Medication Errors: Causes, Theories and Interventions

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Abstract

Rationale, aims and objectives: Following heart disease and cancer, medication errors rank third as the leading cause of death in the United States. For the primary care provider, the root causes of medication errors stem from multiple factors. To improve positive learning outcomes for primary care providers in reducing medication errors, this project sets out to examine the utility of educational interventions in improving the present standard of care as it relates to medication error safety and patient outcomes.

Methods: A literature review was conducted analyzing recent studies that examined the use of educational interventions in promoting positive learning outcomes for primary care providers with respect to the reduction of medication errors.

Results: Five studies were selected focusing on primary care providers with the aim of increasing knowledge and education to reduce medication errors. The studies varied in design, methodology, and assessment criteria. In all but one of the studies analyzed, each respective educational intervention examined was found to have statistically significant positive learning outcomes that promoted the reduction of medication errors.

Conclusion: Educational interventions are a good way to promote positive learning outcomes for primary care providers in the effort to reduce medication errors. Taking into consideration the limitations that will need to be addressed in future studies, implementing education and training for primary care providers is a promising option for improving the standard of care with respect to medication error reduction.

***Keywords*:** Medication errors, primary care providers, educational intervention, pre-test, post-test, medication administration, patient safety, staff training, evaluation, assessments.

Medication Errors: Causes, Theories, and Interventions

Trailing only to heart disease and cancer, medication errors are the third leading cause of death in the United States (DeAngelis, 2016). To put that into perspective, according to a recent statistical analysis from Johns Hopkins University, it is estimated "that 251,000 Americans die each year from such mistakes" (DeAngelis, 2016, p. 48). As a clinical problem viewed through the lenses of the nurse and primary care provider ("PCP") population, medication errors clearly present immense concerns and must be addressed accordingly with appropriate interventions. Therefore, considering the alarming frequency of medication errors, this MSN quality improvement proposal will provide some background education on the causes of medical errors among the above-referenced population before shifting to propose the value of an educational in-service intervention aimed at reducing the overall occurrence of medication errors and thereby improving the overall standard of care.

Problem Statement

From a clinical perspective, medication errors occur for several reasons; each of which must be examined to facilitate productive discussion and appropriate interventions (DeAngelis, 2016). Within the current standard of care, some of the most prevalent obstacles nurses and PCPs face in addressing medication errors include but are not limited to: (1) medical dosage miscalculations; (2) human-based error due to workload burnout and fatigue; (3) poor pharmacological knowledge; (4) lack of communication within healthcare teams and patients; and (5) small nurse-patient ratios resulting in understaffing (Chu, 2016). These obstacles and others, when left unchecked, impose a significant and cumulative negative impact on the practice of healthcare, which permeates throughout the fabric of our society and destabilizes overall institutional confidence in healthcare providers and facilities.

One key factor in addressing medication errors for nurses and PCPs is the miscalculation of medication dosages. Dosage miscalculations arise through a range of causes from simple math errors to inadequate training and proficiency with more high- risk medications such as heparin, insulin and vasopressors (Chu, 2016). Miscalculations of drugs can come down to clerical mistakes, such as numbers containing trailing zeros or even an improperly placed decimal point. Moreover, miscalculations such as those described herein can result in medication doses that either exceed or fall below the prescribed dose, placing patients atrisk for harm and/or interfering with their care (Chu, 2016). Medications in a dosage lower than prescribed, for example, may cause discrepancies in patient treatment plans, which will negatively impact the patient by slowing the patient's recovery. Sometimes, nurses simply may not possess the mathematical acumen necessary for the drug calculation; or may attempt dosage calculations under pressure while a patient is waiting to receive the medication (Chu, 2016).

Another obstacle that leads to medication errors for nurses and PCPs is fatigue and burnout. It is not uncommon for physicians and some nurse practitioners ("NP") to work twenty-four-hour shifts. Further, staff nurses regularly work 12-hour shifts, which can include overtime, being called-in due to short-staffing, or even working multiple days in a row (Chu, 2016). These workload factors, if not managed properly, can quickly cause fatigue and burnout, as they impose an excessive workload for nurses and PCPs (Chu, 2016). Depending on hospital management, nurses may also be pressured to take on more shifts than they normally would, causing them to fatigue more quickly. A nurse or PCP's fatigue is almost certain to produce inadequate work performance, thereby causing medication errors, especially in high-pressure situations where they are rushing to ensure all patients receive their medications in a timely manner (Chu, 2016).

