • 36% of NHs have eMAR, 48% • 6% BCMA have eMAR • Significant correlation with small effect size for medication administration (among other outcomes) and CMS quality rating.	Grey Literature Search
Prevalence/ Uptake	Oregon Office of Health Information Technology[55] 2011	Cross-sectional Survey	United States	Long-term Care (eMAR)	To determine the technology integration currently existing in Oregon LTCF and to identify what challenges exist to expanding the use of HIT in LTCF.	• The extent of eMAR uptake in Oregon LTCF.	Cross-sectional Survey *n=116 LTCF*	• 22% of facilities have eMAR. • 41.9% of facilities with EHR have eMAR.	Grey Literature Search

Research Outcomes	Authors	Type of Study	Country	Setting	Purpose	Relevant Measured Outcomes	Methods	Results/Relevant Findings	Source
Prevalence/ Uptake	Bergstrom *et al.*[61] 2012	Cross-sectional Survey	United States	Nursing Homes (eMAR and BCMA)	To assess adoption, use and exchange of HIT	• Prevalence of eMAR and BCMA	Cross-sectional Survey *n=217 Nursing Homes which have EHR*	*Prevalence:* • 36% of NHs have eMAR, • 6% of NHs have eMAR	Grey Literature Search
Prevalence/ Uptake	CCLC[64] 2006	Cross-sectional Survey	United States	Long-term Care (HIT/eMAR)	To understand the current state of HIT efforts in LTCF including successes and challenges, and determine current and future HIT priorities in LTCF	• Prevalence of eMAR	Cross-sectional Survey *n=34 LTCF organizations*	*Prevalence:* 21% of LTCF have eMAR	Grey Literature Search

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CHAPTER 3

Evaluation of Medication Incidents in a Long-Term Care Facility Utilizing Electronic Medication Administration Records and Barcode Technology

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ABSTRACT

Background: Electronic medication administration records (eMAR) with barcode scanning (BCMA) may increase the safety of medication administration in long-term care facilities (LTCF), but supportive evidence is lacking.

Objectives: To evaluate the frequency, type, and severity of reported medication incidents within a LTCF that utilizes eMAR-BCMA and further explore the characteristics of medication incidents and the residents who experience them.

Methods: Retrospective review of paper-based, medication incident reports submitted voluntarily between June 2015 and October 2017 at a 239-bed designated assisted living facility, in Edmonton, AB, Canada. Using a standardized template, a single reviewer abstracted data from each medication incident report and classified incidents according to medication-use phase, error type, severity and medications involved based on established definitions. Content analysis was used to summarize reported factors that led to a medication administration incident (MAI).

Results: A total of 270 medication incidents reports involving 154 residents were reviewed. There was a total of 175 (66.3%) MAIs, where missed medication (46.3%) and incorrect time (24.6%) were the most common error types. Temporary harm occurred in five (2.9%) MAIs, and 83 (47%) reached the resident and required intervention. Opioids, antihistamines, insulin, and anxiolytics were involved in incidents that caused temporary harm and high-alert medications were involved in 17.7% (n=31) of all MAIs. Suboptimal medication administration processes (54.9%; n=96) and communication within the facility or with the community pharmacy (18.9%; n=33) were the most common factors that led to MAIs. Residents experiencing multiple MAIs were younger (61.6±13.3 vs. 74.6±17.4 years) than those experiencing one MAI and were more likely to reside on non-secure than secure units (55.7% vs. 14.6%; RR: 3.81; 95% CI: 1.89, 7.73;

p<0.001). Medication incidents reported with multiple medication error types were more severe than those with a single error type.

Conclusion: Our study illustrates that MAIs still occur despite implementation of an eMAR-BCMA system. The frequency and types of MAI were similar to LTCF not utilizing eMAR-BCMA; however, few incidents led to patient harm. A prospective, pre-post implementation study is required to robustly assess the impact of eMAR-BCMA on medication administration incidents in LTCF.

3.1 Background

Long-term care involves a variety of services designed to help people live as independently and safely as possible when they can no longer perform everyday activities on their own.[1] The majority of long-term care is provided within nursing homes and other assisted living facilities offering on-site personal care and services.[2] Over 300,000 Canadians and 2.2 million Americans resided in nursing homes or other assisted living facilities in 2011–14.[3-5]

A medication incident, also defined as a medication error, is any preventable event that may cause or lead to inappropriate medication use or resident harm while the medication is in the control of the health care professional, resident, or consumer.[6, 7] Medication incidents can occur at any stage in the medication use process such as prescribing, transcribing, dispensing, administration, communication/documentation and monitoring.[6, 8, 9] Effective medication incident reporting and analysis is a key element in establishing safe medication use systems.[10] The systems approach views most errors as predictable human failings in the context of poorly designed systems, rather than treat errors as failings on the part of individual providers.[11] However, optimizing safety through effective learning systems requires a just culture of patient safety, which finds a balance between a punitive culture which disciplines all deviations from standard operating procedure and a blame-free culture where all behavioral choices are forgiven. Providers must feel safe, encouraged, and enabled to discuss quality and safety concerns in order to learn from everyday errors and allow for systems to be designed to be less error prone and more error tolerant.[12]

Despite ongoing efforts to improve patient safety in LTCF, a recent systematic review found that medication incidents occur in 16% to 27% of LTCF residents.[13] Additional studies have

reported medication administration incident (MAI) rates of 3% to 53%.[9, 14-21] Up to 12.6% of medication incidents cause harm,[8, 18, 22, 23] where the majority are due to medication administration.[18, 22, 23]

LTCF have adopted electronic medication administration records (eMAR) and barcode assisted medication administration (BCMA) technology to address MAIs, where close to 50% of LTCF in some American jurisdictions utilize this technology.[24] Pharmacies that service LTCF have a reported uptake of 18%[25] to 23.3%.[26] In contrast, hospital environments in the U.S. have eMAR and BCMA uptake of more than 88%[27] where it has demonstrated to reduce the overall incidence of MAIs, improve medication administration, and improve the detection of medication incidents.[28, 29]

We recently completed a scoping review on the effectiveness, use and perceptions of eMAR-BCMA in LTCF. We found limited evidence linking eMAR-BCMA use and reduction in medication incidents; in addition to, evidence of new types of medication incidents resulting from nursing staff workarounds, inconsistent influence on nursing time spent during medication administration and an array of perceived benefits and challenges.[30]

In order to explore medication safety issues that occur despite the use of eMAR-BCMA technology and facilitate learning and quality improvement around the medication use process, we conducted a small-scale evaluation within a 239-bed designated assisted living facility in Edmonton, AB, Canada which implemented an eMAR-BCMA system in 2013. The main purpose of this study was to characterize the frequency, type and severity of reported medication

incidents and MAIs. Additionally, we determined if medication incidents were more commonly reported on secure or non-secure units, investigated characteristics of residents that experienced multiple medication incidents, and explored factors that influence medication incident severity.

3.2 Methods

A retrospective review of voluntarily submitted, paper-based, medication incident reports within the LTCF was completed. The medication incident report is an internal document completed by nursing staff and is used as per facility policy for quality improvement/assurance and for external reporting to the LTCF governing body. In Alberta, LTCF that are supported by Alberta Health Services, are required to report medication incidents that could or do result in an unintended injury to a resident.[31] This anonymous data is used to identify risks to resident safety for the purpose of organizational learning. The medication incident report utilized within the study LTCF includes the date, time and the person(s) involved, medication error type, injuries/adverse reactions, the description of the medication incident, and team leader/resident care manager follow-up (See **Appendix 3.1** for the full Medication Incident Report form).

3.2.1 Facility Background

The study site is affiliated with a large conglomerate that consists of over 30 LTCFs throughout the provinces of Alberta and British Columbia. It contains five residential units, of which two are secure units for residents with significant cognitive impairments including dementia. The majority of residents live within the three non-secure units. All medications are administrated by Healthcare Aids (HCA) and Licensed Practical Nurses (LPN) within four designated medication administration times (0800/1200/1700/2100) where nursing staff have a 2-hour window to administer the medication.

During the study period, the site utilized a single outside pharmacy provider for the dispensing

and distribution of all prescription and non-prescription medications. The pharmacy was an affiliate within a nationwide pharmacy chain with multiple retail centers across Canada that offers medication distribution and clinical services to patients, customers, and private care facilities. The implementation of the eMAR-BCMA system was financially supported by the dispensing pharmacy and was introduced to the LTCF as a value-added service in 2013. Ongoing maintenance and nursing staff training was also provided by the dispensing pharmacy. One member of the investigator team (AF) was employed by the contracted dispensing pharmacy as a staff pharmacist and acted as the onsite clinical pharmacist at the study LTCF two days a week from August 2014 to November 2017. The onsite clinical pharmacist roles and responsibilities consisted of conducting medication reconciliation and reviews, participating in multidisciplinary care conferences, acting as a drug information resource for LTCF staff and residents, and providing support in the assessment of medication incidents and associated interventions if they occurred while the pharmacist was onsite. AF acted as the Clinical Operations Manager of the pharmacy chain from Nov 1st, 2017 to Dec 1st 2018, and was involved in implementation of eMAR-BCMA systems with LTCF across Alberta during this time, but had no role in the implementation of the eMAR-BCMA system at the participating site

The eMAR-BCMA system in use is oneMAR (Catalyst Healthcare, Kelowna, BC) and consists of an online resident medication profile and resident specific barcoded medication packaging. Data management and packaging is completed centrally by an outside community pharmacy. All documentation outside of medication administration is found within paper medical charts and the site does not use an electronic medical record (EMR) or computerized physician order entry (CPOE). The eMAR provides access to a residents' profile, including medical conditions,

allergies, vitals and the most current medication list. During medication administration, the nursing staff member scans the residents' mediation using a hand-held device (BCMA) which presents the resident profile on the eMAR. This visually confirms the identification of the resident. HCAs confirm the number and visual description of each unit dosed oral medication within the packaging and review the specific administration directions for topical therapies. LPNs confirm the same; however, they must review the administration directions regardless of formulation and are responsible for administering all high-risk medications. Warnings within the eMAR-BCMA inform nursing staff of an incorrect resident profile or incorrect administration processes if the wrong barcode is scanned or if it is scanned outside of any parameter. Using a unique username and password, nursing staff sign off on medication administration using the eMAR system. After each designated medication administration time, the lead nurse generates an eMAR shift audit report which informs nursing staff which medications for that designated time were not signed off as administered on the eMAR. Nursing staff can then complete the administration of the missed medications, or the medication can be signed off as administered in instances when the nursing staff administered the medication but failed to sign it off as administered.

3.2.2 Inclusion/Exclusion Criteria & Data Access

All medication incident reports submitted between June 2015 to October 2017 were eligible for review. As per facility policy, medication incidents reports are maintained for 2 years, and reports submitted at the study site prior to June 2015 were no longer available, while a new community pharmacy was contracted to provide pharmacy dispensing services starting November 1, 2017. Medication incidents that were discovered and documented at the dispensing pharmacy or outside of the LTCF were not studied. A research agreement was created with the

LTCF to allow access to the medication incident reports. The study was approved by the University of Alberta Research Ethics Board.

3.2.3 Data Abstraction

A single investigator who is a registered clinical pharmacist (AF) reviewed all original medication incidents reports submitted within the LTCF onsite in June 2018 and January 2019 and extracted relevant information into two standardized data collection forms hosted on the REDCap secure web-based database platform at the University of Alberta. Medication error type and injuries/adverse reactions were abstracted based on self-reported data from the nursing staff at the time the incident occurred. Options for error type included incorrect resident, incorrect medication, incorrect time, incorrect dose, incorrect route, missed medication, medication expired, pharmacy error, documentation error/omission, or other and injuries/adverse reactions were recorded as yes, no, or unknown (i.e., missing). (**Appendix 3.1)**

The investigators adjudicated each medication incident report and categorized them according to medication-use phase(s) and severity/perceived harm to the resident. Medication-use phases included: prescription, transcription, dispensing, administration, communication/documentation and monitoring.[6] Resident self-prescribing and self-administration were defined as prescribing and administration medication-use phases respectively.[32] To support categorization of the severity of each medication incident report, the NCC MERP Index for Categorizing Medication Errors and associated Algorithm[33, 34] were utilized. This categorization method has been employed in previous studies evaluating medication incident report severity.[21, 22, 35-39] (see **Appendix 3.2**) For instances where the investigator (AF) was uncertain of the medication-use phase or NCC MERP severity, a second clinical pharmacist investigator (MM) independently reviewed the medication incident report and final categorizations were achieved by consensus.

