Practice-enhancing publications about the medication-use process in 2018

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Purpose. This article identifies, prioritizes, and summarizes published literature on the medication-use process (MUP) from calendar year 2018 that can impact health-system pharmacy daily practice. The MUP is the foundational system that provides the framework for safe medication utilization within the healthcare environment. The MUP is defined in this article as having the following steps: prescribing/transcribing, dispensing, administration, and monitoring. Articles that evaluated one of the steps were gauged for their usefulness toward daily practice change.

Summary. A PubMed search was conducted in February 2019 for articles published in calendar year 2018 using targeted Medical Subject Headings (MeSH) keywords, targeted non-MeSH keywords, and the table of contents of selected pharmacy journals, providing a total of 43,977 articles. A thorough review identified 62 potentially significant articles: 9 for prescribing/transcribing, 12 for dispensing, 13 for administration, and 28 for monitoring. Ranking of the articles for importance by peers led to the selection of key articles from each category. The highest-ranked articles are briefly summarized, with a mention of why they are important within health-system pharmacy. The other articles are listed for further review and evaluation.

Conclusion. It is important to routinely review the published literature and to incorporate significant findings into daily practice. This article assists in identifying and summarizing recent impactful contributions to the MUP literature. Health-system pharmacists have an active role in improving the MUP in their institution, and awareness of significant published studies can assist in changing practice at the institutional level.

Keywords: bar-coded medication administration, computerized prescriber order entry, dispensing, medication reconciliation, medication use process, smart pumps

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The medication-use process (MUP) is the foundational system that provides the framework for safe medication utilization within the healthcare environment, ensuring medications are utilized and secured in the most appropriate manner and across all settings.[1] As stewards for appropriate medication use within healthcare organizations, health-system pharmacists have a leadership role in optimizing the MUP to increase the efficiency and safety of patient care.[1]

The *U.S. Pharmacopeia* describes 5 major steps of the MUP: prescribing, transcribing, dispensing, administration, and monitoring.[2] With 95.6% of US hospitals in 2016 reporting the use of computerized prescriber order entry (CPOE) with an interface to the pharmacy computer system, the transcription step was incorporated into the prescribing step for the purpose of this review since it is no longer a distinct step of the MUP for all organizations.[3] Thus, the MUP, as defined in this review, has the following 4 components: prescribing/transcribing (the process of entering and processing prescriptions for patient care), dispensing (the process of preparing

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medications from a prescription for a patient), administration (the process of administering and documenting administration of a medication), and monitoring (the process of monitoring patients for adverse events and therapeutic effectiveness).

Several policy statements from the American Society of Health-System Pharmacists (ASHP) note the importance of the role of the pharmacist in the MUP.[4,5] Besides these policy statements suggesting the important roles pharmacy professionals play in the MUP, ASHP has been active in publishing surveys that trend different deployments of human resources, practice models, and technologies within the MUP.[3,6,7] ASHP separates the surveys by different steps of the MUP, and the surveys provide input from pharmacy leaders across the country. The surveys in these publications provide input on how different pharmacy departments across the nation are handling various challenges departments of pharmacy face.

Though the surveys provide evidence of trends in different aspects of pharmacy practice, it is important to understand the literature supporting various trends and changes regarding the improvement of the MUP. In order for pharmacy leaders to implement evidence-based best practices across the pharmacy enterprise, it is important that they understand the literature on the MUP that is being published in both pharmacy and nonpharmacy journals.[1] Publications that provide a review of the recent literature regarding the MUP can be an efficient aid to pharmacy leaders without sufficient time to thoroughly review the wealth of pharmacy literature published yearly. A collection of significant studies about the MUP in a calendar year can illustrate important practice changes. Other therapeutic disciplines have published "significant article" series, but the authors are unaware of any with a focus on the MUP apart from previous work published in 2015 and 2019 describing the most impactful articles from 2012 and 2017, respectively.[1,8-13]

KEY POINTS

- The medication-use process (MUP) is the foundational system that provides the framework for safe medication utilization within the healthcare environment, ensuring medications are utilized and secured in the most appropriate manner and across all settings.
- This review summarizes practice-enhancing publications about the MUP, as determined by pharmacy leaders in the state of North Carolina.
- Trends for articles published in 2018 include a skewed distribution of articles pertaining to the monitoring step of the MUP.

The 45 publications that resulted from the 2017 search were primarily categorized as pertaining to either the prescribing/transcribing step or the monitoring step of the MUP.[13] Many of the publications included work that had been conducted internationally. The authors hypothesized that perhaps the MUP is less of a focus of research and publishing within the United States and that international studies could be replicating research that has been already been evaluated and tested in the United States. From the previously conducted research, the authors concluded that the large amount of international literature focused on the MUP demonstrated that this topic is still actively evaluated and discussed in peer-reviewed literature. Alternatively, the authors hypothesized, previously described publication search strategies[1] may not be capturing all the related research being conducted within the United States. The authors decided to make intentional changes to the strategy for the 2018 publications search to capture additional articles published in the United States, if applicable.

The major objective of this article is to review the published literature from calendar year 2018 that has a focus on different areas of the MUP and to summarize publications defined as most significant to health-system pharmacists' daily practice.

Methods

The methods of the study were similar to those used in studies published in 2015 and 2019,[1,13] with a few notable changes. A PubMed search for articles published in calendar year 2018 was conducted in February 2019 using the following Medical Subject Headings (MeSH) keywords: medication systems; management information systems; pharmacy administration; pharmacists; and pharmacy service, hospital. For this review, 2 additional search measures were added to the literature search. First, the following non-MeSH keywords from the articles published in the MUP literature from 2017 were included in the search strategy: alerts, automated drug-dispensing systems, clinical decision support, clinical pharmacy information systems, computerized prescribing order entry, decision support systems, gravimetric i.v. workflow software system, medication alert system, medication errors, medication management, medication reconciliation, medication safety, pharmacy information system, quality assurance, and quality improvement.[13] Additionally, and differently from the previous publication, the table of contents of journals listed in the "General Pharmacy" section under "Pharmacy Practice" in the American Association of Colleges of Pharmacy's Core List of Journals for Pharmacy Education[14] (*American Journal of Health-System Pharmacy, Clinical Therapeutics, Cochrane Database of Systematic Reviews, Drugs, European Journal of Clinical Pharmacology, Journal of Pharmacy and Pharmacology, Journal of Pharmacy Practice, Journal of the American Pharmacists Association, Pharmacotherapy, The Annals of Pharmacotherapy, The Consultant Pharmacist,* and *The International*

Journal of Pharmacy Practice) were included in the search strategy and the total number of articles to review.[14] The authors elected to use a table of contents search due to the delay in indexing articles by MeSH keywords and non-MeSH keywords.[15] The search resulted in 43,977 articles. This represented an increase of 41,689 articles from the previous search.[13] The authors excluded 29,277 articles due to duplication of articles and a large return of articles not related to medication use from searches using the following keywords: clinical decision support, decision support systems, quality assurance, and quality improvement.