Another critical factor leading to medication errors is based upon the nurse or PCP's lack

of pharmacological knowledge (Gracia et al., 2019). Gracia et al. (2019) explain that while many studies focus on other problems such as disorganized facility units or communication problems, issues such as “lack of training and experience” are not highlighted in the same manner, and “poor drug knowledge among professionals . . . strongly influence the medical error rate” (p. 2). Some of the most common manifestations of these knowledge deficiencies arise with improper antibiotic dose intervals; improper administration of medications via nasogastric and gastronomy tubes; as well as the improper dilution, concentration, and infusion speed of high-risk medications (Gracia et al., 2019). Additionally, a lack of knowledge and/or awareness of the side effects of certain drugs can put patients at risk. For example, a medication such as clonidine should not be administered to a patient with a systolic blood pressure below 160, because a side effect of clonidine is severe hypotension. If a nurse lacked knowledge of this drug’s particular side effect, he or she could unknowingly cause a patient’s blood pressure to drop dangerously low, which could lead to lack of perfusion and possibly death (Gracia et al., 2019).

Poor communication between and amongst the interdisciplinary healthcare team and their patients comprises yet another significant underlying cause of medication errors for nurses and PCPs (Shitu et al., 2018). Shitu et al. (2018) states, “[o]ne of the major problems causing medication errors is ineffective communication between patients and health personnel”; and “poor communication among healthcare personnel . . . can lead to medication errors” (p. 115). This particular issue might accurately be considered as the most common and most easily avoidable cause of medication errors. Based on empirical analyses, communication deficiencies in this area include language and culture gaps, illegible medication orders, and use of complex medical terminology with patients (Shitu et al., 2018). One widely known example concerns medication orders illegibly written by PCPs. These illegible medication orders create a risk of error in

interpretation, not just of the type of medication, but also the dosage and frequency as well (Shitu, et al, 2018). Comprehension issues can also arise with telephone orders where there can be a significant risk of miscommunication due to disruptive background noise, language-barriers and poor connection (Shitu et al., 2018). Another example of poor communication presents where the patient is prescribed a new medication to be self-administered at home, and while attempting to educate the patient, the nurse or PCP uses complex medical terminology, leading to patient confusion, misuse/improper administration of medication, and medication errors (Shitu et al., 2018).

Another critical underlying basis for medication errors for nurses and PCPs arises from facility understaffing, particularly where it results in disproportionate nurse to patient ratios. In a study conducted by Gorgich, Barfroshan & Yaghoobi (2016), nurses themselves identified low nurse to patient ratios as the fourth most common factor that overall had the highest impact on medication errors in nursing. The logic of nurse understaffing as a cause of medication errors is straightforward: an insufficient nurse to patient ratio overburdens nurses and results in the inadvertent neglect of patients. This inadvertent patient neglect is manifested in several ways, the most relevant of which being errors in preparing and administering patient medications in a timely manner. While understaffing certainly shares elements in common with the fatigue and burnout factor discussed above, understaffing poses a unique challenge because even the most refreshed, well rested nurse can become overwhelmed where her patient assignment exceeds the reasonable limits of her capacity to deliver quality healthcare services (Chu, 2016). It can be reasonably inferred then, that as a nurse's ability to deliver quality healthcare decreases, the risk for commission of medication errors increases. Therefore, a low nurse to patient ratio can lead to detrimental patient outcomes such as mortalityand infections (Fagerstrom et al., 2018).

Considering the foregoing problems with the current standard of care discussed above, there is much room for improvement in the target population in reducing the occurrence of medication errors through the implementation of an educational in-service intervention.

PICO

For primary healthcare providers, does an educational in-service intervention vs. no educational in-service intervention have a positive effect on learning outcomes related to medication errors?