Each medication incident report may have involved more than one medication error type or medication-use phase.

Narrative free-text descriptions of each incident were reviewed to categorize each according to the medication involved, the primary personnel involved, and the LPN Team Leader and Resident Care Manager follow-up. Medications were categorized according to the ISMP List of High Alert Medications in Long-term Care[40] and the Anatomical Therapeutic Chemical and Metabolism/Defined Daily Dose (ATC/DDD) Index.[41] Primary personnel involved in the incident were categorized as nursing staff, pharmacy, eMAR-BCMA, prescriber, and resident.

Two investigators (AF, MJM) conducted content analysis as described by Schreier to systematically categorize the reported factors that led to MAIs and dispensing errors.[42] Initially we planned to use a concept-driven approach based on Reason's model of accident causation, however, because the descriptions of the medication incident were reviewed retrospectively it was difficult to categorize the reported factors as being related to latent conditions or active failures[11, 43] Therefore we employed a data-driven approach to create a list of categories that related to the factors interpreted as being influential to MAIs and dispensing errors. An iterative approach was utilized to create and assign each individual medication incident report into categories and associated sub-categories based on what was reported within the description of each medication incident report. Categories were first developed by reading the description of a medication incident report until a relevant concept was encountered. If the concept and related category was not yet developed or was not found previously, a new category was created and the medication incident report was assigned to it. If the concept and related category was already

created or found in a previous medication incident report, the medication incident report was assigned to that category. This process was repeated for the development of respective sub-categories for each main category. Category and sub-category definitions were created which included a description, definition, indicators and examples to support appropriate categorization for each medication incident report. To ensure that sub-categories within one main category were mutually exclusive and to prevent uncertainty in categorization for sub-categories that could potentially overlap, decision rules were added. Once the categories and sub-categories were finalized, both investigators independently reviewed the description of each medication incident report again and re-assigned each medication incident into its respective category and sub-category. Final categorizations were achieved by consensus. (See **Appendix 3.3 and 3.4.**)

The investigators did not have access to the eMAR system itself, number of medications administered, the occupancy rate, or the total number of residents who lived within the LTCF during the study period.

3.2.4 Data Analysis

The data collected is presented into two categories, data from all medication incident reports (which includes each medication-use phase) and data from MAIs only. STATA (version 15, Statcorp LLC, College Station Texas) was used for all statistics. Descriptive statistics were recorded as means and proportions as appropriate. Post-hoc analyses were conducted to explore differences in medication incident and MAI occurrence per month between non-secure and secure units and between shifts (0700-1500, 1500-2300, 2300-0700). Due to differences in resident capacity between non-secure and secure units, we further explored the differences in the mean proportion of residents involved in a medication incident and MAI between units. This was based on the residents' first reported medication incident of the month. We investigated

differences in resident characteristics (age, gender and unit) for those who experienced one medication incident vs. multiple incidents and for those who experienced a non-MAI vs. one-MAI vs. multiple-MAIs. Lastly, we explored differences in medication incident severity using both mean severity score and a dichotomized severity grouping (Did not reach resident [NCC MERP severity 1-2] and did reach resident ([NCC MERP severity 3-9]) for medication incidents that contained one vs. multiple medication error types, one vs. multiple medication-use phases, that were reported within vs. after 24 hours of occurrence, and that were reported between nursing shifts.

Student t-tests and one-way ANOVA tests were used to determine differences in means. Shapiro-Wilk tests and analysis of Q-Q plots were used to ensure that mean scores in each group were sufficiently distributed to allow the use of parametric tests. Chi-squared tests were used for categorical cross-tabulation tests, and Fisher's exact was used when sample sizes were small. Significance was set at $\alpha = 0.05$. The Bonferroni Correction was applied to correct for multiple statistical calculations for post-hoc tests across multiple groups, where a statistical significance of $\alpha = 0.017$ was used for three group comparisons.

3.3 Results

3.3.1 Medication Incident Reports

Over the 29-month study period, 270 medication incidents were reported and all were analyzed in this study. None were excluded. Six were non-resident specific and included incorrect narcotic counts (n=4) and eMAR-BCMA software issues (n=2). These are not further included in the descriptive nor the post-hoc data analysis. A longitudinal breakdown of the number of medication incidents and MAIs reported per month is shown in **Figure 3.1.**

3.3.2 Resident Characteristics

The 264-resident specific medication incident reports impacted 154 residents and on average each of these 154 residents experienced 1.71 medication incidents. The majority of residents with medication incidents were women (63.0%) and most residents experiencing medication incidents resided on the non-secure units (68.8%). The mean proportion of residents involved in a medication incident per month based on unit capacity (4.49%±1.68 vs. 2.05±1.53, $p<.001$) and a MAI per month (2.93%±1.35 vs. 1.50%±1.49**,** $p<.001$) was statistically higher in non-secure than secure units. **(Table 3.1)**

3.3.3 Medication Incident Report Characteristics

The characteristics of the 264 reported medication incidents are shown in **Table 3.2**. The majority of medication incidents were reported on the non-secure units (n=207; 78.4%). The medication administration-use phase was involved in 66.3% (n=175) of all medication incidents. On average, 9.10±3.54 medication incidents were reported at the facility per month, of which 6.03±2.83 were MAIs. The most common medication error types reported by the nursing staff included missed medications (32.6%, n=86) and pharmacy dispensing error (23.5%, n=62). Missed medication (46.3%, n=81) and incorrect time (23.4%, n=41) were the most common MAIs. The majority of medication incidents were reported within 24 hours of occurrence (81.4%, n=215). The nursing staff reported that an injury or adverse event occurred in six (2.3%) medication incidents (n=5 were due to medication administration and two of these were resident self-administration medication incidents) and this was consistent with the categorization of severity done by the investigator. The investigators determined that 160 medication incidents (60.6%) reached the resident (NCC-MERP 3-9) and intervention was required for 55.6% (n=89) of them. Similarly, 145 MAIs (82.3%) reached the resident and 57.2% (n=83) required intervention. No permanent harm or deaths as a result of medication incidents were reported.

3.3.4 Medications Involved with Medication Incident Reports

Over 28% of medication incident reports did not specify which medications were involved. However, ISMP high alert medications were involved in 48 medication incidents (18.2%) and 31 MAIs (17.7%), where opioids (9.5%; 8.0%) and anticoagulants (4.2%; 4.6%) were the most common medications documented within medication incidents and MAI reports respectively. Antipsychotics (9.1%; 10.3%) and anti-infectives (7.6%; 8.6%) were the most common non-ISMP medications. Opioids (n=2), antihistamines (n=1), insulin (n=1), and anxiolytics (n=1), were involved in the medication incidents that caused resident harm and in one case the medication involved was missing.

3.3.5 Primary Personnel Involved & Incident Follow-up

Nursing staff were involved in the majority of medication incidents (68.2%; n=180), followed by the dispensing pharmacy (28.4%; n=75). The most common response by the LPN Team Leaders or Resident Care Managers post medication incident was providing education to those involved (58.3%; n=154). (**Table 3.2.**)

3.3.6 Content Analysis: Factors Leading to MAIs and Dispensing Errors

As shown in **Table 3.3**., content analysis for the factors that led to MAIs resulted in the creation of five main categories, with 15 associated sub-categories. The main categories consisted of medication administration processes with eMAR-BCMA, medication packaging, environmental issues and internal/external factors, communication, and other/not available. Content analysis for the factors involved in dispensing errors resulted in the creation of two main categories and five sub-categories. The main categories included pharmacy packaging and delivery, and other/ unknown. The full description of the categories and sub-categories can be found in Appendix 3.4. The most commonly reported factors that led to MAIs included nursing staff not reviewing the eMAR and/or the medication prior to administration, signing off medications as administered

but not actually being administered, problems with providing leave of absence (LOA) medications, and issues with order communication. The reported factors that led to MAIs that caused harm included resident self-administration issues (n=2), medications administered but not signed off (n=1), distracted during medication administration (n=1), and issues with order communication within facility or between facility and pharmacy (n=1). Issues with packaging, delivery or eMAR-BCMA barcodes, were the most common factors involved in dispensing errors. The medication incident involving pharmacy dispensing that caused harm was categorized as medication packaging error (n=1).

3.3.7 Characteristics of Residents with Multiple Medication Incidents

Of the 154 residents, 66 (43.4%) experienced multiple medication incidents and 37 (24.0%) experienced multiple MAIs. (**Table 3.4**.) Residents with multiple medication incidents were significantly younger vs. those with a single medication incident, (61.6±13.3 vs. 74.6±17.4, $p<.001$) and a similar pattern was seen for residents with multiple MAIs vs. a single MAI (59.9±15.8 vs. 73.2±16.2 $p<.001$). A larger proportion of residents with multiple medication incidents (55.7% vs. 14.6%, $p<.001$) and MAIs (20.8% vs. 10.4%, $p=0.013$) lived in non-secure units. Residents residing on non-secure units were 3.81 times (95%CI: 1.89, 7.73) more likely to have multiple medication incidents reported than those on secure units.

3.3.8 Severity of Medication Incidents

Compared to medication incidents coded with a single error, those that involved multiple error types had a greater mean severity score (3.28±1.28 vs. 2.66±1.15 out of 9; $p<.001$), where a medication incident with a severity score of three reached the resident but did not cause harm. Similarly, incidents coded with multiple error types were more likely to have reached the

resident (76.1% vs. 57.3%, p=0.02; RR: 1.33; 95% CI: 1.09, 1.62). (**Table 3.5**.) There was no difference in severity scores for medication-use phase, shift, or time to error report.

3.4 Discussion

This study retrospectively explored 29 months of medication incident reports from a single LTCF to explore medication safety issues that occur despite the use of eMAR-BCMA for medication administration and identify opportunities for quality improvement in medication safety. On average there were approximately nine medication incidents reported per month and the majority were from the three non-secure units. Once we accounted for the difference of resident capacity between the units, there was a greater mean proportion of non-secure residents exposed to a medication incident and MAI per month. Medication administration, dispensing, and communication/documentation were the most common medication-use phases involved. Missed medications and incorrect time were the most commonly reported medication error types by nursing staff for MAIs. There were six mediation incidents that led to an injury and over half of MAIs reached the resident and were determined by the investigator to require monitoring to confirm no harm or interventions to preclude harm. The medications involved were poorly documented with almost 30% of medication incidents being unknown. The medications involved in the six cases which the residents were harmed include opioids, insulin, antihistamine, anxiolytic, and in one case, unknown medications. Nursing staff and the dispensing pharmacy were the primary personnel involved in medication incidents. Medication order communication and inadequate medication administration processes, such as not reviewing the eMAR or medication prior to administration, signing off medications but not administering them, and issues with LOA medications, were the most commonly reported factors leading to MAIs. The residents who experienced multiple medication incidents or multiple MAIs were younger and

more likely to reside on non-secure units. Finally, while there were no delays in reporting more severe incidents and incident severity did not differ between AM and PM designated medication administration times, medication incidents coded with multiple error types were rated by investigators as being more severe.

Despite data that suggests high levels of uptake of eMAR and BCMA in LTCF in some American jurisdictions[24] and evaluations of potential MAIs in LTCF using a BCMA system in the United Kingdom,[44] there is a paucity of published reviews of medication incidents in LTCF using eMAR- BCMA. In contrast, the review of medication incident reports and eMAR-BCMA data within hospital environments has been studied extensively.[28, 29, 37, 45-47] Notably, several published papers exploring medication incidents using data from state wide web-based incident reporting system for nursing homes are available but they are limited in that the proportion of facilities that use eMAR-BCMA in these reports is unclear.[8, 22, 23, 48, 49] Even though medication incidents can occur at any stage of the medication use process, previous studies found that medication administration was involved in the majority of medication incidents.[8, 18, 22, 48-50] Missed medications, incorrect time, incorrect dose, documentation and dispensing errors were the most common error types described by nursing staff and found in earlier studies.[8, 18, 22, 23, 35, 50] While these studies are comparable to ours in that they rely on voluntarily reported data and evaluated medication-use phases and error types within LTCF, again the proportion using eMAR-BCMA is not reported. Using disguised observation and analysis of BCMA records within multiple LTCF, Szczepura et al. determined that incorrect time was the most common potential medication error type for MAIs.[44] eMAR shift audit was only documented twice as a medication error type by nursing staff. The eMAR shift audit report is generated after each

designated medication administration time to prevent missed medications; however, in our study missed medications were still documented in 46.3% of MAIs.