Each author reviewed the titles of the remaining 14,700 articles and selected the ones they deemed to be potentially the most impactful on the MUP. If one author thought the title of one of the initial 14,700 articles was significant, the article was selected for additional screening. After the initial screening, 915 articles remained for additional screening. If all 4 authors thought the title of one of the 915 articles was significant, the article was chosen for additional screening. After the second screen, 71 articles remained for additional screening. These selections were then screened against the following criteria: (1) interventions were feasible and reproducible, (2) the type of study supported objective evaluation of the intervention (ie, the research involved a pre-post study; a retrospective, prospective, and/or randomized control trial, evaluation, or implementation; a systematic review; or a meta-analysis), (3) we unanimously agreed the results warranted discussion within the pharmacy community, and (4) we unanimously agreed the paper should be included. Articles not meeting all 4 criteria were excluded from additional consideration. Articles meeting all 4 criteria were subsequently categorized into 1 of the 4 MUP steps. Discussions were held amongst the authors to ensure articles were categorized into the most appropriate step of the MUP (Figure 1). It was recognized that some articles might span more than one area. If this occurred, the authors evaluated the largest area of impact in the study and classified it based on this.

A total of 62 articles were selected and identified for inclusion in the survey (9 for prescribing/transcribing, 12 for dispensing, 13 for administration, and 28 for monitoring). The process for inclusion and exclusion of articles is illustrated in Figure 1. The article titles and their abstracts were provided to members of the department of pharmacy leadership teams for institutions located in the State of North Carolina and affiliated with the UNC Eshelman School of Pharmacy Master of Science collaborative specializing in health-system pharmacy administration. These institutions included Duke University Hospital, Mission Hospital, Cone Health, the University of North Carolina Medical Center, and Wake Forest Baptist Medical Center. Members of these leadership teams represented broad areas of responsibility, with multiple people having accountability and ownership for various parts of the MUP. These areas included operational management, clinical management, informatics, finance, medication safety, and supply chain management. Each leader was surveyed and asked to rank order each article pertaining to a step of the MUP based upon their perception of it having a significant impact on the MUP. The survey participants were provided the articles as they were embedded in the survey, but they were not explicitly asked or expected to read all 62 articles. The survey received 47 responses (a 34% response rate) from pharmacy leaders across the institutions. The rank order results were summarized, and the median was calculated for each of the 4 categories, with lower scores indicating greater impact. Table 1 lists all the articles selected and their respective median rankings. Based on the previously published articles with similar methodologies, 3 articles from each of the 4 categories were deemed most significant. Each step of the MUP was assigned to 1 author. The selected articles were provided back to the authors, who were asked to summarize the study design, end points (if applicable), key discussion points of the article, and major conclusions of the article, as well as to provide insight as to why an article is important within health-system pharmacy practice.

Prescribing/transcribing

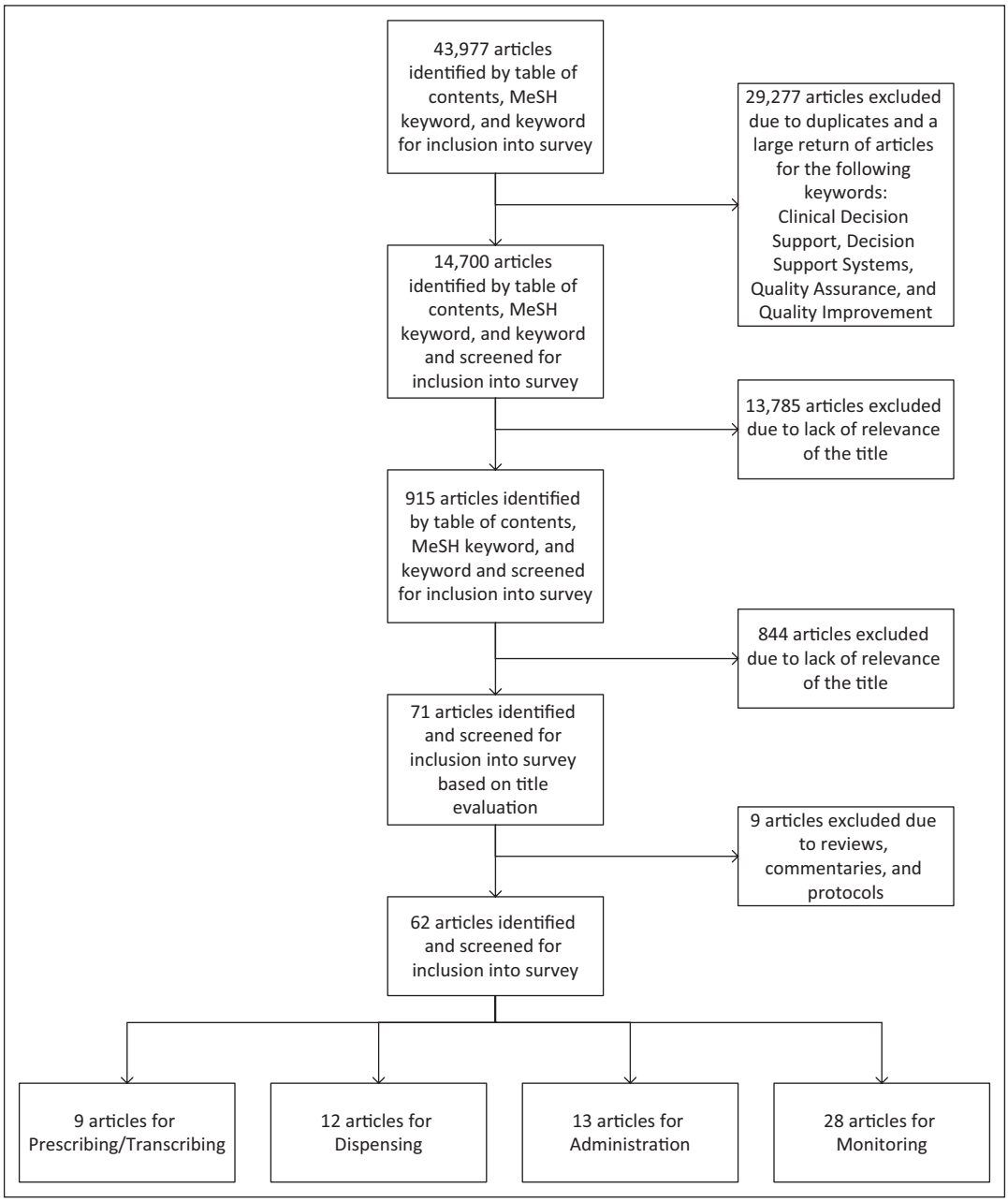
Vélez-Díaz-Pallarés M, Pérez-Menéndez-Conde C, Bermejo-Vicedo T. Systematic review of computerized prescriber order entry and clinical decision support. *Am J Health-Syst Pharm*. 2018;75(23):1909-1921.[16]

This study was a systematic review of literature to understand the benefit of combining CPOE with clinical decision support (CDS) in reducing medication errors and adverse drug events. While these interventions are generally thought to increase safety in the MUP, the impact varies widely, as the terminology and methodology vary greatly. However, not all studies have found increased safety, and CPOE with CDS does introduce new errors to the system. Understanding the benefit of these technologies can further justify the use of CPOE with CDS in improving care and utilization at all points of prescribing.

