Implementation and safety evaluation of autoverification for select low-risk, high-volume medications in the emergency department

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Purpose: Use of autoverification has decreased in many emergency departments (EDs) with the expansion of emergency medicine (EM) pharmacists. Few studies have evaluated ways to prioritize verification of medications. Here we describe a process to design, implement, and measure the safety of autoverification of low-risk, high-volume medications.

Summary: A 3-month retrospective review of medications ordered and administered in the ED generated a list of medications to be considered for autoverification. Concurrently, a novel risk stratification tool was created to identify low-risk medications. Taking these together, medications that were high volume and low risk were considered potentially autoverified medications (PAMs). To evaluate the safety of PAMs, a retrospective review of the ED medication orders placed before implementation of autoverification was performed. A total of 7,433 medication orders were reviewed. Of these, 3,057 orders (41%) were identified as PAMs. EM pharmacists verified 2,982 (97.5%) of the orders without changes. Of the remaining 93 orders that were modified or discontinued and met autoverification criteria, only 2 (0.07%) were identified as potentially inappropriate for autoverification.

Conclusion: Low-risk, high-volume medications can be safely autoverified in the ED by using a systematic approach to order selection. Using these methods can provide large decreases in verification volume, close to 41%, without compromising patient safety.

Keywords: autoverification, clinical pharmacy information systems, emergency department, emergency medicine, medication safety, pharmacy practice

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Clinical pharmacist review of medications in hospital settings leads to improved patient outcomes.[1,2] Pharmacist review of all medication orders for appropriateness before dispensing and administration is considered best practice according to The Joint Commission (TJC) management standard MM.04.10.[2] However, in some settings, such as the emergency department (ED), pharmacist review remains an exception according to TJC standard MM.05.01.01.[2] This exception is intended to minimize treatment delays and patient backup in the ED. Autoverification is a tool within the electronic health record (EHR) that allows for reallocation of pharmacists' time for more urgent activities, but also introduces potential patient safety risks in bypassing the pharmacist's review. By bypassing review, medications are available for administration immediately after orders are placed and signed. In a recent national survey of pharmacy practice in hospital settings, utilization of autoverification was found to be on the rise, increasing from 51% in 2016 to 62% in 2019.[3,4]

The presence of pharmacists in EDs has become commonplace, resulting in the expectation that pharmacists review more medication orders.[5-8] However, there is limited information available on ways to prioritize the

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verification of medications within the ED. In the report "Advances in patient safety: new directions and alternative approaches" published by the Agency for Healthcare Research and Quality, Fairbanks et al[9] found that pharmacists should maintain surveillance of provider orders. However, providers in the study did not express a need for 100% review of orders, but rather a focus on higher-risk medications and increased time at the bedside. Flynn[10] noted that, in the era of computerized prescriber order entry, near-universal prospective order review (NUPOR) has yet to provide a meaningful improvement in patient outcomes data. Emergency medicine (EM) pharmacists must adapt to meet the increasing demands of the ED by prioritization of important responsibilities such as attendance and active participation in emergent situations while balancing the need for medication review. The majority of medication error interceptions by EM pharmacists occur during consultative activities, as described by Patanwala et al,[11] with 89% of medication errors intercepted at the prescribing phase, followed by 7% at the administration phase.[12] Having EM pharmacists at the bedside during critical situations allows for optimization of medication selection while assisting in preparation and administration aspects. The opportunity cost of NUPOR by an EM pharmacist can be substantial, potentially decreasing the overall medication safety processes in the ED.[10] EM pharmacists at our site spend a significant portion of their time on order verification. Autoverification of low-risk, high-volume medications offers the ability to repurpose this time on tasks more impactful to patient outcomes. This investigative report aims to add to the limited literature regarding the appropriate use of autoverification and to refine our health system's approach to pharmacist prospective order review in the ED.

This study was exempt from institutional review board review as the project was considered a quality improvement project and did not meet the definition of research as defined by 45 CFR 46.102(d).

KEY POINTS

- Autoverification of selected medication orders in the emergency department is feasible without compromising safety.
- Selective autoverification can reduce pharmacist verification tasks by up to 40%, improving efficiency and freeing pharmacist time for tasks more impactful to patient care.
- Further research to support the safety of autoverification models such as risk-stratified assisted verification is needed.

Process

This project was approved by clinical pharmacy leadership, the medication management committee, the ED clinical operations committee, the medication safety committee, and the institutional information technology committee.