We determined that 47% of MAIs reported in our facility reached the resident and required monitoring or intervention by the nursing staff, which is considerably greater than that reported by others.[18, 23] We found a low incidence of medication incidents that led to resident harm (2.2%), whereas previous studies report up to 12.6%.[8, 22] For example, through a web-based medication incident reporting tool in North Carolina, Greene et al. found 11% of medication incidents were serious (as described as NCC MERP 4-9).[23] Additionally, Baril et al. determined that the number of medication accidents (as described as NCC MERP 4-9) decreased significantly after medication distribution technology (not eMAR or BMCA) was implemented in six Quebec nursing homes.[35]

Similar to our findings, high alert medications, such as opioids and insulin have been documented as common medications that cause serious resident harm in LTCF when administered in error.[18, 23, 49, 51] Additionally, antipsychotics have been reported to be associated with a high incidence of ADEs in LTCF.[49, 51] Hansen et al.[52] report a similar frequency of medication incidents causing resident harm based on the Beers Criteria medication list.[53]

Review of the narrative descriptions of medication incidents suggested that improper medication administration processes were a common factor leading to MAIs, the dispensing pharmacy played a significant role in the number of medication incidents, and the distribution of leave of absence (LOA) medications to a resident was also a common factor that led to medication

incidents in our study. When analyzing these factors, it is important to fully consider them in the context of the systems approach where issues such as the environment, working conditions, distractions, management decisions, and limitations in the drug distribution systems may result in the manifestation of these incidents.[54, 55] While many of the descriptions of reported factors that follow appear to focus on shortcomings on the part of individual providers, because of the retrospective nature of our study, we were not able to evaluate the causative factors in depth and differentiate those occurring as a result of flaws in the underlying system or as a result of behavioral choices.[56] For example, there were many instances where LPNs and HCAs were scanning and signing off a medication as administered; however, the medication was not actually given. Additionally, reports indicated that the LPNs were not reviewing the eMAR to confirm when the last as needed (PRN) dose was administered or the specific PRN directions, therefore preventing either an early dose or administering an incorrect order. In our study, there were also examples of MAIs where nursing staff administered medications prior to scanning the barcode, thus not confirming medication correctness or allowing the safety warning prompt to appear. Similar workarounds with eMAR-BCMA technology in LTCF have been reported by others.[16, 57] Communication issues within the LTCF and between the LTCF and the pharmacy contributed to MAIs, which has also been reported previously.[8, 44]

The dispensing pharmacy played a significant role in the number of medication incidents, where the majority were related to medication packaging errors, such as missing or extra medications, eMAR-BCMA operational issues and delivery problems. There were several medication incidents where the medication was delivered to the LTCF, but the pharmacy did not include or update specific barcodes or upload the medication orders into the eMAR, consequently

preventing the ability for the nursing staff to confirm correctness prior and during medication administration. Further evaluation of the pharmacy's operational challenges with eMAR-BCMA could also be an area of future research and no published data exists on this topic.

The distribution of leave of absence (LOA) medications to a resident was also a common factor that led to medication incidents in our study. Examples include providing an incorrect duration of medication, either too short or too long, residents incorrectly self-administering the medications when off site or non-routine medications being missed completely. LOAs are a period of transition for both the resident and nursing staff, and could be similar to a hospital discharge or a residents' transition into a LTCF where residents are at a greater risk of medication incidents.[22, 48]

Nursing staff and the dispensing pharmacy were reported to be the primary personnel involved in the reviewed medication incidents and this information can help focus quality improvement efforts aimed at preventing future medication incidents on the administration and dispensing phases of the medication use process. LPNs have been previously documented to be involved in 59% to 69% of medication incidents,[8, 18, 22, 23, 48] HCAs up to 12%[8, 18, 23] and the pharmacy/pharmacist up to 6% of incidents.[8, 18, 23, 48]

Post hoc, we explored medication incident and MAI frequency based on resident characteristics; as well as, resident harm based on medication incident report characteristics. Non-secure unit residents and younger residents were exposed to multiple medication incidents and MAIs more frequently. The impact of repeat medication incidents has been studied previously where older,

cognitively impaired residents were more at risk.[8] The reasons for this discrepancy are not clear, but the study by Crespin et al. may be more generalizable as it included medication incident report data from 294 LTCF, rather than a single site as in our study. We did not assess the severity of repeat medication incidents in this study; however, studies have shown that repeat medication incidents are more likely to cause resident harm versus non-repeat medication incidents[8, 48] Medication incidents with multiple error types (as defined by nursing staff) had a greater mean severity score and a higher proportion reached the resident. The medication incidents may have been more thoroughly documented as the medication incident reached the resident and required an assessment or intervention.

Lastly, while it is difficult to make comparisons to other studies, we expected that the frequency of MAIs may have been lower and the corresponding medication error types may be different than those reported in previous studies that did not include eMAR-BCMA. In theory, the prompts and safety alerts when the medication is scanned in error should warn nursing staff prior to administration to prevent incorrect time, incorrect dose and incorrect resident medication error types and the eMAR shift audit report should prevent missed medications. That being said, this specific eMAR-BCMA software, does not have a safety warning for PRN medications when they are administered early or too frequently. The LPN has to review the last documented administration time within the eMAR in addition to the directions to ensure appropriateness. Even though we did not assess the preventability of medication incidents as done in other studies,[21, 36, 44, 47, 58] it appeared that a significant proportion of medication incidents may have been prevented, especially if more established procedures for administration were in place, as illustrated by the failure to scan a medication prior to administration confirming the date and

time of each medication as indicated on the packaging or the number of LOA medication incidents. There are many factors that influence medication administration processes, including nursing staff workarounds with the eMAR-BCMA, which may be inhibiting the full optimization of this technology.

3.4.1 Strengths

Our study has two strengths. First, our methodology was robust as it was consistent with those employed by others reporting descriptive statistics and severity categorization of medication incident reports within LTCF and acute care settings. Second, few other studies have explored differences in resident and mediation incident report characteristics and NCC MERP severity classification.

3.4.2 Limitations

However, our study has several limitations. First, medication incidents are universally underreported by nursing staff in both LTCF and acute institutions.[59-63] Thus the collected data may not be reflective of the actual number of medication incidents that occurred during the study period. Second, the medication incident reports showed signs of poor/inadequate reporting for certain characteristics, particularly, the medication involved and injury/adverse reactions. Third, medication incidents that are electronically tracked within the eMAR-BCMA software were not collected. Review of a residents' eMAR, could facilitate determination of the true number of medication incidents including those that were administered outside of the 2-hour administration window (i.e. incorrect time) and resident refusals (i.e. missed medication), which were not found within the medication incident reports, or uncover new medication incidents that may not have been reported, such as missed medications or early/inappropriate PRN administrations. That being said, medication incidents detected by the eMAR-BCMA that were not documented, are most likely to be of low clinical significance and pose minimal safety risks to a resident.[47]

Fourth, we did not have access to the number of medications dispensed and administered and the exact number of residents living within the LTCF during the study period. This prevented us determining the medication incident rate. Fifth, we were unable to determine if medication incidents occurred during times of transition beyond LOAs, such as new admissions and hospital discharges, where residents are known to be at a greater incident risk.[22, 48] Sixth, previous studies included medication incident report data from multiple facilities or state-wide, while our study focused only on one LTCF which is likely not generalizable to other settings. Seventh, unlike other studies, the small number of incidents and limited patient demographic information precluded us from performing multivariate logistic regression to explore certain characteristics related to an increased likelihood of a medication incident or resident harm.[8, 22, 48] Eighth, we only used retrospective data within the medication incident reports and we did not conduct formal root cause analyses for reported medication incidents. Lastly, we cannot conclude that eMAR BCMA technology influences medication safety due to the lack of medication incident report data prior to eMAR-BCMA implementation.

3.5 Conclusion

This analysis of medication incident reports adds to our knowledge concerning medication incidents that occur despite implementation of eMAR-BCMA in a single LTCF. While it is difficult to compare across institutions and contexts, MAIs appeared to be reported with similar frequency rates when compared to other LTCF without eMAR-BCMA. However, the MAIs were mostly of low severity. We identified several opportunities to optimize the use of eMAR-BCMA and improve medication incident reporting at the participating facility. The majority of medication incidents were related to improper medication administration practices and dispensing errors and potential solutions should focus on how the eMAR supports medication

administration and processes around medication distribution and resident self-administration during leaves of absence. A prospective study to address the most common factors identified in both the LTCF and pharmacy would provide further understanding of optimal use of this technology. Future study of eMAR data relating to MAIs could further assist in characterizing un-reported and poorly reported medication incidents at the participating facility.

3.6 Glossary of Terms

High Alert Medications – drugs that bear a heightened risk of causing significant patient or resident harm when they are used in error.

Workaround – a method to overcome or bypass a problem or limitation in a program or system.

As needed – the medication is requested according to need by the resident or patient (i.e. PRN as written in prescriptions)

Figure 3.1. Number of medication incidents and medication administration incidents reported over a 29-month period.