A robust strategy was used to identify all potential articles for inclusion. Utilizing 2 independent reviewers for final decisions, the researchers selected a total of 19 articles for detailed review and to classify medication errors into stages and types.

When compared to manual prescribing, CPOE was found to yield a significant (71%) reduction in prescribing errors, but the technology did not impact any other stages of the MUP. In reviewing the types of medication errors, the investigators found that CPOE did not have an impact in any category except for duplication errors, which were increased. The categories that had measured reductions due to use of CPOE included wrong drug, dose, or strength errors; frequency errors; administration route errors; and drug-drug interactions. Another type of error that was increased was wrong drug selection, and this was mainly observed

Figure 1. Inclusion and exclusion of articles.



when drop-down boxes were used for drug selection.

This article demonstrates the impact that CPOE with CDS has on the prescribing phase of the MUP. While the time and resources that go into implementing and maintaining these systems is significant, it can also positively impact patient care. However, there are new errors that are introduced, and one must be vigilant to ensure that the design and monitoring of the system continues to make improvements to patient care.

Korb-Savoldelli V, Boussadi A, Durieux P, et al. Prevalence of computerized physician order entry systems–related medication prescription errors: a systematic review. *Int J Med Inform*. 2018;111:112-122.[17]

This study was a systematic review to evaluate the impact of CPOE implementation on the prevalence of medication prescription errors. The secondary objective was to categorize the different reasons for the described errors.

Two investigators independently screened all studies for inclusion and abstracted the data for review. Fourteen studies were included and summarized. The extracted data included all reported medication errors pooled into the following categories: wrong dose, wrong drug, wrong patient, wrong route, and wrong time. The

Table 1. Aggregate Scores for Selected Articles About Medication-Use Process (n = 47)[a]

MUP Step and Reference Number	Importance Ranking	
	Mean	Median (Range)
Prescribing/transcribing		
16	2.70	2 (1-9)
17	4.12	4 (1-8)
18	4.55	4 (1-9)
19	4.76	5 (1-8)
20	5.27	6 (1-9)
21	5.45	6 (1-9)
22	5.79	6 (1-9)
23	5.88	6 (1-9)
24	6.48	8 (1-9)
Dispensing		
25	3.81	3 (1-12)
26	4.69	4 (1-12)
27	4.97	5 (1-10)
28	5.63	6 (2-10)
29	6.03	6 (1-12)
30	6.03	6 (1-11)
31	6.00	6.5 (1-12)
32	6.56	6.5 (1-12)
33	7.16	8 (1-12)
34	8.25	9.5 (1-12)
35	9.13	9.5 (1-12)
36	9.75	11 (2-12)
Administration		
37	4.48	4 (1-9)
38	4.94	4 (1-13)
39	4.97	4 (1-13)
40	5.19	5 (1-13)
41	5.48	5 (1-13)
42	6.13	6 (1-13)
43	6.42	7 (1-13)
44	7.74	8 (1-13)
45	7.94	8 (1-13)
46	8.23	9 (1-13)
47	8.35	9 (1-13)
48	10.32	11 (2-13)
49	10.81	12 (2-13)

researchers then determined if each error occurred due to CPOE or not. The median percentage of CPOE-related medication prescription errors in the included studies was 26.1% (interquartile range, 17.6%-42.1%). The median prevalence of wrong dose errors was 31.5%, while the median prevalence of wrong drug errors was 15%. The errors that arose from the implementation of CPOE were attributed to the ergonomy of the computer; alerts that failed, were overridden, or did not exist; and design limitations inherent in the CPOE system (eg, the system was unable to handle complex prescriptions).

Due to wide differences in how the studies reported results, it is difficult to compare errors across the studies. However, wrong dose and wrong drug errors were the most prevalent. Unique to this study was an analysis of why errors are occurring with CPOE. These reasons included incorrect selection of a drug from the drop-down menu and not ensuring that order sets and CPOE default settings are correct before implementation. Understanding these reasons can assist one in ensuring that the CPOE system is optimized based upon the data to minimize the occurrence of errors.

Légat L, Van Laere S, Nyssen M, et al. Clinical decision support systems for drug allergy checking: systematic review. *J Med Internet Res.* 2018;20(9):e258.[18]

This study describes a systematic review of the impact of CPOE with CDS systems on drug allergies. It is generally understood that drug allergies are overreported in patients' electronic health records. However, when true allergies exist, they can lead to significant morbidity and mortality. CDS systems can be very helpful in reducing medication errors by limiting the number of patients receiving a medication to which they have a true drug allergy.

A total of 69 studies were included in the systematic review. One of the major learnings was that there is no globally accepted systematic process for documenting drug allergies in the

Table 1. *Continued*

MUP Step and Reference Number	Importance Ranking	
	Mean	Median (Range)
Monitoring		
50	5.9	3.5 (1-27)
51	7.0	4 (1-27)
52	6.5	5 (1-21)
53	7.10	5.5 (1-20)
54	6.47	6 (1-18)
55	8.40	7 (1-25)
56	10.57	9 (1-27)
57	11.63	9 (3-28)
58	10.17	11 (1-18)
59	5.68	12 (2-28)
60	12.03	12 (3-26)
61	12.03	13 (1-25)
62	15.10	14 (7-26)
63	12.73	15 (1-21)
64	15.83	15 (6-28)
65	15.50	17 (1-23)
66	16.47	17 (2-23)
67	16.67	19 (1-23)
68	17.43	19 (1-26)
69	17.27	20 (2-27)
70	16.10	21 (2-27)
71	21.57	22 (2-28)
72	22.70	23 (11-28)
73	18.33	24 (1-28)
74	20.30	24 (2-27)
75	21.03	26 (3-27)
76	23.57	27 (4-28)
77	25.8	28 (3-28)

Abbreviation: MUP, medication-use process.
[a]Survey respondents ranked all articles within each group from most to least impactful, with the most impactful receiving a score of 1 and the least impactful receiving a score equal to the number of articles in that group (9 for prescribing/transcribing, 12 for dispensing, 13 for administration, 28 for monitoring). Articles are arranged from most to least impactful (ie, from lowest to highest median score).

medical record. This process includes the approach taken to engage with each patient, defining what is a drug allergy and what is a drug intolerance, and ensuring that the list is maintained over time. Having the same process, using the same location and database, and having the same taxonomy for all hospitals and all healthcare workers who engage with the patient is important. Without this for prescribers, there is inappropriate reporting of drug allergies, and this can lead to medication errors. Another concern that was identified is outdated or inaccurate allergy information. When this information is not correct, it can lead to either a drug being given to a patient who is allergic or withholding of a drug when the patient can safely receive it. A final issue that was raised is overall alert fatigue with drug allergy alerts. Knowing when to fire an alert and when to suppress it can be a critical insight with regard to CPOE settings.