Background and Significance

With specific reference to PCPs, medication errors are a key point of concern because the consequences of such errors are a significant cause of inadvertent injury and harm for patients (Sheehan et al., 2019). In tackling this multifaceted issue, multiple studies have found value in educational training and empowerment as an intervention tool to produce positive learning outcomes for PCPs with respect to medication errors (Amiri et al., 2018; Johnson et al., 2019; Solodiuk et al., 2019; Custodio et al., 2021; Sheehan et al., 2019). For example, using an educational intervention to promote positive growth in patient safety culture, as well as PCP culture and expectations concerning medication administration have been shown to strengthen the safety net against medication errors (Amiri et al., 2018; Johnson et al., 2019; Solodiuk et al., 2019). Studies also support the notion that educational interventions can be employed to effectively promote positive learning outcomes by targeting specific PCP pitfalls such as prescribing, use, administration, and interruption management (Custodio et al., 2021; Johnson et al., 2019). Outcomes from the implementation of educational interventions are most readily measured by (1) tracking successful medication administration events (Johnson et al., 2019; Solodiuk et al., 2019); or (2) testing PCP

knowledge (Amiri et al., 2018; Sheehan et al., 2019; Custodio et al. 2021), which occurs both before and after the intervention.

It must be acknowledged however, that barriers to the full implementation of educational interventions still exist within the literature. Such barriers include (1) small sample sizes (Custodio et al, 2021; Sheehan et al, 2019; Johnson et al, 2019); (2) ensuring participants complete the full educational intervention (Johnson et al., 2019; Custodio et al., 2021), and (3) self-reporting of results rather than direct observation (Amiri et al., 2018). Nonetheless, with appropriate steps taken to eliminate these concerns, educational interventions remain a powerful tool for promoting positive learning outcomes in primary care with respect to medication errors. This is especially true when these educational interventions are delivered through pre-existing nursing theoretical frameworks tested and proven to facilitate knowledge and learning.

Theory

Nursing theories are best understood as structured collections of foundational knowledge—unique from the study of medicine—that explain the nursing discipline and help to evolve its conceptual landscape (Wayne, 2020). As a key component of the nursing discipline, nursing theories also play an essential role for NPs in fostering the ongoing evolution and improvement of healthcare practices—particularly for the primary care setting—to the overall benefit of the patient (Wayne, 2020).

To develop a comprehensive theoretical framework to examine the aforementioned clinical research question, this paper will select and examine the practical utility of, and synergistic interplay between: Donabedian's quality framework; and Social Learning theory. Together, these two fundamental nursing theories will forge a multifaceted systemic-level framework to facilitate the creation of an education-based intervention for PCPs that will effectuate the stated objective—

reducing the occurrence of medication errors.

Theory I: **Donabedian Quality Assessment Framework**

The Donabedian quality framework is a readily straightforward healthcare research model that focuses on healthcare quality evaluation and assessment and is centered around three primary conceptual pillars: (1) structures; (2) processes, and (3) outcomes (Botma & Labuschange, 2017). Under the Donabedian model, the concept of structure refers to the foundational structural apparatus through which healthcare is delivered to patients, such as healthcare facilities, equipment, personnel, as well as the functional and financial institutional mechanisms through which healthcare services are offered and delivered to the general public (Botma & Labuschange, 2017).

The second conceptual pillar of the Donabedian model is processes, which makes reference to the concrete healthcare-based actions that are undertaken to coordinate and deliver healthcare to patients (Botma & Labuschange, 2017). Processes then are the mechanisms through which healthcare is administered to patients in clinical settings, and they include all aspects of healthcare, from admission, examination, imaging, diagnosis, treatment, follow-up, and preventative care (Botma & Labuschange, 2017). Because processes operate within structures in the Donabedian model, they are, therefore, inherently subject to the characteristics and limitations of the structural apparatus through which they are delivered. This means that care must be taken to ensure that processes are developed and optimized for their structural environment.

The third conceptual pillar of the Donabedian model is outcome (Botma & Labuschange, 2017). Outcomes are derived directly from processes occurring within the structural framework, which are performed with the goal of producing specific results, such as improved patient health through recovery, rehabilitation, and overall patient satisfaction (Botma & Labuschange, 2017). By selecting outcomes as the final analytical factor, Donabedian's model delivers an easy-to-use tool for

measuring improvement and progress in healthcare settings where new initiatives are introduced within existing structures to enhance the value of healthcare systems, or to correct existing deficiencies therein.

Theory II: **Social Learning Theory**

Social learning theory, as advocated through the work of Albert Bandura, is an effective tool for understanding the process of learning, and it stands for the notion that individuals learn and/or acquiring knowledge and specific behaviors by observing the conduct of others, witnessing the positive outcomes such behavior produces, and then modeling that behavior to replicate that result (Horsburgh & Ippolito, 2018). Logically, it follows therefrom that a cognitive element exists within the theory, as individuals "internali[z]e and make sense of what they see in order toreproduce the behavior themselves" (Horsburgh & Ippolito, 2018, p. 2).