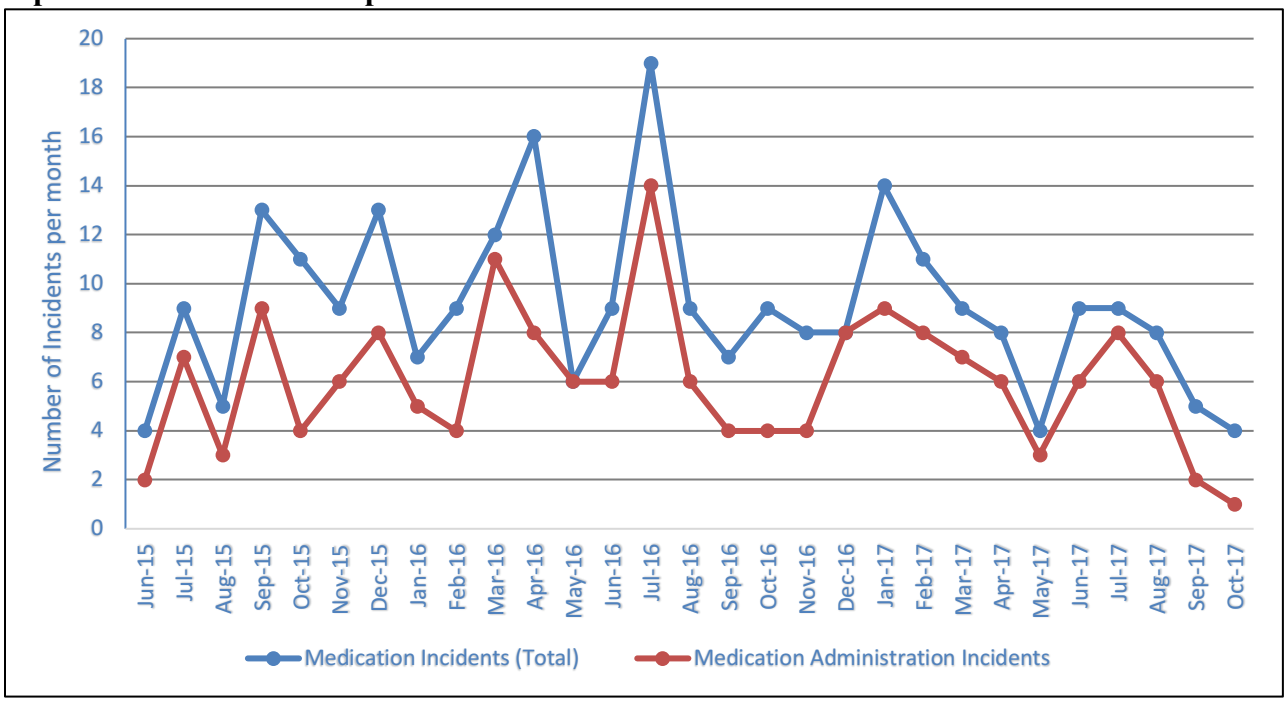

Table 3.1. Resident Characteristics

	Number of Residents with Medication Incidents	**Number of Residents with Medication Administration Incidents**
Resident Characteristics	**Number (%)**	**Number (%)**
Total number of residents	154 (100.0%)	114 (74.0%)
Age at time of first reported Medication Incident [years]	69.18 ± 16.91	68.88 ±17.15
Gender		
Female	97 (63.0%)	70 (61.4%)
Male	57 (37.0%)	44 (38.6%)
Location of first reported Medication Incident		
Non-Secure Units [a]	106 (68.8%)	78 (68.4%)
Secure Units[b]	48 (31.2%)	36 (31.6%)
Age of resident at first reported Medication Incident [years]		
Non-Secure Units[a]	61.76 ± 14.67	61.42 ± 14.62
Secure Units[b]	85.02 ± 9.02	85.03 ± 9.34
p-value	***P*<.001**	***P*<.001**
Date of residents' first reported Medication Incident		
June 2015 – September 2015	26 (16.9%)	22 (19.3%)
October 2015 – January 2016	27 (17.5%)	17 (14.9%)
February 2016 – May 2016	26 (16.9%)	22 (19.3%)
June 2016 – September 2016	27 (17.5%)	19 (16.7%)
October 2016 – January 2017	22 (14.3%)	16 (14.0%)
February 2017 – May 2017	15 (9.7%)	12 (10.5%)
June 2017 – October 2017	11 (7.1%)	6 (5.3%)
Mean number of residents involved in a Medication Incident per month		
Non-Secure Units[a]	6.52 ± 2.43	4.24 ± 1.96
Secure Units[b]	1.93 ± 1.44	1.41 ± 1.40
Mean proportion of residents involved in a Medication Incident per month (based on LTCF unit resident capacity)		
Non-Secure Units[a]	4.49% ± 1.68	2.93% ± 1.35
Secure Units[b]	2.05% ± 1.53	1.50% ± 1.49
p-value	***P*<.001**	***P*<.001**
Number of residents with repeat Mediation Incidents		
6 Medication Incidents	2	2
5 Medication Incidents	4	4
4 Medication Incidents	4	4
3 Medication Incidents	16	15
2 Medication Incidents	40	31
1 Medication Incident	88	58

[a] Non-secure unit capacity (n=145)
[b] Secure unit capacity (n=94)

Table 3.2. Medication Incident Characteristics

	Number of Medication Incidents	**Number of Medication Administration Incidents**
Medication Incident Report Characteristics	**Number (%)**	**Number (%)**
Total number of Medication Incidents	264 (100.0%)	175 (66.3%)
Location of Medication Incidents		
Non-Secure Units[a]	207 (78.4%)	134 (76.6%)
Secure Units[b]	57 (21.6%)	41 (23.4%)
Date of Medication Incidents		
June 2015 – September 2015	31 (11.7%)	21 (12.0%)
October 2015 – January 2016	40 (15.2%)	23 (13.1%)
February 2016 – May 2016	43 (16.3%)	29 (16.6%)
June 2016 – September 2016	44 (16.7%)	30 (17.1%)
October 2016 – January 2017	39 (14.8%)	25 (14.3%)
February 2017 – May 2017	32 (12.1%)	24 (13.7%)
June 2017 – October 2017	35 (13.3%)	23 (13.1%)
Mean number of Medication Incidents per month		
LTCF	9.10 (+/-3.54)	6.03 (+/-2.83)
Mean number of Medication Incidents per month by LTCF unit		
Non-Secure Units[a]	7.14 (+/-2.96)	4.62 (+/-2.29)
Secure Units[b]	1.97 (+/-1.50)	1.41 (+/-1.40)
p-value	***P*<.001**	***P*<.001**
Shift of Medication Incidents		
Shift 1 (0700-1500)	132 (50.0%)	80 (45.7%)
Shift 2 (1500-2300)	120 (45.5%)	85 (48.6%)
Shift 3 (2300-0700)	12 (4.5%)	10 (5.7%)
Mean number of Medication Incidents per month by shift		
Shift 1 (0700-1500)	4.55 (+/-2.37)	2.76 (+/-1.68)
Shift 2 (1500-2300)	4.14 (+/-2.30)	2.93 (+/-2.10)
Shift 3 (2300-0700)	0.41 (+/-0.63)	0.34 (+/-0.55)
p-value (Shift 1 vs. Shift 2)	***P* =.50**	***P*=.47**
p-value (Shift 1 vs. Shift 3)	***P*<.001**	***P*<.001**
p-value (Shift 2 vs. Shift 3)	***P*<.001**	***P*<.001**
Medication-use phases		
Prescription	4 (1.5%)	-
Transcription	2 (0.8%)	-
Dispensing	59 (22.3%)	-
Dispensing & Documentation/Communication	1 (0.4%)	-
Administration	153 (58.0%)	153 (87.4%)
Administration & Prescription	1 (0.4%)	1 (0.6%)
Administration & Dispensing	7 (2.7%)	7 (4.0%
Administration & Documentation/Communication	13 (4.9%)	13 (7.4%)

Administration, Dispensing & Documentation/Communication	1 (0.4%)	1 (0.6%)
Monitoring	1 (0.4%)	-
Documentation/Communication	22 (8.3%)	-
Number of medication-use phases within Medication Incidents		
One Medication-use phase	241 (91.3%)	153 (87.4%)
Two Medication-use phases	22 (8.3%)	21 (11.9%)
Three Medication-use phases	1 (0.4%)	1 (0.6%)
Medication Error Types within Medication Incidents (as documented by nursing staff)		
Incorrect Resident	2 (0.8%)	2 (1.1%)
Incorrect Medication	7 (2.7%)	7 (4.0%)
Incorrect Time	32 (12.1%)	31 (17.6%)
Missed Medication	69 (26.1%)	65 (36.9%)
Incorrect Dose	12 (4.5%)	11 (6.3%)
Incorrect Route	1 (0.4%)	1 (0.6%)
Expired Medication	1 (0.4%)	1 (0.6%)
Pharmacy Dispensing Error	51 (19.3%)	2 (1.1%)
Documentation Error	21 (8.0%)	9 (5.1%)
eMAR Shift Audit	-	-
Other (*this was not further defined)	21 (8.0%)	7 (4.0%)
Missed Medication & Documentation Error	11 (4.2%)	11 (6.3%)
Missed Medication & Pharmacy Dispensing Error	4 (1.5%)	3 (1.7%)
Missed Medication & Other	1 (0.4%)	1 (0.6%)
Incorrect Medication & Resident	4 (1.5%)	4 (2.3%)
Incorrect Medication & Pharmacy Dispensing Error	1 (0.4%)	-
Incorrect Dose & Resident	1 (0.4%)	1 (0.6%)
Incorrect Dose & Documentation Error	2 (0.8%)	2 (1.1%)
Incorrect Dose & Pharmacy Dispensing Error	2 (0.8%)	2 (1.1%)
Incorrect Time & Pharmacy Dispensing Error	1 (0.4%)	-
Incorrect Time & Documentation Error	1 (0.4%)	1 (0.6%)
Incorrect Time & Medication	3 (1.1%)	3 (1.7%)
Documentation Error & eMAR Shift Audit	6 (2.3%)	2 (1.1%)
Documentation Error & Pharmacy Dispensing Error	1 (0.4%)	1 (0.6%)
Other & Pharmacy Dispensing Error Dispensing Error	1 (0.4%)	1 (0.6%)
Incorrect Time, Medication & Dose	5 (1.9%)	5 (2.8%)
Missed Medication & Incorrect Time & Medication	1 (0.4%)	1 (0.6%)
Incorrect Dose, Resident, & Medication	1 (0.4%)	1 (0.6%)
Incorrect Time & Dose & Pharmacy Dispensing Error	1 (0.4%)	-
Number of medication error types within Medication Incidents		
One Medication Error Type	217 (82.2%)	136 (77.7%)

Two Medication Error Types	39 (14.8%)	32 (18.2%)
Three Medication Error Types	8 (3.0%)	7 (4.0%)
Time to error report		
Less than 24 hours	215 (81.4%)	140 (80.0%)
Greater than 24 hours	49 (18.6%)	35 (20.0%)
Medication Incident severity (Nursing Staff)		
ADE – No	239 (90.5%)	156 (89.1%)
ADE – Yes	6 (2.3%)	5 (2.9%)
ADE – Unknown	19 (7.2%)	14 (8.0%)
Medication Incident severity (Investigators)		
NCC MERP 1-4: No Harm	258 (97.7%)	170 (97.1%)
NCC MERP 5-9: Harm	6 (2.3%)	5 (2.9%)
Medication Incident severity (NCC MERP Classification)		
1 – Circumstances or events that have the capacity to cause error	55 (20.8%)	23 (13.1%)
2 – An error occurred but the error did not reach the resident	49 (18.6%)	7 (4.0%)
3 – An error occurred that reached the resident but did not cause resident harm	71 (26.9%)	62 (35.4%)
4 – An error occurred that reached the resident and required monitoring to confirm that it resulted in no harm to the resident and/or required intervention to preclude harm.	83 (31.4%)	78 (44.6%)
5 – An error occurred that may have contributed to or resulted in temporary harm to the resident and required intervention	3 (1.1%)	2 (1.1%)
6 – An error occurred that may have contributed to or resulted in temporary harm to the resident and required initial or prolonged hospitalization	3 (1.1%)	3 (1.7%)
7 – An error occurred that may have contributed to or resulted in permanent resident harm	-	-
8 – An error occurred that required intervention necessary to sustain life	-	-
9 – An error occurred that may have contributed to or resulted in the residents' death	-	-
Medications involved in Medication Incidents		
ISMP High Alert Medications		
Opioids	25 (9.5%)	14 (8.0%)
Anticoagulant	11 (4.2%)	8 (4.6%)
Hypoglycemics	7 (2.7%)	6 (3.4%)
Insulin Preparations	5 (1.9%)	3 (1.7%)
Non-ISMP Medications		
Analgesic	15 (5.7%)	12 (6.9%)
Antidepressant	13 (4.9%)	10 (5.7%)

Antiepileptic	7 (2.7%)	4 (2.3%)
Anti-infective	20 (7.6%)	15 (8.6%)
Antipsychotic	24 (9.1%)	18 (10.3%)
Anxiolytic	20 (7.6%)	13 (7.4%)
Hypertension	6 (2.3%)	6 (3.4%)
Hypnotic and Sedative	5 (1.9%)	3 (1.7%)
Vitamin/Mineral/Supplement	17 (6.4%)	11 6.3%)
Unknown	76 (28.8%)	46 (26.3%)
Antihistamine	1 (0.4%)	1 (0.6%)
Miscellaneous	45 (17.0%)	33 (18.9%)
Number of medications involved in Medication Incidents		
One Medication	165 (62.5%)	109 (62.3%)
Two Medications	18 (6.8%)	16 (9.1%)
Three Medications	4 (1.5%)	4 (2.3%)
Four Medications	-	-
Five Medications	1 (0.4%)	1 (0.6%)
Unknown	76 (17.0%)	45 (25.7%)
Primary contributing influences in Medication Incidents		
Nursing Staff	168 (63.6%)	148 (84.6%)
Pharmacy	65 (24.6%)	1 (0.6%)
eMAR-BCMA	2 (0.8%)	2 (1.1%)
Prescriber	2 (0.8%)	-
Resident	15 (5.7%)	13 (7.4%)
Nursing Staff and Pharmacy	9 (3.0%)	8 (4.6%)
Nursing Staff and eMAR-BCMA	1 (0.4%)	1 (0.6%)
Nursing Staff and Prescriber	1 (0.4%)	1 (0.6%)
Nursing Staff, Pharmacy and eMAR-BCMA	1 (0.4%)	1 (0.6%)
Number of primary contributing influences in Medication Incidents		
One	252 (95.5%)	164 (93.7%)
Two	11 (4.2%)	10 (5.7%)
Three	1 (0.4%)	1 (0.6%)
Team Leader/Resident Care Manager follow-up to Medication Incident		
Education to Staff	102 (38.6%)	91 (52.0%)
Education to HCA	9 (3.4%)	8 (4.5%)
Education to HCAs	1 (0.4%)	1 (0.6%)
Education to LPN	29 (11.0%)	22 (12.6%)
Education to LPN and Physician	2 (0.8%)	1 (0.6%)
Education to Staff and Pharmacy Notified	5 (1.9%)	5 (2.9%)
Education to Resident	6 (2.3%)	5 (2.9%)
Pharmacy informed/notified	80 (30.3%)	17 (9.7%)
Pharmacy and LPN Informed	1 (0.4%)	1 (0.6%)
Pharmacy informed to update directions	1 (0.4%)	-
Pharmacy Error	1 (0.4%)	-
Moved medications from HCA to LPN cart	1 (0.4%)	1 (0.6%)
Moved medications to LPN cart	2 (0.8%)	2 (1.1%)