While this is an area that is well known to be an issue for patient care, the published data in the systematic review is variable. Further research needs to be completed, including research to improve the coding and taxonomy of drug allergies, in order to minimize medication errors for drug allergies.

Dispensing

Roberts PA, Willoughby IR, Barnes N, et al. Evaluation of a gravimetric-based technology-assisted workflow system on hazardous sterile product preparation. *Am J Health-Syst Pharm*. 2018;75(17):1286-1292.[25]

Technology-assisted workflows (TAWFs) for compounded sterile product (CSP) preparation is an actively discussed topic in the profession of pharmacy, specifically in hospitals and health systems. Popular approaches to TAWFs include volumetric, gravimetric, or both volumetric and gravimetric technologies. This study assessed the impact of a gravimetric-based TAWF on CSP production time, staff perception of safety, and job satisfaction.

The study was a pre- and postintervention study of a TAWF in a cancer center satellite pharmacy. Prior to implementation of the TAWF, staff documented the time to prepare and check CSPs and took surveys regarding perceptions of and satisfaction with non-TAWF methods for CSP preparation. At 30 and 90 days post implementation, staff took the same surveys regarding gravimetric-based TAWF. Overall, relative to non-TAWF methods, TAWF use was associated

with improved preparation and verification times (445 seconds vs 359 seconds and 45 seconds versus 19 seconds, respectively). The investigators concluded that this decreased preparation and verification time resulted from reducing the amount of transcribing and the streamlining of the preparation and verification processes with a TAWF. Additionally, staff preferred the TAWF for CSP preparation over non-TAWF methods. However, there was no change in staff perception regarding medication safety.

This study further increases the literature in the area of TAWF for CSP preparation. As this topic continues to be discussed, additional research to evaluate TAWF vs non-TAWF methods is needed. Future studies should focus on both medication safety and productivity and efficiency.

Gurusamy KS, Best LM, Tanguay C, et al. Closed-system drug-transfer devices plus safe handling of hazardous drugs versus safe handling alone for reducing exposure to infusional hazardous drugs in healthcare staff. *Cochrane Database Syst Rev*. 2018;3:CD012860.[26]

Closed system transfer devices (CSTDs) aid in the preparation and administration of hazardous medications. Patient and staff exposure to hazardous medications can result in negative health outcomes. The objective of this systematic review was to assess the effects of using CSTDs and safe handling vs safe handing alone for reducing staff exposure to hazardous medications and the risk of staff contamination.

The researchers reviewed 23 observational cluster studies that spanned use of a broad range of CSTDs from different manufacturers. They concluded that there is no difference in the proportion of people with positive urine tests for exposure between CSTD and control groups. Additionally, the review illustrated that the studies evaluated did not focus on atmospheric contamination, blood tests, or other measures of exposure to hazardous medications. None of the studies included in the review reported on short-term health benefits. Five included studies reported the potential costs savings, but the studies used different methods and were significantly variable. Ultimately, the investigators concluded that there is no evidence to support or reduce the routine use of CSTD in addition to safe handling of hazardous medications, as there is no evidence of a difference in exposure or financial benefits between CSTDs plus safe handling vs safe handling alone. Additionally, they noted that the evidence was of low quality and that none of the studies reported on health benefits.

Due to the researcher's conclusions regarding CSTDs, additional research is needed. However, it should be noted that the conclusions of this review are a topic of debate in the profession of pharmacy.[78] Future studies in this area should focus on decreasing the risk of bias, increasing consistency, improving the level of evidence, and reporting on health benefits.

Rodriguez-Gonzalez CG, Herranz-Alonso A, Escudero-Vilaplana V, et al. Robotic dispensing improves patient safety, inventory management, and staff satisfaction in an outpatient hospital pharmacy. *J Eval Clin Pract.* 2019;25(1):28-35.[27]

Apart from acute care settings, hospital and health-system departments of pharmacy are continuing to investigate opportunities to better utilize automation and robotics in ambulatory care settings. One such avenue includes the utilization of robotics for dispensing in ambulatory care spaces. The purpose of this study was to identify the frequency of medication dispensing errors before and after the implementation of a robotic dispensing system in an ambulatory hospital pharmacy. The researchers also wanted to assess the impact of the robotics on the quality of stock management and staff satisfaction.

This study consisted of a before-and-after medication error assessment conducted through use of observations. Additionally, the investigators monitored indicators of stock management and staff satisfaction. During the preimplementation phase, staff used a barcode system for dispensing, and during the postimplementation phase, staff retrieved medications that were dispensed from a robot. The researchers concluded that the introduction of the robot in an ambulatory pharmacy reduced rates of dispensing errors (from 1.31% to 0.63%) and "stockouts" of medications (from 0.85% to 0.17%). Additionally, staff perceived this technology to be beneficial, and stocking time was reduced.

When used appropriately, automation and robotics can aid in improving the MUP. In addition to improving the MUP, these areas of practice can improve medication safety and staff satisfaction. However, future studies should look to evaluate automation and robotics use in ambulatory care settings to add to the overall body of knowledge.

Administration

Biltoft J, Finneman L. Clinical and financial effects of smart pump–electronic medical record interoperability at a hospital in a regional health system. *Am J Health-Syst Pharm*. 2018;75(14):1064-1068.[37]

Administration of i.v. medications is essential in advanced medical care. The use of smart i.v. infusion pumps with dose-error reduction software has been proven to help avert potential administration errors, but a previous study demonstrated that even when smart pumps are used there is a high likelihood of discrepancy between what is ordered, administered, and documented as administered. Interoperability of smart pumps and the electronic health record (EHR) makes it possible for infusion pump programming to be automatically prepopulated by the EHR and checked against medication orders to prevent discrepancies and administration errors. Interoperability also provides accurate infusion start and stop times, which is necessary for reimbursement of outpatient infusions by payers.

This study described the implementation of pump-EHR interoperability at a 286-bed hospital within an 8-hospital health system and evaluated the

impact on medication safety, financial performance improvements, and stakeholder satisfaction. Interoperability reduced manual keystrokes in the smart pumps by 86%, eliminating 3.5 million keystrokes and opportunities for error every month. The mean number of monthly pump programming alerts decreased by 22%, and the mean number of alert overrides decreased by 20.5%. Self-reported annual safety events related to infusion pump programming were reduced from 3 to 1. The mean amount of lost charges for outpatient infusions decreased by 40%, representing $370,000 in incremental revenue. Nursing staff reactions to the new process were favorable, and clinicians reported increased satisfaction from knowing they could confidently manage i.v. medications with greater safety.