Ideally, social learning theory operates most optimally in social settings where individuals have the opportunity to observe, internalize, and then reproduce specific behaviors (Horsburgh & Ippolito, 2018). This process is theoretically broken down into four separate stages—known as "attention, retention, reproduction, and motivation" (Horsburgh & Ippolito, 2018, p. 2). In the attention stage, learners literally pay attention and/or observe the behavior that they are seeking to reproduce. In the retention stage, the learner will internalize their observations and begin the process of cognitively rehearsing the behavior, establishing the neural pathways necessary for learning and reproduction. Once the behavior is observed and internalized, the learner will be ready for the third stage—reproduction—where they will model and/or replicate the observed and internalized behavior in a new process of their own.

The fourth stage, the motivation stage, involves a consideration of the learners' individual motivation to "enact or imitate the behavior they have observed" (Horsburgh &

Ippolito, 2018, p. 2). Scholars assert that motivation is derived from reinforcement—which can be gleaned from direct, vicarious, or internal sources (Horsburgh &Ippolito, 2018).

Theories Influence on Advanced Practice of Nursing

Because the selected PICO inquiry herein contemplates an educational in-service intervention for the purpose of promoting positive learning outcomes with respect to reducing medication errors within the PCP population, the rationale for choosing the Donabedian and Social Learning theories as a theoretical framework are: (1) enhancing overall patient safety through the reduction of medication errors among PCPs; and (2) and the need to seek out the most practical means of obtaining that objective (Khalil et al., 2017). For example, the primary influences for the selected theoretical framework—i.e. the combination of the Donabedian model and Social Learning theory—in the context of the selected PICO inquiry—are the need for : (1) accurate quality measurement protocols to evaluate the effectiveness of education-based in-service interventions aimed at reducing medication errors; and (2) utilizing best learning practices for the educational intervention through observation, internalization, and imitation and/or replication inherent to the social learning theoretical model (Botma & Labuschange, 2017; Horsburgh & Ippolito, 2018).

Theoretical Framework Analysis

The most effective way to apply the theoretical framework to the selected MSN project is through the proper identification and designation of theory-based trigger-point markers for quality assessment and learning purposes. Beginning with the Donabedian model; structure, processes and outcome will be implemented to examine the effectiveness of the education-based intervention and can best be understood through direct application. Structure will refer to the patient care setting, i.e., the healthcare facility, the target population—here, PCPs—as well as the environments in

which patients are examined, diagnosed, treated and prescribed and/or administered medications. Processes will then be designated as the specific education-based intervention rolled out to PCPs for the purpose of reducing medication error rates among them. Outcomes will then be measured by the overall rate to which medication errors are reduced (Botma & Labuschange, 2017; Redmond et al., 2018).

Turning then to social learning theory, PCP's will receive the standardized education-based intervention, which will be comprised of informational lectures, combined with a direct demonstration of best practices in patient-interaction, thereby allowing PCPs to observe proper medication prescription, administration, and dosing practices, internalize and retain them, and then reproduce and/or replicate the internalized practices to produce a positive outcome (Horsburgh & Ippolito, 2018). The PCPs' direct experience with the positive results attained through their replicated/imitated use of best practices will serve to engrain confidence and incentivize them to continue using the practices; thereby invoking the fourth stage of social learning theory—motivation (Horsburgh & Ippolito, 2018). Seeing their learned practices produce positive patient outcomes will reinforce the PCP's cognitive understanding of their effectiveness, encouraging them to continue using the practices long after the education-based intervention is complete.

Theoretical Contribution to APRN Profession

The MSN project articulated and discussed herein theoretically contributes to the APRN profession through its establishment of a foundational framework for future quality assessment surveys pertaining to medication error reduction—using the Donabedian model. Because the Donabedian model can be very easily implemented and deployed to evaluate the quality of healthcare services, it will serve as an effective tool to measure whether the standardized

education-based intervention is producing positive results in reducing the rate of medication errors (Botma & Labuschange, 2017). Additionally, the flexibility of the structure, process, outcome components within the Donabedian model ensure that it may be applied for the purpose of measuring medication error reduction strategies in any conceivable healthcare setting, with no bars to its implementation (Botma & Labuschange, 2017).