The American Society of Health-System Pharmacists (ASHP) states that, while NUPOR is ideal, triage systems should be in place to help prioritize evaluation of "high-risk medications, high-risk patient populations, and emergent or urgent situations."[13]

The 2019 ASHP House of Delegates report echoed this statement and called for further research to support the safety of autoverification models such as risk-stratified assisted verification.[14] In the absence of existing standardized models, we created a risk stratification scoring tool to define low-risk medications in the ED. Concurrently, we designed and built specific logic into the EHR to ensure appropriate autoverification vs manual review of our selected medications. To ensure the safety of our process, we conducted a retrospective review of our selected medications.

Setting. The study site included one academic hospital ED and one community hospital ED within the same health system located in Madison, WI. Characteristics of the EDs are provided in Table 1. The academic hospital had at least one EM pharmacist present in the ED at all hours of the day, 7 days a week. The affiliated community hospital did not have a pharmacist present in the ED; however, a centralized pharmacist reviewed all medications dispensed and administered in the community hospital ED and responded to the ED bedside for emergent events.

Selection of low-risk medications. To generate a list of high-volume medications to be considered for autoverification, a 3-month retrospective review of medications ordered and administered in the academic hospital ED from August 1 to October 31,

Table 1. Emergency Department Characteristics

Characteristic	Hospital 1	Hospital 2
Hospital type	Academic	Community
Annual ED visits	65,000	24,000
ED beds	58 (11 pediatric)	16
Trauma center	Yes	No
Order entry system	CPOE	CPOE
Pharmacist hours	EM pharmacist review 24/7 coverage	Central pharmacist review 24/7 coverage

Abbreviations: CPOE, computerized prescriber order entry; ED, emergency department; EM, emergency medicine.

2019, was performed. A total of 36,010 orders were verified by EM pharmacists in this time period. The top 10 medications are included in Table 2. These medications corresponded to 17,563 medication orders (48.7%) within the 3-month retrospective review. This initial list was then used as the basis to identify high-volume and perceived low-risk medications.

Development of a risk stratification scoring tool. The Institute for Safe Medication Practices provides robust definitions and guidance for the identification of high-alert medications.[15] Similarly to the study by Washburn et al,[16] we developed a modified high-alert medication checklist that assessed the inherent risk of medications (Appendix A). To objectively categorize these medications, we established a multidisciplinary committee consisting of an ED physician, an ED registered nurse, 2 EM pharmacists, and an informatics pharmacist. This committee met on several occasions and provided clinical recommendations and opinions for all medications that could be autoverified within the ED. Medications considered for autoverification by this committee had to meet the following criteria: (1) available in automated dispensing cabinets (ADCs) or ED floor stock and (2) not currently excluded from ADC override. Therefore, all medications dispensed from central pharmacy, antibiotics, long-acting pain medications, and vaccinations were not considered for autoverification, as they require prospective pharmacist review.[17,18] Priority of review and discussion was placed on the medications of highest volume based on the 3-month retrospective review. Medications that scored 2 or greater on the checklist were considered "high risk" and were not considered for autoverification. If disagreements occurred, they were discussed as a committee. The addition of an EM pharmacist with significant informatics experience allowed for discussion and generation of ideas to add to the informational model within the EHR to mitigate any concerns. A finalized list of medications is provided in Appendix B.

Informational model. For an order to be autoverified, it must pass a ruleset within the EHR. Figure 1 shows the logic utilized by the rules. First, the ordered medication must be included on the list of preselected low-risk medications. Second, medication orders could not trigger any warnings, whether these be warnings related to dose, allergy, or drug-drug interaction. These warnings were dictated by Medi-Span (Wolters Kluwer), a comprehensive drug database built within the EHR. Dose warnings would be triggered if a medication exceeded the maximum dose within a dosing range specified by the database. This database also considers renal and hepatic function. If a patient's allergy history had not been reviewed, the medication order would not autoverify. Third, the medication orders must be dispensed from ADCs located in the ED or the ED central supply stock. The health system utilizes a centralized medication distribution model; maintenance medications were therefore excluded with this rule. Fourth, only patients who were considered "ED patients," defined within the EHR as patients without a corresponding admitting primary team, were included for autoverification, thus excluding admitted patients, inpatients, and boarders to maintain compliance with TJC standards for pharmacist review of these patients.[2]Click or tap here to enter text. Because of safety concerns in the pediatric population (patients less than 18 years old), these patients were also excluded.

Safety evaluation. Retrospectively, all ED medication orders placed between January 20 and January 29, 2020, were collected. This time period was before implementation of autoverification and before changes in order volume secondary to the coronavirus disease 2019 (COVID-19) pandemic. From this group of orders, identification of all orders that would have been autoverified based on our EHR logic occurred, with the associated medications termed potentially autoverified medications (PAMs). Orders for these PAMs were then reviewed to evaluate whether pharmacist intervention was required to determine safety and appropriateness.