This study demonstrated that smart pump and EHR interoperability decreases the likelihood of pump programming errors and increases the accuracy of documentation. The measured improvement in i.v. charge capture produced by interoperability could help leaders gain additional administrative support for implementation. Interoperability of additional smart medical devices with the EHR will play an increasing role in improving patient safety, clinical outcomes, staff productivity, and financial performance in the years ahead.

Shah PK, Irizarry J, O'Neill S. Strategies for managing smart pump alarm and alert fatigue: A narrative review. *Pharmacotherapy*. 2018; 38(8):842-850.[38]

One challenge associated with the use of smart infusion pump technology is high alarm and alert burden, often with low predictive power for clinically meaningful events. While alerts can help prevent medication errors, alert fatigue can occur when users receive an overwhelming number of clinically insignificant alerts and unintentionally begin ignoring alerts. Alert fatigue could limit the benefits of smart pump technology and potentially increase the occurrence of errors if users blindly trust the technology and bypass verification of the traditional medication administration "rights."

The authors of this review article used a systematic approach to identify articles describing the types of alerts and alarms seen with smart pumps and present strategies for managing alert fatigue related to smart pump use. Twenty-nine articles were included in the final review. Multiple frameworks for evaluating alert fatigue exist, but there has not been consensus on which metrics or proxy measures to use, and none have been validated. The most common types of alerts included dose alerts, concentration alerts, and duration or rate alerts. Smart pump alerts contributed 9.6% of the total alarm burden experienced in one included observational study and had a lower positive predictive value than that of all medical devices combined (7.6% vs 36.2%).

The researchers reported that although many strategies for reducing alert fatigue have been proposed in the literature, few have been evaluated using appropriate study designs. Most of the published literature on smart pump quality improvement efforts suggested the use of a multidisciplinary team to oversee the efforts. There was not consensus on how to optimally set occlusion alarm thresholds and air-in-line alarms. The researchers described several different approaches for retrospectively analyzing smart pump logs and updating the drug limit library.

Reducing alert fatigue from smart pumps and other medical technologies remains a high priority for healthcare organizations and is necessary to improve patient safety. There is a need for future studies to continue to identify and evaluate strategies for reducing alert fatigue and quantify the impact on patient safety.

Lyons I, Furniss D, Blandford A, et al. Errors and discrepancies in the administration of intravenous infusions: a mixed methods multihospital observational study. *BMJ Qual Saf*. 2018;27(11):892-901.[39]

Although smart pumps reportedly improve patient safety by incorporating dose-error reduction software, programming procedures may be bypassed and dose limits may be overridden. Evidence regarding smart pumps' true impact on patient safety is mixed, and questions about whether smart pumps meaningfully reduce the occurrence of potentially harmful errors remain.

The objectives of this observational point prevalence study were to determine the prevalence, types, and severity of errors and discrepancies in intravenous infusions across 16 hospitals in the United Kingdom. Trained researches at each site observed and compared 2,008 in-progress medication administrations with prescribed orders and local policies. Deviations were classified as errors or discrepancies based on their potential for patient harm. Just 32% of infusions were administered using a smart pump because some of the hospitals did not use smart pumps at all while others limited smart pump use to specific care areas or had incomplete smart pump drug libraries. Errors and discrepancies were observed in 11.5% and 53% of infusions, respectively. Ninety percent of observed errors were considered unlikely to cause patient harm, while 23 errors were considered potentially harmful and none were judged likely to prolong hospital stay or result in long-term harm. Interestingly, the error rate for infusions delivered using smart pumps was similar to that with use of other pumps (10.3% vs 10.8%, $P = 0.8$) and error rates also did not differ when prebuilt drug libraries were used. The investigators concluded that smart pumps, as currently implemented in UK hospitals, did not seem to reduce the risk of error in everyday practice. They hypothesized that using smart pumps as part of an integrated system with barcode scanning and electronic prescribing and medication administration records, all of which were rarely used by the included hospitals, could guard against a broader range of deviations.

This study provides valuable insight into the prevalence, type, and severity of i.v. infusion deviations in everyday

practice. It also underscores the importance of taking a multifaceted approach to improving safety due to the interconnectedness of each of the steps in the MUP.

Monitoring

Winterstein AG, Jeon N, Staley B, et al. Development and validation of an automated algorithm for identifying patients at high risk for drug-induced hypoglycemia. *Am J Health-Syst Pharm.* 2018;75(21): 1714-1728.[49]

Hypoglycemia is a common condition and is one of the most concerning adverse events that can occur in institutionalized and critically ill patients. Utilizing predictive modeling and data analytics can be a beneficial tool to identify high-risk patients and minimize this adverse event.

This study was a retrospective cohort analysis of hospitalized patients using EHR data from 2 large University of Florida–affiliated hospitals. The study population consisted of 21,840 patients who received any medications that could increase the risk of hypoglycemia within the first 5 days of hospital admission. Candidate risk predictors were identified using EHR data. Variables considered fell into different categories, including demographic related, blood glucose related, antihyperglycemic drug related, oral intake related, service location related, laboratory value related, and comorbidity related. The development and validation period included 60,762 risk model days followed by 1,256 days with hypoglycemic events. The strongest hypoglycemic risk factors were blood glucose fluctuations, blood glucose trend, history of hypoglycemia, lower body weight, lower creatinine clearance, use of insulin, and use of a sulfonylurea. The risk model predicted 48.5% to 63.1% of hypoglycemic events.

The widespread adoption of the EHR allows for the collection of significant data. This project illustrated the importance of using this data to help prevent unwanted adverse events and subsequently improve quality of care. Results of the project indicated that use of an automated risk algorithm would prevent 1 hypoglycemic event per approximately 9 admissions. A significant limitation of this study was that the risk model was limited to data obtained in routine clinical care. This study highlighted how using data and the EHR can help target efforts towards improving care.

Peyko V, Friedman-Jakubovics M. Novel approach to vancomycin level monitoring: Impact of a multidisciplinary monitoring system on timing of vancomycin levels. *Am J Health-Syst Pharm.* 2018;75(3): 121-126.[50]

Significant pharmacy resources are dedicated across the country to managing vancomycin levels due to the fine balance between therapeutic levels and potential toxicity. However, many institutions use different methods to monitor vancomycin levels, and true pharmacokinetic analysis is time consuming and often burdensome to perform.

This before-and-after study evaluated a novel approach to monitoring vancomycin levels at an 864-bed teaching hospital in New York. Orders for vancomycin trough concentration determinations were added to the medication ordering system at a large teaching hospital. These orders were automatically generated when vancomycin was ordered, and pharmacists were able to adjust the order time so that blood sampling for trough measurements would be done at the appropriate time. The orders came up on the nurse's work list, and nurses were required to document blood sampling times. Outcomes in the prospective group were compared to those in a retrospective cohort in which vancomycin trough measurement was not ordered as part of the vancomycin order (ie, prior to implementation of the new process). There were 228 patients in the retrospective group and 199 patients in the prospective group. The study found that 24% of trough concentration measurements were performed within 2 hours of the true trough in the retrospective group, as compared with 87.2% of measurements in the prospective group ($P < 0.0001$).