Moreover, utilizing social learning theory, the MSN project will also contribute to the nursing profession through its development of logic-based step-by-step methods for developing standardized education-based interventions aimed at reducing the rate of occurrence for medication errors that can be replicated, scaled out and applied to multiple healthcare settings and PCPs (Horsburgh & Ippolito, 2018). The importance of this research analysis and initiative cannot be understated, and it is imperative that further efforts be made to reduce the occurrence rate of medication errors. At a time when medication errors are the third leading cause of death in the United States, trailing only to heart disease and cancer, proactive intervention is needed to educate PCPs on how to avoid them, and measure and evaluate that progress in a straightforward scalable manner (DeAngelis, 2016).

Theories Implications to Guide Personal APRN Practice

In addition to providing an effective system for navigating this proposal, the theoretical framework developed herein will guide the APRN's personal future advanced nursing practice as well. For example, the Donabedian model of structure, process, outcome can be pared down to the individual NP to assess and measure the quality of the patient care delivered each day. Implementing the Donabedian model of quality control on an individual level promotes patient safety because it equips the NP with a mechanism to self-evaluate and guide themselves toward improving the level and quality of healthcare services delivered to their patients (Redmond et al.,

2018). Also inherent to the nursing discipline is the fact that learning involves an ongoing process of learning, gaining new knowledge, and incorporating that knowledge into the advanced practitioner's existing practice (Horsburgh & Ippolito, 2018). In recognition of this reality, implementing social learning theory on an individual level also promotes overall patient safety, because it guides the advanced practice nurse to create a framework for observing, absorbing and retaining new knowledge, patient-care strategies and practices, and then reproducing those practices in their future patient- interactions (Horsburgh & Ippolito, 2018). Utilizing the Donabedian model and social learning theory, the NP can develop a system for constant self-assessment and improvement, ultimately benefiting their patients (Redmond et al., 2018; Horsburgh & Ippolito, 2018).

As discussed, nursing theories are essential to the practice of nursing. Through the combined use of the Donabedian model and Social learning theory, the hybrid theoretical framework contemplated herein will serve to give researchers a straightforward system to measure and assess the quality and effectiveness of a standardized education-based intervention,while simultaneously leveraging cognitive learning processes to develop that education-based intervention in a way that PCPs can readily observe, internalize, reproduce, and derive benefit from—through the production of positive patient outcomes. Additionally, the MSN project contributes theoretically to the APRN's personal practice by establishing the suitability of the Donabedian model and social learning theory for medication error reduction research. In addition, the theoretical framework discussed also facilitates the advanced nursing practice by allowing the NP to apply the theoretical principles on an individual level to promote patient safety. Ultimately, the theoretical framework discussed herein is a tool to promote the evolution and improvement of efforts to reduce medication errors through education-based interventions. Only through an

ongoing process of assessment, learning, and refinement can we mitigate the prevalence of this issue, and the best starting point for answers begins with a review of the existing literature itself.

Literature Search

To determine whether educational in-service interventions vs. no educational in-service interventions have a positive effect on learning outcomes relating to medications errors among PCPs, a literature search was conducted. The databases Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Library, and Pub Med were used. The following search terms "medication errors" yielded 66 results. Additional search terms of "staff training" or staff education" or staff development" AND "medication errors" or "drug errors" or "medication administration errors" or "drug administration errors" AND "pre-test" or "post-test" OR "evaluation" were added, narrowing the results to 39 articles. The search was narrowed down to studies that utilized an educational intervention to evaluate whether PCPs experienced positive learning outcomes relating to medication errors and included access to the full-text of the article(s). Only peer reviewed, current studies within the past five years were included. The final search resulted in five total studies which will comprise the evidence for this review, including; two randomized controlled trial studies (Amiri et al., 2018; Johnson et al., 2019); one quasi-experimental study (Custodio et al. 2021); one interventional study (Sheehan et al., 2019); and one retrospective cohort study (Solodiuk et al., 2019).

Definitions

This project will use the following definitions:

1) *Medication Error* refers to a preventable event that may cause or lead to inappropriate medication use or patient's harm while the medication is in control of the healthcare professional, patient, or the consumer (Sarfati et al., 2019).