LPN to monitor Room frequently	1 (0.4%)	1 (0.6%)
Regular Room Checks	1 (0.4%)	1 (0.6%)
Reviewed with Family and LPN	1 (0.4%)	1 (0.6%)
Education to Family to not provide medications to resident	1 (0.4%)	1 (0.6%)
Discussion with Family	1 (0.4%)	1 (0.6%)
Update Residents file to only give pass meds to family	1 (0.4%)	1 (0.6%)
Unknown	18 (6.8%)	15 (8.6%)

[a] Non-secure unit capacity (n=145)
[b] Secure unit capacity (n=94)

Table 3.3. Factors Involved in Medication Administration Incidents and Dispensing Errors

Factors Involved in a Medication Administration Incidents	n=175
Categories and Sub-categories	Number (%)
Medication Administration Processes with eMAR-BCMA	
Not reviewing eMAR and/or medication prior to administration	28 (16.0%)
Medications signed off, but not administered	20 (11.4%)
Issue with LOA medications	20 (11.4%)
Medications administered, but not signed off (refusals not signed off)	14 (8.0%)
Administered next interval medication dose in error	13 (7.4%)
Medication not administered, not signed off as administered on eMAR	1 (0.6%)
Medication Packaging	
Incidents involving non-pouch medication packaging	8 (4.6%)
Packaging/Dispensing issue	3 (1.7%)
Environmental Issues and Internal/External Factors	
Distracted During Medication Administration	9 (5.4%)
Medication Supply or Storage Issues	10 (5.7%)
Resident Self Administration Issues and Medication Refusals	6 (3.4%)
Warfarin Issue or Restricted Medication Issue	7 (4.0%)
Communication	
Manual Documentation on the eMAR	10 (5.7%)
Issues with order communication within facility or between facility and pharmacy	23 (13.1%)
Other and Not Available	
Other and Not Available	3 (1.7%)
Factors Involved in Dispensing Errors	n=67
Categories and Sub-categories	Number (%)
Pharmacy Packaging and Delivery	
Medication Packaging Error	34 (50.8%)
Delivery Error	7 (10.4%)
Errors in eMAR-BMCA Barcodes	7 (10.4%)
Other and Unknown	
MIR already defined	8 (11.9%)
Other and Unknown	11 (16.4%)

Table 3.4. Characteristics of Residents by Number of Reported Medication Incidents and Number of Medication Administration Phase Incidents

	Medication Incidents			**Medication Administration-use Phase Incidents (MAI)**				**p-value 0.017 (Bonferroni Correction)**		
	One Medication Incident (n=88 residents) (88 MIRs)	Multiple Medication Incidents (n=66 residents) (176 MIRs)		No MAI (n=40 residents)	One MAI (n=77 residents)	Multiple MAIs (n=37 residents)	p values (no vs. one vs. multiple)	p value (no MAI vs. one MAI)	p value (no MAI vs. multiple MAIs)	p value (one MAI vs. multiple MAIs)
Age [years]	74.6 +/- 17.4	61.6 +/- 13.3	***P*<.001**	69.4 +/- 16.8	73.3 +/- 16.2	59.9 +/- 15.8	***P*<.001**	***P*=.24**	***P*=.013**	***P*<.001**
Gender	***RR (CI)***	**0.80 (0.56 to 1.15)**	***P* =0.23**				***P*=.048**	**1.02 (0.77-1.36)**	**0.64 (0.40-1.01)**	**0.53 (0.32-0.90)**
Female	59 (60.2%)	38 (39.8%)	97 (100%)	27 (27.8%)	53 (54.6%)	17 (17.5%)	97 (100%)	***P*=.88**	***P*=.056**	***P*=.019**
Male	29 (50.9%)	28 (49.1%)	57 (100%)	13 (22.8%)	24 (42.1%)	20 (35.1%)	57 (100%)			
	88 (57.1%)	66 (42.9%)	154 (100%)	40 (26.0%)	77 (50.0%)	37 (24.0%)	154 (100%)			
Unit	***RR (CI)***	**3.81 (1.89 to 7.73)**	***P*<.001**				***P*=.013***	**0.86 (0.67-1.12)**	**1.81 (0.84-3.93)**	**2.95 (1.26-6.95)**
Non-Secure	47 (44.3%	59 (55.7%)	106 (100%)	28 (26.4%)	46 (43.4%)	32 (30.2%)	106 (100%)	***P*=.32**	***P*=.10***	***P*=.005**
Secure	41 (85.4%)	7 (14.6%)	48 (100%)	12 (25.0%)	31 (64.6%)	5 (10.4%)	48 (100%)			
	88 (57.1%)	66 (42.9%)	154 (100%)	40 (26.0%)	77 (50%)	37 (24.0%)	154 (100%)			

ᴪp-value 0.017 (Bonferroni Correction) (p-value= 0.05/number of comparisons (i.e. 3) = 0.017)

*Fishers Exact Test

(Note: Age at time of first reported incident)

Table 3.5. Comparison of Severity of Medication Incidents (n=264)

	Mean Severity Score (SD)	Did Not Reach Resident (Categories 1-2) (n=104)	Reached Resident (Categories 3-9) (n=160)	p value
Medication error Type	***P*=.001**	**RR (CI)**	**1.33 (1.09 to 1.62)**	***P*=.02***
Multiple Error Types (n=46)	3.28±1.28	11 (23.9%)	35 (76.1%)	46 (100%)
One Error Type (n=218)	2.66± 1.15	93 (42.7%)	125 (57.3%)	218 (100%)
		104 (39.4%)	160 (60.6%)	264 (100%)
Medication Use Phase	***P*=.33**	**RR (CI)**	**1.25 (0.96 to 1.62)**	***P*=.19***
>1 Medication use phase involved (n=23)	3.00± 1.28	6 (26.1%)	17 (73.9%)	23 (100%)
One Medication use phase involved (n=241)	2.75±1.19	98 (40.7%)	143 (59.3%)	241 (100%
		104 (39.4%)	160 (60.6%)	264 (100%)
Time to error report	***P*=.77**	**RR (CI)**	**1.15 (0.92 to 1.45)**	***P*=.32***
Reported after 24 hours (n=47)	2.72± 1.10	15 (31.9%)	32 (68.1%)	47 (100%)
Reported within 24 hours (n=217)	2.78±1.22	89 (41.0%)	128 (59.0%)	217 (100%
		104 (39.4%)	160 (60.6%)	264 (100%)
Shifts	***P*=.19**			***P*=.46***
(1) 0700-1500 (n=132)	2.63±1.17	57 (43.2%)	75 (56.8%)	132 (100%)
(2) 1500-2300 (n=120)	2.91±1.22	43 (35.8%)	77 (64.2%)	120 (100%)
(3) 2300-0700 (n=12)	2.83±1.11	4 (33.3%)	8 (66.7%)	12 (100%)
		104 (39.4%)	160 (60.6%)	264 (100%)

***Fishers Exact Test**

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CHAPTER 4

GENERAL DISCUSSION AND CONCLUSIONS

4.1 General discussion

Medication incidents are common in long-term care facilities (LTCF) and while few contribute to permanent disability or death, a small but significant proportion lead to resident harm. Technology solutions have been proposed to improve medication safety in LTCF, with electronic medication administration records (eMAR) and barcode assisted medication administration (BCMA) being a main focus of adoption. However, the impacts of eMAR-BCMA on medication administration and medication administration incidents (MAIs) within LTCF have not been well defined. Within this thesis, different methodologies were used in two projects (a scoping review of the literature and a retrospective review of medication incident report data) to expand our understanding of eMAR-BCMA use within LTCF and how the technology influences medication administration and safety.

4.1.1 Electronic Medication Administration Records in Long-Term Care Facilities: A Scoping Review

The first study was a scoping literature review that aimed to map the extent, range, and nature of research on the effectiveness, level of use, and perceptions of eMAR and BCMA in LTCF. In addition, we identified gaps in current knowledge and prioritized areas for future research. Using methodologies developed by Arksey and O'Malley,[1] we summarized 34 studies, of which 17 were published in the peer-reviewed literature and 17 in the grey literature. The included studies fell into three main categories: medication and medication administration error (MAE) rates, benefits and challenges and eMAR prevalence/uptake. We found two descriptive case

reports in the grey literature that claimed a positive impact of eMAR on MAE rates after eMAR implementation; however, these reports provided weak evidence of benefit because of weaknesses in study design and reporting. Two additional prospective studies utilized BCMA reporting functions to determine the incidence of potential MAEs averted by BCMA, suggesting that MAEs, such as incorrect time, wrong resident or attempting to administer a discontinued medication, are prevented by the safety warnings/prompts of BCMA technology. Several studies reported nursing staff perceptions of eMAR which includes decreased medication errors or the elimination of errors, a lowered the risk of MAEs, lowered stress levels and positivity towards the medication administration process.

Twelve studies reported benefits of eMAR and BCMA, which included improved medication reconciliation and real-time access to resident information, while evidence of efficient medication administration was inconsistent. Improvement to safety and quality, mostly related to the warning prompts and alerts, resident photographs and mandatory documentation of administration, and quality improvement and compliance to organization and regulatory policies, such as documentation practices and ability to monitor drug use were reported. Seven studies reported challenges with eMAR and BCMA, such as unreliability of the internet or eMAR system, lack of training or IT support and nursing staff workarounds. Lastly, 12 studies evaluated the prevalence of eMAR and BCMA in LTCF. Depending on the timeframe and location, uptake in LTCF ranged from 18% to 49%, while pharmacy uptake was reported to be up to 23.3%.

Due to the lack of evidence-based reports on the impact of eMAR-BCMA on MAEs within LTCF, we can only compare our observations from the scoping review to hospital environments where several studies have demonstrated positive but inconsistent results on MAE rates. For example, in a 2010 systematic review evaluating barcode medication administration systems and MAE rate in acute care settings by Young et al., the authors concluded that eMAR-BCMA inconsistently decreased the overall incidence of MAEs.[2] A subsequent before-and-after quasi experimental study in an academic medical center implementing eMAR-BCMA published in 2010 by Poon et al., found the medication error rate in order transcription and medication administration; as well as, ADEs were substantially reduced post eMAR-BCMA implementation. However, they concluded that the system did not eliminate errors entirely.[3] Most recently, a survey and evaluation of MAEs before and after BCMA implementation in a Taiwanese medical center published by Lin et al., demonstrated a MAE rate decrease of 22.5%, from 405 MAIs at pre-implementation to 314 post-implementation ($p<0.001$).[4]

There are similarities in the benefits and challenges of eMAR-BCMA reported in the hospital and long-term care literature, such as immediate access to patient information[5] and positive nursing perceptions about patient safety;[6] as well as, nursing staff workarounds to the safety alerts of the eMAR-BCMA system[7] and the perception that medication administration was slower.[8]

In contrast to LTCF, it appears that eMAR and BCMA adoption is higher in acute care facilities where a 2014 U.S. national survey found that hospitals have an eMAR-BCMA adoption rate of 93%.[9]

The observations from our scoping review provide the most up to date summary of the literature on eMAR-BCMA in LTCFs, focusing on medication errors, benefits, challenges and eMAR-BCMA uptake. We noted a lack of rigorously designed studies to inform LTCF administrators and clinicians about the impact eMAR-BCMA has on MAEs and resident safety in LTCF. Even though LTCF have adopted eMAR-BCMA for medication administration without direct supporting evidence of an improvement to medication administration practices, reductions in medication incidents and increases to resident safety, we believe that there is sufficient opportunity to further investigate standalone eMAR-BCMA systems and the influence on medication management and LTCF resident safety.