This study highlighted how a combination of technology (enabled by the EHR), pharmacist involvement, and multidisciplinary planning can help improve monitoring for patients. Not only did this combination of interventions help increase appropriate timing of trough determinations, but it also increased the number patients who had a trough measurement ordered from 90% to 100%. This demonstrates efforts that institutions can employ to ensure compliance with best practices.

Su CP, Hidayat L, Rahman S, et al. Use of an anti-infective medication review process at hospital discharge to identify medication errors and optimize therapy. *J Pharm Pract.* 2019;32(5):488-492.[51]

Medication reconciliation is an essential step of the MUP and is an area that, if not addressed, can contribute to significant medication errors. Transitions of care, as it relates to antimicrobials, is a specific concern due to complexities in dosing regimens, length of therapy, and the high potential for inappropriate therapy based on lack of available patient data.

This study was a single-center prospective study with the aim to describe a multidisciplinary approach to reviewing antimicrobials at discharge and measuring the impact of this stewardship-initiated antimicrobial review to identify medication errors. A multidisciplinary approach to review discharge prescriptions was developed; this approach included identification of anticipated discharges in the next 48 hours, prescriptions being entered in the EHR, anti-infective agent evaluation by the antimicrobial stewardship team, and recommendations to the primary team prior to discharge. Medication errors were identified according to NCC MERP (National Coordinating Council for Medication Error Reporting and Prevention) guidelines and were classified into the following predefined categories: safety,

efficacy, and simplification.[79] Forty-five patients who were taking a total of 59 anti-infective medications at discharge were ultimately evaluated. The most common indications were pneumonia, bacteremia, and skin and soft tissue infections. A medication error was identified in 42% of discharge regimens. When errors were identified, pharmacist recommendations were accepted 70% of the time.

This study demonstrated a successful approach to addressing a critical need for pharmacist intervention at transitions of care through medication reconciliation. It also demonstrated that medication errors are prevalent at discharge. Studies have shown that medication errors can occur more frequently at discharge due to the complex coordination often required. Developing structured processes to evaluate discharge medications is crucial to minimize harm and proven to be a valuable use of clinical pharmacist resources.

Conclusion

As summarized here, there were many practice-enhancing articles published in 2018 that focused on improving the MUP. For this review the authors expanded a previously used search strategy, and we believe that this increased the strength of returned articles. However, being aware of the articles that were determined to be the most impactful can assist clinicians in ensuring that their operations are following the evidence. The authors noticed that more identified articles pertained to the monitoring step than the other 3 steps, which is consistent with the results of the study completed previously.[13] Due to there being a large amount of literature focused on the MUP, this demonstrates that this area of pharmacy practice is still actively evaluated and discussed in peer-reviewed literature.

Among other limitations, this review was based on a review of the literature by pharmacy leaders within a single state, potentially biasing the rating of the articles toward specific issues that are more prevalent in that state. However, each person involved in rating was asked to consider the broader practices of pharmacy in his or her review. The review contained a significantly larger sample of articles than a previous similar review in order to ensure that all potentially relevant articles were included. Due to the large volume of articles reviewed, this could have resulted in an article being missed for evaluation. In future literature reviews, the authors plan to include hospital leaderships from additional sites to further expand applicability of significant articles to a boarder audience. Additionally, search strategies will be optimized to identify articles describing newer technologies and interventions that may not be otherwise captured using MeSH terms.

Pharmacists have a duty to review and incorporate these best practices into their organizations in order to improve efficiency of care and cost outcomes, to optimally utilize the technology that is in use, and to reduce the potential for medication errors.[1] Providing a review of key articles from 2018 surrounding the MUP can educate health-system pharmacists on evidence-based solutions that will be helpful, no matter their practice setting or location.

Disclosures

Dr. Eckel is currently serving on the ASHP Board of Directors. The other authors have declared no potential conflicts of interest.

References

1. Moore SJ, Jenkins AT, Poppe LB, Rowe EC, Eckel SF. Significant publications about the medication use process in 2012. *J Pharm Pract.* 2015;28(4):387-397.
2. U.S. Pharmacopeia National Formulary. Revision bulletin: <1006> physical environments that promote safe medication use. https://www.uspnf.com/sites/default/files/usp_pdf/EN/USPNF/c1066.pdf. Published October 1, 2010. Accessed September 6, 2018.
3. Pederson CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: prescribing and transcribing—2016. *Am J Health-Syst Pharm.* 2017;74(17):1336-1352.
4. The consensus of the Pharmacy Practice Model Summit. *Am J Health-Syst Pharm.* 2011;68(12):1148-1152.
5. American Pharmacists Association. Vision and mission for the pharmacy profession: APhA vision for the profession. https://www.pharmacist.com/vision-and-mission-pharmacy-profession. Published June 2011. Accessed September 6, 2018.
6. Pederson CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: monitoring and patient education—2015. *Am J Health-Syst Pharm.* 2016;73(17):1307-1330.
7. Schneider PJ, Pedersen CA, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: dispensing and administration—2017. *Am J Health-Syst Pharm.* 2018;75(16):1203-1226.
8. Fong G, Skoglund EW, Phe K et al. Significant publications on infectious diseases pharmacotherapy in 2016. *J Pharm Pract.* 2018;31(5):469-480.
9. Babic JT, Sofjan A, Babin M et al. Significant publications on infectious diseases pharmacotherapy in 2015. *Am J Health-Syst Pharm.* 2017;74(4):238-252.
10. Wong A, Erdman M, Hammond DA et al. Major publications in the critical care pharmacotherapy literature in 2015. *Am J Health-Syst Pharm.* 2017;74(5):295-311.
11. Skoglund EW, Dotson KM, Dempsey CJ et al. Significant publications on infectious diseases pharmacotherapy in 2017. *J Pharm Pract.* 2019;32(5):534-545.
12. Jackevicius CA, Page RL, Buckley LF, Jennings DL, Nappi JM, Smith AJ. Key articles and guidelines in the management of heart failure: 2018 update. *J Pharm Pract.* 2019;32(1):77-92. doi.org/10.1177/0897190018819413.
13. Vest TA, Gazda NP, Schenkat DH, Eckel SF. Practice-enhancing publications about the medication use process in 2017. *Am J Health-Syst Pharm.* 2019;76(10):667-676.
14. Beckett RD, Bickett S, Gu X et al. *AACP core list of journals for pharmacy education*, 6th edition. Alexandria, VA: American Association of Colleges of Pharmacy; 2016.
15. Rodriguez RW. Delay in indexing articles published in major pharmacy practice journals. *Am J Health-Syst Pharm.* 2014;71(4):321-324.
16. Vélez-Díaz-Pallarés M, Pérez-Menéndez-Conde C, Bermejo-Vicedo T. Systematic review of computerized