2) *Primary Care* refers to the provision of integrated, accessible health care services by clinicians who are accountable for addressing a large majority of personal health care needs, developing a sustained partnership with patients, and practicing in the context of family and community (Ellner & Phillips, 2017).
3) *Educational Intervention(s)* refers to the implementation of knowledge and information-based training in a primary care setting to effectuate an intended outcome on healthcare professional practices and patient safety (Al Garsan et al., 2020).

Literature Review

During this evidence appraisal, key themes identified in the evidence included use of various methodologies, differences in technologies used, as well as differences in learning outcomes. As such, this literature review examines similarities, differences, strategies, and progress identified in the evidence with respect to the use of educational interventions and their ability to effectuate positive learning outcomes relating to medication errors.

Theme #1: Methodologies

In each of the studies reviewed, the population focus was PCPs responsible for medication administration. Despite this similarity, however, the specific metrics employed to evaluate outcomes were varied. For example, Johnson et al. (2019) and Solodiuk et al. (2019) examined approximately 806 and 1487 specific medication administration events, respectively, and the respective educational interventions of each study were measured against the rate of successful—error free—medication administration events. Whereas Johnson et al. (2019) utilized randomized controlled trial methodology to evaluate the precise rate of clinical errors per 100 medication administration events between the intervention and control groups, Solodiuk et al. (2019) utilized a retrospective analysis methodology to assess the rate of medication administration errors in the four quarters pre-

intervention to the last four quarters of the study period (during which the intervention was fully implemented).

In contrast, the remaining studies Amiri et al., (2018), Sheehan et al. (2019), and Custodio et al. (2021) examined a total of 279 PCPs directly. Similar to Johnson et al. (2019), Amiri et al. (2018) relied on the randomized controlled trial study methodology; however, results were derived through score measurements on the PCPs' pre and post intervention assessments between the experimental and control groups. Similarly, Custodio et al. (2021) and Sheehan et al. (2019) utilized quasi-experimental and interventional study methodologies, respectively, to analyze pre and post intervention assessment score results among PCPs.

In all but one of the studies, a key takeaway strength was the fact that regardless of methodology used, each respective educational intervention was found to have statistically significant positive learning outcomes which promoted: (1) the PCP's overall knowledge of patient safety culture (Amiri et al, 2018); (2) increased confidence in prescribing medications and favorable patient outcomes (Sheehan et al, 2019); (3) positive results regarding medication incident prevention and patient safety (Custodio et al, 2021); and (4) a decrease in unnecessary practice variations which allowed for complex patients to be managed within the hospital without increase the length of patient stays (Solodiuk et al, 2019). In the remaining study (Johnson et al 2019), while there was no finding of a statistically significant difference in the number of clinical errors between the pre-test and post-test populations, the study did observe a positive learning outcome related to an increase in the knowledge and use of strategies for managing interruptions during medication administration. However, this observation does not come without its obstacles. For example, multiple studies identified methodology-based limitations to their findings, including, but not limited to: (1) small sample sizes (Custodio et al, 2021; Sheehan et al, 2019; Johnson et al, 2019); (2) use of self-

reporting instruments to examine effectiveness (Amiri et al, 2018); and (3) the lack of reliability associated with retrospective data collection (Solodiuk et al, 2019). Therefore, while the studies are cautiously optimistic in their support for educational intervention initiatives and the promotion of positive learning outcomes for PCPs related to medication error reduction, additional studies with larger sample sizes and observational data collection methods should be conducted.

In addition, a gap in the literature was identified with respect to the methodology used across the studies having to do with the metrics for intervention effectiveness. As discussed above, in all studies reviewed, two main metrics were identified for measuring effectiveness—PCPs' self-reported increases in knowledge, practice strategies, and confidence (Amiri et al., 2018, Sheehan et al., 2019, and Custodio et al., 2021); and successful error-free medication administration events (Johnson et al., 2019 and Solodiuk et al., 2019). However, one key consideration notably absent from the literature, however, was any qualifiable metric utilized to measure understanding, input, or responses to medication administration events from the patient's perspective, which could have potentially been used as a feedback tool for PCP progress and provided significant insights on learning processes.

Nonetheless, based on the varying methodologies used and the respective findings, there is evidentiary support to state with caution the reasonable inference that educational interventions produce positive learning outcomes for PCPs in relation to medication errors, irrespective of the type of study used or metrics employed.