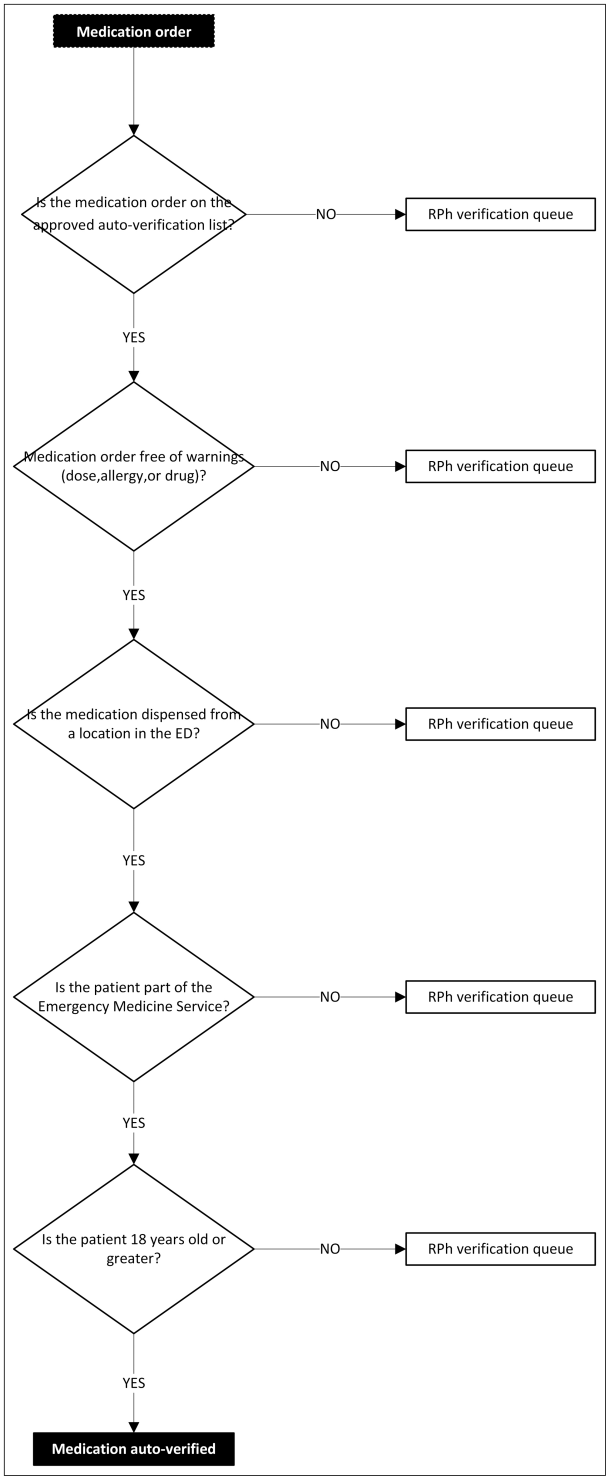
Data collection and processing for the safety evaluation. The internal EHR reporting functionality generated a comprehensive report that identified all medication orders placed in the selected period during January 2020. The report identified medication orders by dispensing location, date/

Table 2. Top 10 Medications Verified by Emergency Medicine Pharmacists in a 3-Month Period Before Autoverification Implementation[a]

Medication	Orders verified (N = 36,010)
0.9% sodium chloride (IV)	3,787 (10.5)
Acetaminophen (oral)	2,247 (6.2)
Non-IV lidocaine	2,218 (6.2)
Ondansetron (IV)	2,064 (5.7)
Hydromorphone (IV)	1,952 (5.4)
Lactated Ringer's (IV)	1,302 (3.6)
Ketorolac (IV)	1,184 (3.3)
Fentanyl citrate (IV)	1,067 (3.0)
Ibuprofen (oral)	1,033 (2.9)
Oxycodone (oral)	709 (2.0)

Abbreviation: IV, intravenous.
[a]Data shown as No. (%).

Figure 1. Logic for autoverification in the electronic health record. ED indicates emergency department.



time of order entry and verification, verifying user, medication record, and whether the medication met the predefined criteria for autoverification.