prescriber order entry and clinical decision support. *Am J Health-Syst Pharm.* 2018;75(23):1909-1921.
17. Korb-Savoldelli V, Boussadi A, Durieux P et al. Prevalence of computerized physician order entry systems-related medication prescription errors: a systematic review. *Int J Med Inform.* 2018;111:112-122.
18. Légat L, Van Laere S, Nyssen M et al. Clinical decision support systems for drug allergy checking: systematic review. *J Med Internet Res.* 2018;20(9):e258.
19. Kang A, Thompson A, Rau J et al. Effects of clinical decision support and pharmacist prescribing authority on a therapeutic interchange program. *Am J Health-Syst Pharm.* 2018;75(17)(suppl 3):S77-S81.
20. Rouayroux N, Calmels V, Bachelet B et al. Medication prescribing errors: a pre- and post-computerized physician order entry retrospective study. *Int J Clin Pharm.* 2019;41(1):228-236.
21. Chung C, Patel S, Lee R et al. Implementation of an integrated computerized prescriber order-entry system for chemotherapy in a multisite safety-net health system. *Am J Health-Syst Pharm.* 2018;75(6):398-406.
22. Desmedt S, Spinewine A, Jadoul M et al. Impact of a clinical decision support system for drug dosage in patients with renal failure. *Int J Clin Pharm.* 2018;40(5):1225-1233.
23. Harvey S, Brad Hall A, Wilson K. Impact of an emergency medicine pharmacist on initial antibiotic prophylaxis for open fractures in trauma patients. *Am J Emerg Med.* 2018;36(2):290-293.
24. Sato I, Yamamoto Y, Kato G et al. Potentially inappropriate medication prescribing and risk of unplanned hospitalization among the elderly: a self-matched, case-crossover study. *Drug Saf.* 2018;41(10):959-968.
25. Roberts PA, Willoughby IR, Barnes N et al. Evaluation of a gravimetric-based technology-assisted workflow system on hazardous sterile product preparation. *Am J Health-Syst Pharm.* 2018;75(17):1286-1292.
26. Gurusamy KS, Best LM, Tanguay C et al. Closed-system drug-transfer devices plus safe handling of hazardous drugs versus safe handling alone for reducing exposure to infusional hazardous drugs in healthcare staff. *Cochrane Database Syst Rev.* 2018;3:CD012860.
27. Rodriguez-gonzalez CG, Herranz-alonso A, Escudero-vilaplana V et al. Robotic dispensing improves patient safety, inventory management, and staff satisfaction in an outpatient hospital pharmacy. *J Eval Clin Pract.* 2019;25(1):28-35.
28. Lin AC, Deng Y, Thaibah H et al. The impact of using an intravenous workflow management system (IVWMS) on cost and patient safety. *Int J Med Inform.* 2018;115:73-79.
29. Achey TS, Riffle AR, Rose RM et al. Development of an operational productivity tool within a cancer treatment center pharmacy. *Am J Health-Syst Pharm.* 2018;75(21):1736-1741.
30. Mekoba BC, Turingan EM, Roberts PA et al. A pharmacy-led *United States Pharmacopeia* (*USP*) chapter 800 compliance collaborative at an academic medical center. *Am J Health-Syst Pharm.* 2018;75(10):627-632.
31. Hickman L, Poole SG, Hopkins RE et al. Comparing the accuracy of medication order verification between pharmacists and a tech check tech model: a prospective randomised observational study. *Res Social Adm Pharm.* 2018;14(10):931-935.
32. Murugan S, Parris P, Wells M. Drug preparation and administration errors during simulated paediatric resuscitations. *Arch Dis Child.* 2019;104(5):444-450.
33. Fleagle Miller R, Cesarz J, Rough S. Evaluation of community pharmacy tech-check-tech as a strategy for practice advancement. *J Am Pharm Assoc (2003).* 2018;58(6):652-658.
34. Berdot S, Blanc C, Chevalier D et al. Impact of drug storage systems: a quasi-experimental study with and without an automated-drug dispensing cabinet. *Int J Qual Health Care.* 2019;31(3):225-230.
35. Berdot S, Korb-Savoldelli V, Jaccoulet E et al. A centralized automated-dispensing system in a French teaching hospital: return on investment and quality improvement. *Int J Qual Health Care.* 2019;31(3):219-224.
36. Beobide Telleria I, Ferro Uriguen A, Miró Isasi B et al. The impact of automation on the safety of drug dispensing in nursing homes. *Farm Hosp.* 2018;42(4):141-146.
37. Biltoft J, Finneman L. Clinical and financial effects of smart pump-electronic medical record interoperability at a hospital in a regional health system. *Am J Health-Syst Pharm.* 2018;75(14):1064-1068.
38. Shah PK, Irizarry J, O'Neill S. Strategies for managing smart pump alarm and alert fatigue: a narrative review. *Pharmacotherapy.* 2018;38(8):842-850.
39. Lyons I, Furniss D, Blandford A et al. Errors and discrepancies in the administration of intravenous infusions: a mixed methods multihospital observational study. *BMJ Qual Saf.* 2018;27(11):892-901.
40. Brown TD, Michael M, Grady DS. Implementation of smart pump technology with home infusion providers: an assessment of clinician workflow and patient satisfaction. *J Infus Nurs.* 2018;41(6):344-349.
41. Walroth TA, Smallwood S, Arthur K et al. Development of a standardized, citywide process for managing smart-pump drug libraries. *Am J Health-Syst Pharm.* 2018;75(12):893-900.
42. Thompson KM, Swanson KM, Cox DL et al. Implementation of bar-code medication administration to reduce patient harm. *Mayo Clin Proc Innov Qual Outcomes.* 2018;2(4):342-351.
43. Ni Y, Lingren T, Hall ES et al. Designing and evaluating an automated system for real-time medication administration error detection in a neonatal intensive care unit. *J Am Med Inform Assoc.* 2018;25(5):555-563.
44. Wilkinson AS, Allwood MC, Morris CP et al. Performance testing protocol for closed-system transfer devices used during pharmacy compounding and administration of hazardous drugs. *PLoS ONE.* 2018;13(10):e0205263.
45. Brunsman AC. Using lean methodology to optimize time to antibiotic administration in patients with sepsis. *Am J Health-Syst Pharm.* 2018;75(5)(suppl 1):S13-S23.
46. Macias M, Bernabeu-andreu FA, Arribas I, Navarro F, Baldominos G. Impact of a barcode medication administration system on patient safety. *Oncol Nurs Forum.* 2018;45(1):E1-E13.
47. Van Ornum M. Improving bar code medication administration compliance in a community hospital through a nursing leadership initiative. *J Nurs Care Qual.* 2018;33(4):341-347.
48. Delaurentis P, Hsu KY, Bitan Y. Prevalence of wireless smart-pump drug library update delays. *Am J Health-Syst Pharm.* 2018;75(15):1140-1144.
49. Schutijser BCFM, Klopotowska JE, Jongerden IP et al. Interruptions during intravenous medication administration: a multicentre observational study. *J Adv Nurs.* 2019;75(3):555-562.
50. Winterstein AG, Jeon N, Staley B et al. Development and validation of an automated algorithm for identifying patients at high risk for drug-induced hypoglycemia. *Am J Health-Syst Pharm.* 2018;75(21):1714-1728.
51. Peyko V, Friedman-Jakubovics M. Novel approach to vancomycin level monitoring: impact of a multidisciplinary monitoring system on timing of vancomycin levels. *Am J Health-Syst Pharm.* 2018;75(3):121-126.