4.1.2 Evaluation of Medication Incidents in a Long-Term Care Facility Utilizing Electronic Medication Administration Records and Barcode Technology

The second study of this thesis was a retrospective review of medication incidents reports submitted voluntarily by nursing staff within a 239-bed LTCF that has been utilizing eMAR-BCMA since 2013. The aim of the study was to characterize the frequency, type and severity (i.e. resident harm) of reported medication incidents and medication administration incidents (MAI). Ideally, we wanted to compare medication incidents before and after eMAR-BCMA implementation, but because the medication incident reports prior to implementation were no longer available at the LTCF, we focused on post-implementation medication incidents only. Furthermore, we determined if medication incidents were more commonly reported on secure units (where residents with moderate to severe dementia who may have a high risk of wandering and unpredictable behaviors reside), or non-secure units, investigated characteristics of residents

that experienced multiple medication incidents, and explored factors that influence medication incident severity.

An average of nine medication incidents were reported each month at the study LTCF, with the majority coming from the three non-secure units. Medication administration, dispensing, and communication/documentation were the most common medication use-phases involved in medication incidents. Missed medications and incorrect time were the most frequently reported medication error types for MAIs. Six mediation incidents led to resident harm and over half of MAIs reached the resident. Close to 30% of medication incidents reports did not have a documented medication involved, while, opioids, insulin, antihistamine, and anxiolytic medications were involved in medication incidents where residents were harmed. Inadequate medication administration processes with eMAR-BCMA and medication order communication issues were the most common factors reported to lead to MAIs. Younger residents and those residing on the non-secure units were more likely to experience multiple medication incidents or multiple MAIs. The residents experiencing multiple events were approximately 13 years younger than those experiencing one event (i.e., 61.6±13.3 vs. 74.6±17.4, *p<.001 for medication incidents* and 59.9±15.8 vs. 73.3±16.2 *p<.001 for MAIs*). Those residing on the non-secure units were almost four times more likely to experience multiple medication incidents (55.7% vs. 14.6%, RR: 3.81; 95% CI: 1.89, 7.73; *p<.001*). Medication incidents coded with multiple error types were rated by investigators as being more severe. Based on our findings, we determined that several influential factors lead to MAIs despite the presence of an eMAR-BCMA. These factors prevent an eMAR-BCMA from entirely mitigating the risk of medication incidents and associated harm within LTCF.

Comparisons with other published data are difficult as there is limited information exploring eMAR-BCMA in LTCF in Canada.[10] Even though American data from specific states suggests high levels of uptake of eMAR-BCMA in LTCF in some areas, there is limited published evaluation data in LTCF that utilize eMAR-BCMA. This is in contrast to the body of literature of medication incident report data and direct observations of medication administration available from hospital environments[2, 4, 11-14] or from LTCF that do not use eMAR-BCMA.[15-19] Our study findings are consistent with a 2017 systematic review of the prevalence of medication incidents in LTCF residents by Ferrah et al.[15] This review did not include studies that used eMAR-BCMA. Studies within this review were primarily based on medication incident report data, and the authors found that the majority of medication incidents occurred in the medication administration and communication phases (20%-53%). Additionally, missed medications and wrong dose error types were most commonly associated with MAIs. Opioids, anticoagulants, and antidiabetics were a few of the most common medications involved in medication incidents. Similarly, opioids and insulin had a greater risk of causing serious adverse drug events (ADE) or harm.

In contrast to our study, Ferrah et al. found that older age and cognitive impairment were associated with greater risk of repeat medication incidents. This discrepancy may be explained by the fact that we included only a single LTCF, while Ferrah et al. reviewed multiple sites and included statewide data from North Carolina. Ultimately, our study site may not be reflective of a typical LTCF and generalizability to other settings may be limited. Ferrah et al., concluded that human error and nursing staff distractions accounted for a significant number of medications

incidents within their systematic review. We found evidence of these within our study as well, although in situations where staff were reportedly not following proper medication administration processes or employing workarounds to eMAR-BCMA technology we were not able to conclusively differentiate if this was a result of flaws in the underlying medication use process or as a result of behavioral choices by individual providers. Similar to Ferrah et al., we suggest that the narrative descriptions we reviewed may indicate a lack of recognition of the role of systemic or latent factors by those reporting the medication incident. Two studies within the systematic review address that during periods of LTCF resident transition (i.e. new admissions or hospital discharges) missed medications and incorrect doses were reported,[20, 21] which is comparable to the transitions that we found within our study for LTCF residents leaving or returning from a leave of absence. While medication incidents were almost twice as likely to be repeated within seven days of a transition as reported by Crespin et al.,[22] our study only evaluated resident characteristics (i.e. age, gender and unit) that could impact repeat medication incident and MAIs. We were unable to find comparative data on the impact of medication incident severity based on specific medication incident report characteristics.

Overall, while it is difficult to compare incident rates across LTCF or institutions, we noted several similarities in reported medication incidents at our study site in comparison to LTCF that do not utilize eMAR-BCMA. Unfortunately, our method is not robust enough to determine if the eMAR-BCMA implementation affected medication incident rate at our study LTCF. However, it is clear that the use of eMAR-BCMA has not entirely eliminated medication incidents including those associated with harm. Our study provides further understanding of the ongoing

medication safety issues that occur despite the ongoing use of an eMAR-BCMA in a large LTCF.

4.2 Implications and Future Directions

4.2.1 for clinical practice:

Our work has several potential implications on improving the medication safety in practice at the participating site as well as other similar facilities where voluntary paper-based medication incident reporting is the norm. First, the use of paper-based medication incident report forms that lack critical data elements such as medication involved and contributing factors found in modern online medication incident reporting forms such as those from the Canadian Medication Incident Reporting System, may not facilitate optimal documentation of a medication incident and limits their ability to be used for quality improvement purposes. Literature suggests that medication incidents are under-reported for many reasons[23-29] and medication incident reports tend to be incomplete.[30] Almost 30% of the medication incidents reports reviewed in our second study did not specify which medications were involved.

There are two potential strategies to improve the quality of submitted medication incident reports; implementing electronic medication incident reporting or revising existing paper-based processes to ensure they are consistent with reporting best practices. Electronic medication incident reporting is used in many jurisdictions and may represent a strategy for a large coordinated approach to improving medication safety. For example, the Medication Error Quality Initiative (MEQI) in North Carolina USA, could be used as an example where all nursing homes licensed by the state were required by law to report all medication incidents and potential medication incidents through web-based reporting.[31] The purpose was for each nursing home to

oversee each medication incident and evaluate their cause to reduce subsequent error and enhance resident safety and the pooled data from this initiative resulted in several academic publications. [21, 22, 32, 33] In a benefits evaluation study of an electronic clinical safety reporting system in Newfoundland and Labrador by Elliot et al., electronic reporting contributed to improved clinical safety and was preferred over the paper-based incident reporting system.[34] Electronic incident reporting is recommended by ISMP Canada and the Canadian Society of Hospital Pharmacists (CSHP) to improve the ability to analyze medication incident data, and to facilitate the development of recommendations on how to adapt and update processes and practices that may impact patient safety.[35, 36] On a national level, Canadian healthcare facilities can participate in anonymous electronic incident reporting through the National System for Incident Reporting (NSIR)[37] where data is used to inform quality improvement activities to foster improvements in healthcare delivery.

Notably, the eMAR/BCMA system in place within the study facility does have medication incident reporting functionality and while it is not currently used, it represents a potentially feasible way to move toward electronic reporting at the study LTCF. If electronic reporting is not feasible, we recommend that the facility implement an updated paper-medication incident report template with associated reporting processes as promoted by the Canadian Patient Safety Institute[38] and ISMP Canada.[39]

We noted several factors that contributed to reported medication incidents and we suggest focusing on the root causes of these common incidents. There are opportunities to reduce the number MAIs associated with the improper use of the eMAR-BCMA system. This would

include addressing inappropriate medication administration processes (such as nursing staff not checking the medication or the eMAR prior to administration) and the incorrect distribution of LOA medications. Nursing staff workarounds to eMAR-BCMA are also noted as a factor that can lead to MAIs; however, workarounds are multifaceted and could be related to the culture of the LTCF, the individual nursing staff member, the medication administration processes or the technology itself for example. Ultimately, workarounds occur to overcome or bypass a problem or process. Actively engaging nursing staff in prospectively evaluating and addressing identified suboptimal practices, problems and processes could be an area of prioritization in tackling medication safety issues at the study facility. In addition, communication between nursing staff and the communication of new medication orders between the LTCF and the dispensing pharmacy were also recognized as influential factors that led to MAIs and medication incidents. Empowering nursing staff and the dispensing pharmacy to re-evaluate current communication practices could assist in establishing new policies and procedures to address this issue. These engagement activities could be tied to an evaluation around the culture of safety at both the facility and dispensing pharmacy which would further inform optimal ways to address the identified process and communication issues. The Nursing Home and Community Pharmacy versions of the Survey on Patient Safety (SOPS) from the Agency for Healthcare Research and Quality could be used for this purpose.[40, 41]

While the participating LTCF has processes in place to address medication incidents as they occur, we hope that our scoping review and the summary data from our formal evaluation will lead to greater awareness of the literature around eMAR-BCMA use and common medication incidents, and lead to further opportunities to adapt and improve medication administration

processes at the participating site. Hopefully, in turn this will ultimately improve medication safety for all those residing at the facility.

4.2.2 for research

Our two studies identified opportunities to further understand the impact of eMAR-BCMA on medication administration practices in LTCF. Our scoping review determined that there was very limited published research on the use of eMAR-BCMA in LTCF. There remains opportunity for a rigorously designed before and after implementation study to directly evaluate the impact of eMAR-BCMA on MAIs in LTCF, similar to those conducted in hospital environments. In this regard, formal partnerships between LTCF and community pharmacies who want to implement eMAR-BCMA with academics who have expertise in technology implementation could partner to allow a more robust evaluation of eMAR-BCMA. Additionally, family members of LTCF residents or residents themselves should be engaged as partners in research teams and help in governance, priority setting, and development of further research questions to ensure relevance of the research output.

Future research should also explore medication safety in LTCF using data sources beyond medication incident reports. Other methodologies, such as manual chart reviews,[30] direct observation[42] or utilizing data generated by reporting functions within some BCMA systems[43, 44] can provide further understanding of medication incidents within LTCF.

Further exploration of medication safety with eMAR-BCMA in LTCF from a community pharmacy perspective should occur. The dispensing pharmacy is a vital component of medication management and was involved in a significant number of medication incidents within

our study from failing to include necessary operational requirements such as medication barcodes, or updating new medication orders within the eMAR. Relatively little is known about the impact of eMAR-BCMA from a pharmacy workflow and pharmacist perspective. Our scoping review included two cross-sectional survey studies of LTCF pharmacy providers on the uptake of eMAR-BCMA, one study that completed in-depth interviews to determine the perceptions of eMAR-BCMA by two pharmacists and one study that used a semi-structured interview to determine one pharmacists' experience with eMAR. The perception of hospital pharmacists towards eMAR-BCMA has been studied previously, where the ease of eMAR-BCMA use was low and it was not useful for improving either personal job performance or patient care.[45] We suggest exploring ways to optimize communication between the LTCF and pharmacy, as nurses and pharmacists are not co-located like they are in hospital settings. The majority of communication between the LTCF and dispensing pharmacy is through phone and fax. However, the eMAR-BCMA system utilized within the study LTCF consists of a one-way communication function, similar to direct messaging, where nursing staff can request real-time medication refills or updates to a resident profile to the dispensing pharmacy. Two-way electronic communication may improve efficiency; as well as, provide a secure method to track and document communications.

Lastly, access to grants or subsidies promoting standardized, large-scale (e.g., province wide) incident reporting systems in LTCF, similar to the MEQI in North Carolina, could be a focus for building capacity to study the impact of safety and quality improvement initiatives in long-term care.