Theme #2: Mode of Education and Effect on Outcomes

In each study reviewed, educational interventions were implemented with the goal of producing positive learning outcomes for PCPs with respect to medication error reduction. While the specific educational interventions in each study varied, the format and mode of the educational

interventions used did contain some inherent similarities. For example, Amiri et al. (2018) and Custodio et al. (2021) utilized in-person educational interventions consisting of a two-day educational workshop and workplace training; while Sheehan et al. (2019) and Solodiuk et al. (2019) utilized a hybrid approach that combined in-person learning and e-learning components consisting of e-learning modules, classroom learning, and supervised practice; and Johnson et al. (2019) focused solely on an e-learning educational intervention delivered through an e-learning module accessible through an online learning management system.

The specific mode of educational interventions used in each study also contained interesting differences. For example, the educational interventions utilized in Amiri et al. (2018), Johnson et al. (2019), and Solodiuk et al. (2019) consisted of a single-phase training program that focused on changing the overall patient safety culture, changing PCP culture, and changing PCP expectations with respect to medication administration, respectively. In contrast, the educational intervention used in Custodio et al. (2021) utilized a three-phase training system that focused on addressing specific problem area issues relating to medication errors such as prescription, use, and administration protocols, while Sheehan et al. (2019) focused specifically on safe prescribing practices with a single-phase educational intervention. Similar to Custodio et al. (2021), Johnson et al. (2019) also addressed a specific problem area related to medication errors—the management of interruptions to PCPs during medication administration events.

With respect to how the mode of each educational intervention affected the outcome, a key strength was evident in the finding that each study's results were mostly positive. Studies that utilized in-person educational learning interventions exclusively, both noted statistically significant positive learning outcomes by emphasizing increased provider knowledge of medication error safety, specifically through the exchange of ideas flowing within the group discussions that followed the

training sessions (Amiri et al., 2018; Custodio et al., 2021). The two studies that utilized hybrid approaches pairing in-person learning with e-learning modules also noted statistically significant positive learning outcomes (Sheehan et al., 2019; Solodiuk et al., 2019). Interestingly, Sheehan et al. (2019) found no change in actual knowledge reported among PCPs but noted increased confidence during the prescribing process, while Solodiuk et al. (2019) identified a significant reduction in variation within the practices of PCPs, increasing uniformity in medication administration processes and outcomes. In the remaining study which utilized e-learning modules alone, no statistically significant reduction in medication administration interruption rates were found, but the study did note an increase in use of behavioral strategies among PCPs to manage the interruptions. However, there were also limitations identified in the mode of education used. For example, two of the studies that utilized e-learning modules did not include any additional group discussion regarding the educational intervention after the e-learning (Johnson et al., 2019; Solodiuk et al., 2019). Group discussions were found to generate success within studies that used in-person educational interventions (Amiri et al., 2018; Custodio et al., 2021). Additionally, the single-phase educational interventions utilized in Amiri et al. (2018), Johnson et al. (2019), Johnson, et al. (2019) and Solodiuk et al. (2019) may have been more effective at reinforcing ideas, knowledge, and practices if additional phases were included as they were in Custodio et al. (2021). Another limitation identified was the failure to ensure all participants completed the entire educational intervention (Johnson et al., 2019; Custodio et al., 2021).

With respect to gaps in literature, one of the most obvious gaps was in the shallow use of technology. While it is true that e-learning modules were used in three studies, these modules were delivered in a single-use format that did not take advantage of additional technology to provide

follow-up training. For example, no electronic communication was used in any studies, whether to provide feedback to PCPs or for additional electronic learning purposes.

However, despite the above-discussed limitations and gaps, each educational intervention was found to be effective in producing positive learning outcomes for PCPs in addressing medication errors. As interpreted by the data, virtually all groups that received the educational interventions reported increased knowledge and confidence and/or were objectively found to have fewer adverse medication administration events, as interpreted by the data. As such, it may be stated confidently that educational interventions do produce positive learning outcomes for PCPs in relation to medication error management.

Conclusion

As discussed herein, this proposal set out to identify the value of an educational intervention vs. no educational intervention in promoting positive learning outcomes for PCPs with respect to the reduction of medication errors. The reviewed literature supports such an endeavor and serves to improve the current quality of care relating to medication errors based on the findings identified therein, particularly when employed through the lens of the Donabedian model and Social Learning theories, which promote effective measurement protocols for progress and practicality. It must be noted however, that while the literature is encouraging, further study is needed to develop stronger support for educational interventions in this context with larger sample sizes and observational data collection to ensure reliability of future findings.

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