52. Su CP, Hidayat L, Rahman S et al. Use of an anti-infective medication review process at hospital discharge to identify medication errors and optimize therapy. *J Pharm Pract.* 2019;32(5):488-492.
53. Nguyen AD, Lam A, Banakh I et al. Improved medication management with introduction of a perioperative and prescribing pharmacist service [published online ahead of print October 8, 2018]. *J Pharm Pract.* doi:10.1177/0897190018804961.
54. Nguyen MR, Mosel C, Grzeskowiak LE. Interventions to reduce medication errors in neonatal care: a systematic review. *Ther Adv Drug Saf.* 2018;9(2):123-155.
55. Van de Vreede M, Mcgrath A, De Clifford J. Review of medication errors that are new or likely to occur more frequently with electronic medication management systems [published online ahead of print May 14, 2018]. *Aust Health Rev.* 2018. doi:10.1071/AH17119.
56. Deronde K, Palmer C, Gralla J et al. Establishment of a medication acuity scoring tool at a tertiary pediatric teaching hospital: a 2-phase process [published online ahead of print August 21, 2018]. *J Pharm Pract.* doi:10.1177/0897190018795261.
57. Austin JA, Smith IR, Tariq A. The impact of closed-loop electronic medication management on time to first dose: a comparative study between paper and digital hospital environments. *Int J Pharm Pract.* 2018;26(6):526-533.
58. Davis J, Harrington N, Bittner Fagan H et al. The accuracy of trigger tools to detect preventable adverse events in primary care: a systematic review. *J Am Board Fam Med.* 2018;31(1):113-125.
59. Carver KH, Burgess LH, Cooper M et al. Use of clinical decision support to identify i.v.-to-oral conversion opportunities and cost savings. *Am J Health-Syst Pharm.* 2018;75(23)(suppl 4):S82-S86.
60. Hunt KV, Harding AM, Taylor SE et al. Evaluation of medication dose omissions amongst inpatients in a hospital using an electronic medication management system. *J Eval Clin Pract.* 2018;24(4):688-694.
61. Abdulghani KH, Aseeri MA, Mahmoud A et al. The impact of pharmacist-led medication reconciliation during admission at tertiary care hospital. *Int J Clin Pharm.* 2018;40(1):196-201.
62. Uppuluri EM, Mccomb MN, Shapiro NL. Implementation of a direct oral anticoagulation screening service at a large academic medical center provided by a pharmacist-managed antithrombosis clinic as a method to expand antithrombotic stewardship efforts [published online ahead of print September 13, 2018]. *J Pharm Pract.* doi:10.1177/0897190018799200.
63. Craynon R, Hager DR, Reed M et al. Prospective daily review of discharge medications by pharmacists: Effects on measures of safety and efficiency. *Am J Health-Syst Pharm.* 2018;75(19):1486-1492.
64. Bledsoe S, Van Buskirk A, Falconer RJ et al. Errors detected in pediatric oral liquid medication doses prepared in an automated workflow management system. *Am J Health-Syst Pharm.* 2018;75(3):127-131.
65. Mcauliffe LH, Zullo AR, Dapaah-Afriyie R et al. Development and validation of a transitions-of-care pharmacist tool to predict potentially avoidable 30-day readmissions. *Am J Health-Syst Pharm.* 2018;75(3):111-119.
66. Warttig S, Alderson P, Evans DJ et al. Automated monitoring compared to standard care for the early detection of sepsis in critically ill patients. *Cochrane Database Syst Rev.* 2018;6:CD012404.
67. Fennelly JE, Coe AB, Kippes KA, et al. Evaluation of clinical pharmacist services in a transitions of care program provided to patients at highest risk for readmission [published online ahead of print October 21, 2018]. *J Pharm Pract.* doi:10.1177/0897190018806400.
68. Jobin J, Irwin AN, Pimentel J et al. Accuracy of medication histories collected by pharmacy technicians during hospital admission. *Res Social Adm Pharm.* 2018;14(7):695-699.
69. Harvin A, Mellett JJ, Knoell D et al. Implementation of a prioritized scoring tool to improve time to pharmacist intervention. *Am J Health-Syst Pharm.* 2018;75(1):e50-e56.
70. Shull MT, Braitman LE, Stites SD et al. Effects of a pharmacist-driven intervention program on hospital readmissions. *Am J Health-Syst Pharm.* 2018;75(9):e221-e230.
71. Peterson J, Hinds A, Garza A et al. Impact of physician-pharmacist covisits at a primary care clinic in patients with uncontrolled diabetes [published online ahead of print November 14, 2018]. *J Pharm Pract.* doi:10.1177/0897190018807374.
72. Amin PB, Bradford CD, Rizos AL et al. Measuring the impact of medication-related interventions on 30-day readmission rates in a skilled nursing facility [published online ahead of print October 21, 2018]. *J Pharm Pract.* doi:10.1177/0897190018803229.
73. Leary MH, Morbitzer K, Walston BJ et al. Evaluation of targeted pharmacist interventions to reduce length of stay in an acute care practice model. *Ann Pharmacother.* 2019;53(5):471-477.
74. Digiantonio N, Lund J, Bastow S. Impact of a pharmacy-led medication reconciliation program. *PT.* 2018;43(2):105-110.
75. Powers EM, Shiffman RN, Melnick ER et al. Efficacy and unintended consequences of hard-stop alerts in electronic health record systems: a systematic review. *J Am Med Inform Assoc.* 2018;25(11):1556-1566.
76. Maaskant JM, Smeulers M, Bosman D et al. The trigger tool as a method to measure harmful medication errors in children. *J Patient Saf.* 2018;14(2):95-100.
77. Johnson K, Burkett GS, Nelson D et al. Automated e-mail reminders linked to electronic health records to improve medication reconciliation on admission. *Pediatr Qual Saf.* 2018;3(5):e109.
78. McDiarmid MA, Polovich M, Power LA et al. Published review of closed-system drug-transfer devices: limitations and implications. *Am J Health-Syst Pharm.* 2018;75(24):1982-1985.
79. Heintz BH, Halilovic J, Christensen CL. Impact of a multidisciplinary team review of potential outpatient parenteral antimicrobial therapy prior to discharge from an academic medical center. *Ann Pharmacother.* 2011;45(11):1329-1337.