4.2.3 for policy

LTCF in Alberta that are supported by Alberta Health Services (AHS) have to adopt and adhere to established policies and procedures (as a minimum standard) for medication administration to ensure consistency and awareness of safe medication administration practices.[46] Even though eMAR-BCMA is being utilized within Alberta LTCF, the AHS medication administration policy, which was updated in September 2018, makes no reference to the use of eMAR or eMAR-BCMA systems for medication administration. As the provincial leader in establishing and approving safe and appropriate clinical practices, AHS has not addressed or provided direction for the use of eMAR-BCMA to LTCF, leaving individual LTCF or organizations to establish such protocols and procedures on their own. As evidence regarding eMAR-BCMA systems in LTCF emerges, the gap in medication administration policy should be addressed to support the introduction of new health information technologies in LTCF by establishing appropriate guidelines and procedures that will uphold nursing staff and LTCF resident safety.

4.3 Conclusion

This thesis examined the use of eMAR-BCMA in supporting medication administration practices in LTCF. The findings from our two studies, a scoping review and a retrospective audit of medication incident reports, identified limited direct evidence linking eMAR-BCMA use and reduction in medication incidents and MAIs and suggests that more rigorous, prospective research in LTCF and community pharmacies is required to demonstrate the impact of stand-alone eMAR-BCMA systems on medication safety. It also highlights that opportunities remain to optimize use of eMAR-BCMA and improve medication incident reporting in the LTCF setting.

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Appendices

Appendix 2.1. Search Strategy

Pubmed eMAR Search Strategy (((((((((long-term care/ OR nursing care/ OR home nursing/ OR respite care/)) OR (residential facilities/ OR assisted living facilities/ OR group homes/ OR halfway houses/ OR homes for the aged/ OR nursing homes/ OR intermediate care facilities/ OR skilled nursing facilities/)) OR Housing for the Elderly/) OR ((nursing home* OR extended care* OR care home*) AND .mp.)) OR (((senior* OR continuing care OR disabled OR old age OR geriatric* OR elder care* OR rehabilitat* OR long term care) AND adj2 AND (lodge* OR facility* OR home* OR residence* OR centre* OR center*)) AND .mp.)) OR supportive living.mp.) OR ((assisted living OR residential facilit* OR group home*) AND .mp.))) AND (((((((Medication Management Information Technology.mp.) OR Bar-Code* AND Medication Administration.mp.) OR BarCode* AND Medication Administration.mp.) OR electronic medication administration.mp.) OR electronic treatment administration.mp.)) AND ((((Medication Therapy Management/) OR ((medication administration OR medication management OR medication therapy management OR drug therapy management OR medication reconciliation*) AND .mp.))) AND ((((((exp medical informatics/ OR nursing informatics/)) OR systems integration/) OR (automatic data processing/ OR computer systems/ OR computer communication networks/)) OR Electronic Health Records/) OR ((health information technolog* OR barcode* OR computer system* OR electronic health record* OR electronic medical record*) AND .mp.))))
CINAHL eMAR Search Strategy 1.) (MH "Medical Informatics") OR (MH "Nursing Informatics") OR (MH "Systems Integration") OR (MH "Computer Systems+") OR (MH "Computer Communication Networks+") OR (MH "Computerized Patient Record") OR ("health information technolog*" or barcode* or "computer system*" or "electronic health record*" or "electronic medical record*") 2.) "medication administration" or "medication management" or "medication therapy management" or "drug therapy management" or "medication reconciliation*" 3.) 1 and 2 4.) (MH "Long Term Care") OR (MH "Nursing Care+") OR (MH "Home Nursing") OR (MH "Respite Care") OR (MH "Residential Facilities+") OR (MH "Assisted Living") OR (MH "Halfway Houses") OR (MH "Housing for the Elderly") OR (MH "Nursing Homes+") OR (MH "Skilled Nursing Facilities") OR ("nursing home*" or "extended care*" or "care home*" OR "supportive living" OR "assisted living" or "residential facilit*" or "group home*") OR ((senior* or "continuing care" or disabled or "old age" or geriatric* or "elder care*" or rehabilitat* or "long term care") N2 (lodge* or facility* or home* or residence* or centre* or center*)) 5.) 3 and 4

Cochrane Library search:
"medication administration" or "medication therapy" or "medication reconciliation" or "medication management":ti,ab,kw
and
electronic or computer* or technolog*:ti,ab,kw
and
"long term care" or "nursing homes" or "assisted living" or "supportive living":ti,ab,kw

SCOPUS eMAR Search Strategy
(medication management information technology) OR (barode* medication administratio n) OR (barcode* medication administration) OR (electronic medication administration) OR (electronic treatment administration) OR (medical informatics OR nursing infor matics) OR (systems integration) OR (automatic data processing OR computer system s OR computer communication networks) OR (electronic health records) OR (health information technolog* OR barcode* OR computer system* OR electronic health record * OR electronic medical record*)

AND

(medication therapy management) OR (medication administration OR medication mana gement OR medication therapy management
OR drug therapy management OR medication reconciliation*)

AND
(longterm care OR nursing care OR home nursing OR respite care) OR (residential fa cilities OR assisted living facilities OR grouphomes OR halfway houses OR homes for the aged OR nursing homes OR intermediate care facilities OR skilled nursing facilitie s) OR (housing for the elderly) OR (nursing home* OR extended care* OR care ho me*) OR ((senior* OR continuing care OR disabled OR old age OR geriatric* OR e lder care* OR rehabilitat* OR long term care) n/2 (lodge* OR facility* OR home* O R residence* OR centre* OR center*)) OR (supportive living) OR (assisted living O R residential facilit* OR group home*))

ProQuest Dissertations and Theses search:
("medication management" OR "medication administration" OR "medication therapy" OR "medication reconciliation")

AND

(electronic OR computer* OR technolog*)

AND

("long term care" OR "nursing home*" OR "assisted living" OR "supportive living")

GREY LITERATURE SEARCH **Google Search Terms** emar AND (“long term care” OR “nursing home” or “Assisted living” or “skilled nursing facility”) “electronic medication administration record” AND (“long term care” OR “nursing home” or “Assisted living” or “skilled nursing facility”) “barcode medication administration” AND (“long term care” OR “nursing home” or “Assisted living” or “skilled nursing facility”) “health information technology” AND (“long term care” OR “nursing home” or “Assisted living” or “skilled nursing facility”)

Appendix 3.1. Study LTCF Medication Incident Report Template

MEDICATION INCIDENT REPORT

Facility: □ VM □ SP Report Date: _____ Report Time: _____

Reporting Team Member(s): (*print*) _____ Signature: _____

Incident Date: _____ Incident Time: _____ Person Responsible for Error: (*print*) _____

Resident Suite: _____ Resident Name: _____

Type of Medication Error/Omission: (*check as appropriate*)

□ Incorrect Resident
□ Incorrect Medication
□ Incorrect Time
□ Incorrect Dose
□ Incorrect Route
□ Medication Expired
□ Medication Omission (*Attach Med Pouch*)
□ Pharmacy Error
□ Documentation Error/Omission
□ OneMAR Shift Audit
□ Other:

Injuries/Adverse Reaction as a Result of Medication Error:

□ Yes
□ No

If Yes, please describe:

Description of Incident

_____

_____

_____

_____

_____

_____

_____

LPN Team Leader Follow Up (*specify Nursing Interventions/Assessment*)

_____

_____

_____

_____

_____

Action Taken

RCM Notified:
□ Yes Name of RCM: (*print*) _____Date: _____Time: _____
□ No, by Incident Report as per Policy

Resident Own Personal Decision Maker? □ Yes □ No (*if No, complete next two lines)*

Guardian Notified:
□ Yes Name: (*print*) Date:
Time:
If unable to reach Guardian, why?
Follow up:

Pharmacy Notified □ Phone □ Fax Name: Date:
Time:
If no, why?

_____

_____

_____

_____

HCA Progress Notes □ Yes □ No	*LPN* Progress Notes □ Yes □ No (Include pain, behaviour, VS, NVS, BGM) Shift Report LPN/HCA □ Yes □ No

RCM Follow Up
Reportable Incident: □ Yes □ No
CM Verbally Notified? □ Yes □ No

Name of CM:_____ Date:_____ Time:_____

_____

_____

_____

_____

_____

_____

Administration

_____ _____

Signature of LPN Team Member Date

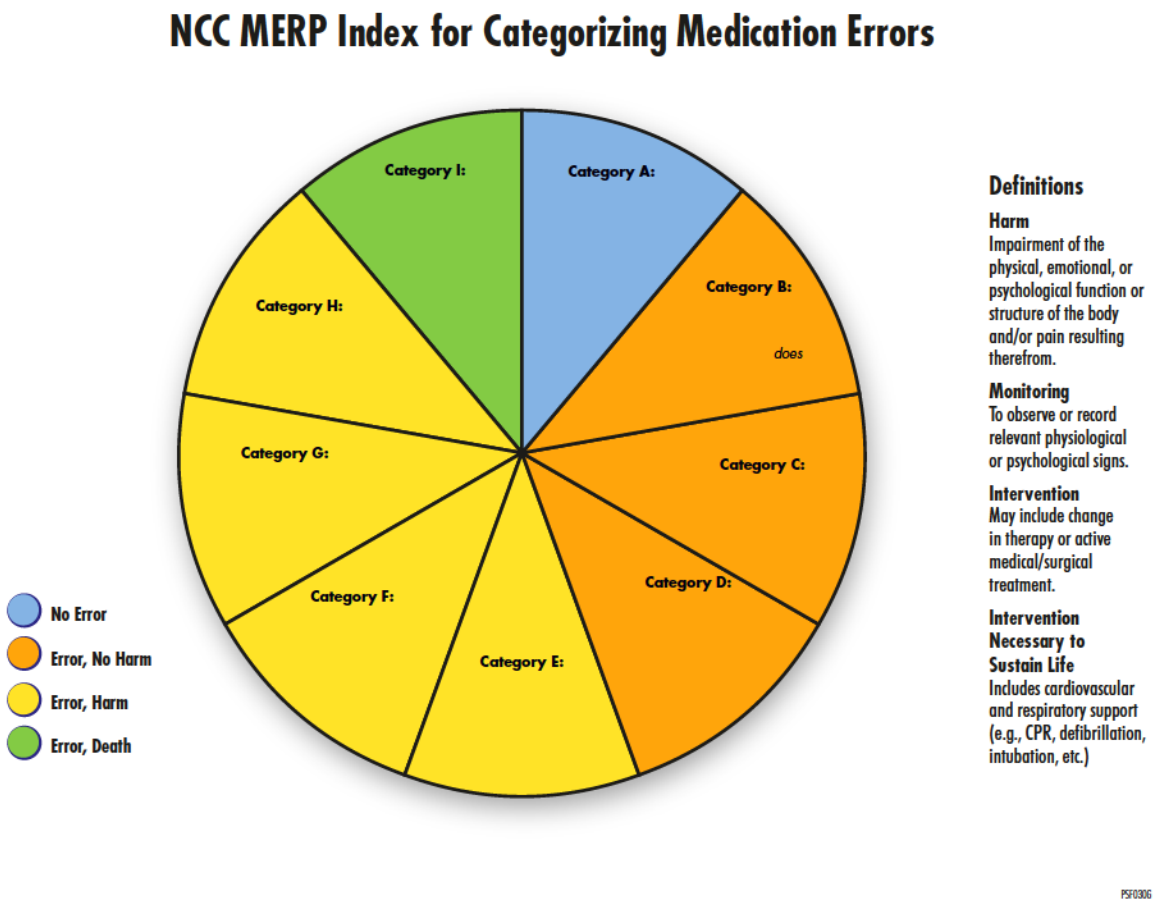
_____ _____

Signature of Resident Care Manager Date

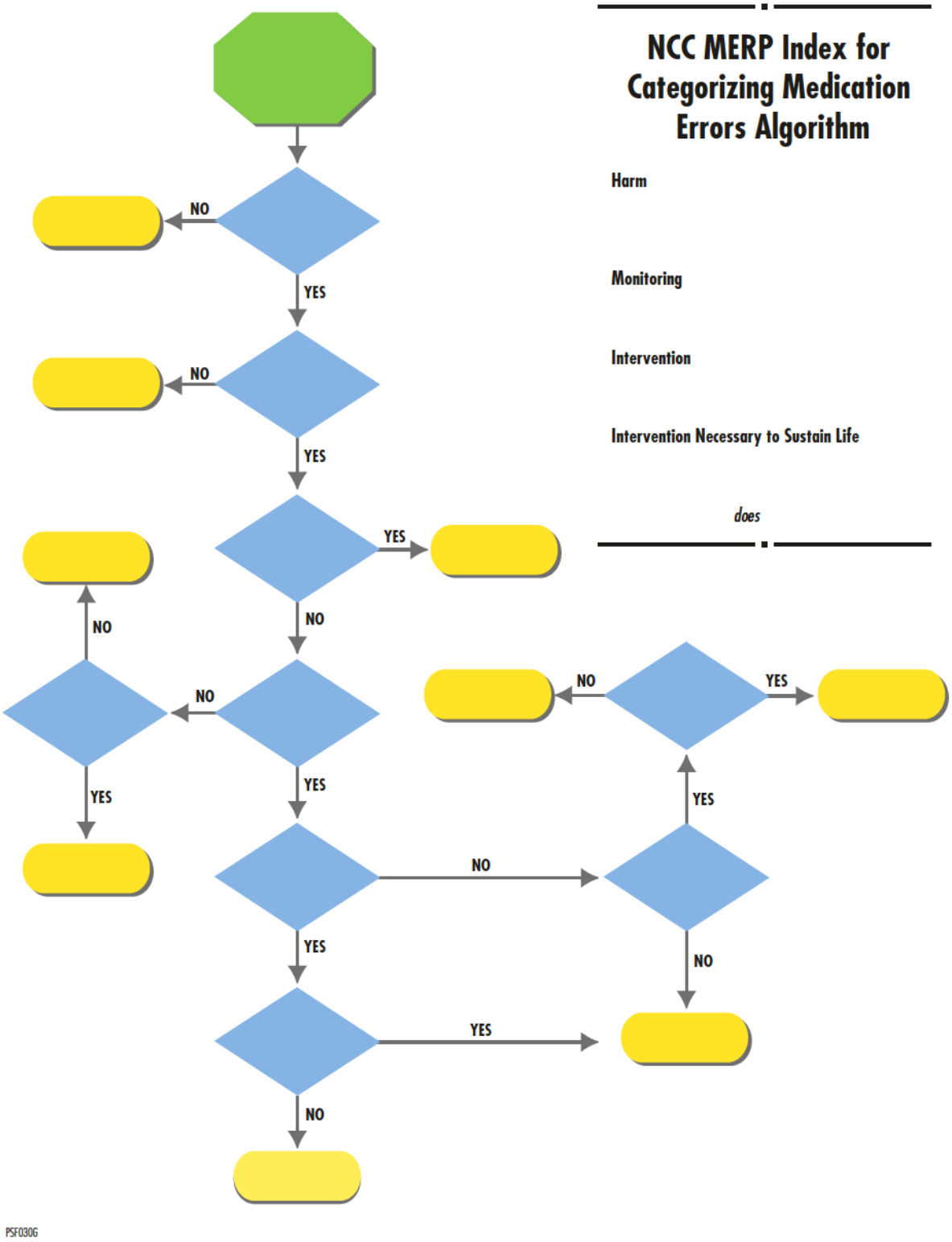
_____ _____

Signature of Director of Care (if applicable) Date

Appendix 3.2.1 NCC MERP Index for Categorizing Medication Errors



Appendix 3.2.2 NCC MERP Index for Categorizing Medication Errors Algorithm



Appendix 3.3. Medication Administration Incident Review Factors Definitions

Content Analysis: Medication Administration Categories and Definitions

CATEGORY 1: Medication Administration Processes with eMAR-BCMA

Sub-Categories:
1.) Not reviewing eMAR and/or medication prior to administration
Description:

Definition: This category applies if the MIR descriptions states that the correct medication was barcode scanned and administered, but was given at the wrong time or administered incorrectly. The nurse failed to follow specific medication orders regarding administration (e.g., PRN frequency/indication, crushing/not crushing a medication, etc.). The nurse failed to confirm the right medication prior to administration.
Indicators: The HCA or LPN "didn't look at the directions on the eMAR" "wrong dose given"
Example: "LPN did not look at the eMAR prior to administering PRN Ativan. Dose was given early." "LPN did not confirm medication dose. 3mg was given instead of 1mg"

2.) Medications signed off, but not administered

Definition: This category applies if the MIR description states that the medications were signed off as administered in the eMAR-BCMA, but some or none were actually administered to the resident.
Indicators: Medications were found in the medication cart at the next medication pass, but was signed off as administered during the earlier pass.
Example: "Medication was administered as per eMAR at 1200, but medication was found in cart at 1700" "HCA signed off on medication, but did not provide 7of7 pouch"

3.) Issue with LOA medications

Definition: This category applies if the MIR description states that the MI relates to medication administration prior to or while the resident was on a leave of absence or pass from the facility.
Indicators: "LOA" Leave of Absence, Pass Medications
Example: "Resident was provided LOA medications but he did not take all of them upon return." "Resident went on a LOA and was provided 1200 medications. LPN signed off 1200 and 1700 as given for LOA"

4.) Medications administered, but not signed off (refusals not signed off)

Definition: This category applies if the MIR description states that the medication(s) were administered, but not signed off. It includes situations where refusals to take meds were not signed off as 'refusals.'
Indicators: Medications flashing overdue, but medications not found, resident not home for administration
Example: "LPN administered Insulin at 1640, but did not sign off admin on eMAR, 2nd LPN didn't know that insulin was already administered and administered the insulin again" "HCA did not sign off medication after administration"

5.) Administered next interval medication dose in error

Definition: This category applies if the MIR description states that the correct medications were scanned and signed off, but additional medications from the next or subsequent medication pouches were administered as well in error.

Indicators: 1 of 2 pouch for 1200 missing, medications for the 5th and 6th were given together.

Example: "HCA scanned 2100 medications, but grabbed 2100 and 0800 medication pouches. Gave both at 2100"

6.) Medication not administered, not signed off as administered on eMAR

Definition: This category applies if the MIR description states the medication was not administered and was not scanned and signed off. The medication was missed all together

Indicators: Medication still in cart and eMAR is flashing that medication requires administration

Example: "Medication was not administered. Was not signed off on eMAR"

CATEGORY 2: Medication Packaging

Sub-categories:

1.) Incidents involving non-pouch medication packaging

Definition: This category applies if the MIR description states that the MI involved a medication that was dispensed in a pre-filled, single-use or multidose packaging (i.e., not medication pouch unit dose).

Indicators: Inhaler, Cream, Insulin, Pre-filled syringes, Ampoule

Example: "Risperidone liquid in AM and PM. Different doses. Staff were using AM doses for PM" "LPN scanned Depo-Provera but grabbed the Clopixol instead and administered the wrong medication." "LPN used only one ampoule, when 2 should have been used"

2.) Packaging/Dispensing issue

Definition: This category applies if the MIR description states that the MI occurred because of the way that the medications were packaged/dispensed or delivered from the pharmacy. This includes missing or extra medications in a blister, incorrect labelling of medications, packaged medication does not match prescription, etc.

Indicators: pouch medications, narcotics not in lock box, incorrect labelling

Example: "Extra tablet in pouch" "Dispensing and labelling"

CATEGORY 3: Environmental Issues and Internal/External Factors

Sub-categories:

1.) Distracted During Medication Administration

Definition: This category applies if the MIR description uses the word distracted.

Indicators: "distracted" "in a hurry"

Example: "HCA was distracted during the pass and handed another residents' medication to this resident who was speaking with her."

2.) Medication Supply or Storage Issues

Definition: This category applies if the MIR description states that the medications could not be found or were in the wrong location or the lead nurse did not 'receive' new medications.

Indicators: Back order, pharmacy did not send injection, wrong porter, wrong room, not received

Example: "0800 meds could not be found. Replace pouch given instead." "Missing medication" "HCA found medication in the wrong med porter for a different resident" "Medication not received on to eMAR by LPN. Medications not administered."

3.) Resident Self Administration Issues and Medication Refusals

Definition: This category applies if the MIR description relates to resident self-administration, self-harm or administration refusal within the LTCF

Indicators: Medication compliance, self-administration

Example: "Resident did not come for medications," "Self-harm"

Rules: If the issue relates to self-administration/medication refusals while on LOA or pass (outside the facility), it should be assigned to the LOA category.

4.) Warfarin Issue or Restricted Medication Issue

Definition: This category applies if the MIR description relates to procedures for use of warfarin were not followed or when other policies regarding the use of restricted medications were not followed.

Indicators: Warfarin

Example: "HCA administered LPN only medication"

Rules: If the issue relates to incorrect/up to date Warfarin orders, it should be assigned to the Communication category.

CATEGORY 4: Communication

Sub-categories:

1.) Manual Documentation on the eMAR

Definition: This category applies if the MIR description relates to staff manually signing off on the eMAR rather than barcode scanning or documenting/not documenting administration on a paper MAR. Category also includes manual documentation of medication orders on eMAR for medications not dispensed by the pharmacy.

Indicators: "manually signed off" "paper MAR" "non-pharmacy supply"

Example: "IM injection was manually signed off by HCA. Should be signed off and given by LPN. Med was never administered" "Staff were using Green MAR to document admin but did not communicate at shift change. Resident missed dose." "LPN did not put medication as non-pharmacy supplied (got from hospital)"

2.) Issues with order communication within facility or between facility and pharmacy

Definition: This category applies if the MIR description relates to issues in order/reorder communication between nursing staff at the facility or between the facility staff and the pharmacy. This includes MI caused by waiting for Special authorization for medication coverage.

Indicators: Communication

Example: "Clozapine not ordered, delay of 3 days until Pharmacy was aware and sent" "LPN did not know that resident had new meds" "HCA did not inform LPN to reorder nitropatch" "The active Warfarin Rx did not match what was dispensed."
Rules: If the issue relates to communication at shift change regarding paper/green MARs, it should be assigned to the Manual Documentation category.

CATEGORY 5: Other and Not Available

1.) Other and Not Available

Definition: This category applies to the MIR description when none of the above categories/subcategories apply or there was insufficient information to allow categorization.
Indicators: Unknown, no information
Example: Description of incident left blank.

Appendix 3.4. Pharmacy Dispensing Errors Factors Codebook Definitions

CATEGORY 1: Pharmacy Packaging and Delivery

1.) Medication Packaging Error

Definition: This category applies if the MIR description relates to errors with how the medications were packaged or labeled by the Pharmacy. This includes the pharmacy packaging incorrect medications, providing incorrect directions/information, packaging, and labeling, or packaging discontinued medications.
Indicators: Extra tablet, missing tablet, wrong tablet, incorrect label
Example: "Missing tablet in pouch" "Pharmacy labeled Narcotic Blister with wrong resident info" "Medication missing from strip" "Medication in strip was D/C"

2.) Delivery Error

Definition: This category applies if the MIR description relates to errors in the delivery of the medication to the LTCF.
Indicators: Medication not delivered, delivered to wrong location, wrong medication delivered.
Example: "Pharmacy did not send full Rx that was Rx'd" "Pharmacy sent 2 medications strip"
Rules: If the pharmacy delivered a different medication then what was ordered, place in Medication Packaging Error sub-category.

3.) Errors in eMAR-BMCA Barcodes

Definition: This category applies if the MIR description relates to the pharmacy not following proper processes relating to eMAR-BCMA requirements.
Indicators: Barcode for medication was not provided, wrong barcode, eMAR not updated
Examples: "Updated barcodes with insulin change not provided" "Barcode not sent for eyedrops"

CATEGORY 2: Other and Unknown

1.) MIR already defined

Definition: This category applies if the MIR description involves both the medication administration-use phase (which has already been defined previously) and dispensing-use phase.
Indicators: Medications dispensed incorrectly and was administered by nursing staff. MIR already assigned to a MAE category and sub-category
Example: "Medication directions error and staff administered incorrect dose"

2.) Other and Unknown

Definition: This category applies to the MIR description when none of the above categories/subcategories apply or there was insufficient information to allow categorization.
Indicators: Unknown, no or minimal information
Examples: Dispensing Error, pharmacy dispensing, pharmacy error