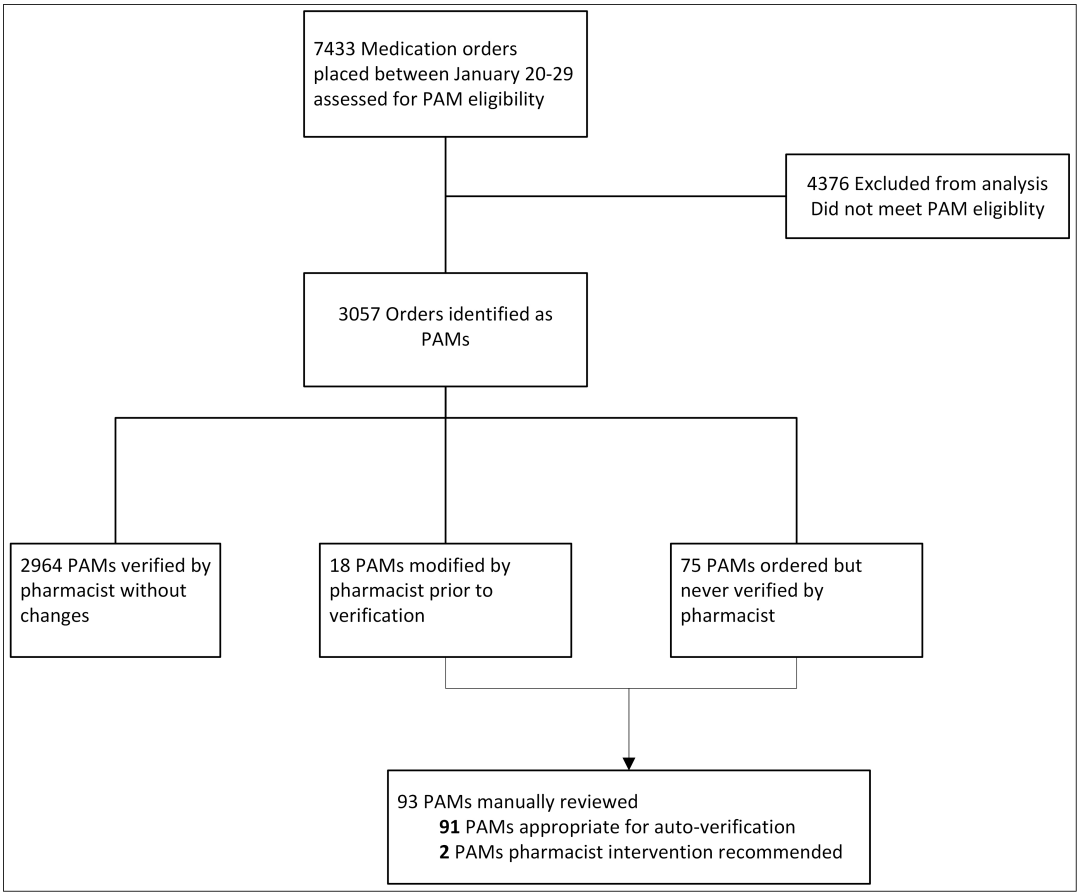
All PAMs that were verified by a pharmacist without changes were considered appropriate for autoverification, as a pharmacist reviewed the order in real time and verified it. All other PAMs that were discontinued or modified were manually reviewed retrospectively to capture the changes that pharmacists made based on their review of the medication orders. These orders were independently reviewed by 2 EM pharmacists to ensure consistency with the review process. Any order that the pharmacist would not have verified as ordered was documented.

To complete the manual retrospective review of orders not verified by a pharmacist, 2 subreports were created. The first subreport of "order changes" identified any changes to a medication order in the verification queue that could have been made by a pharmacist on verification and included the categories of priority, dose, route, rate, duration, volume, frequency, first dose, number of doses, start time, end time, note to pharmacy, administration instructions, medication dispense code, and patient age. The second subreport "nonverified" included all medication orders that were not manually verified by a pharmacist to identify any medication orders that may have been discontinued as a result of pharmacist intervention on the order. The orders represented in this report included orders that were never verified and were then discontinued by the same person who entered the order (and therefore assumed to be entered in error), orders that were never verified and were discontinued by someone other than the ordering user (presumably a pharmacist), and orders that was not manually verified and did not meet the criteria for the other categories.

Results of safety evaluation

Retrospective review of medication orders was completed before autoverification go-live. A total of 7,433 medication orders were entered in the EHR. Of these orders, 3,057 (41%) were identified as PAMs, as shown in Figure 2. The top 7 medications made up 67% of the total orders, the most frequent of which was 0.9% sodium

Figure 2. Retrospective review of orders before implementation of autoverification. PAM indicates potentially autoverified medications.



chloride. A total of 2,964 PAM orders (97%) were initially verified by the pharmacist without changes and were therefore considered appropriate for autoverification. Of the remaining orders, 18 were changed by the pharmacist within the verification queue, before verification, and 75 orders were placed by a provider and considered to be PAMs, but were never verified by a pharmacist. These 93 orders were manually reviewed. Two of these 93 orders were identified as needing pharmacist intervention by the 2 independent pharmacist reviewers. These 2 orders represented 0.07% of total orders. Both of these orders occurred at the academic hospital ED.

Discussion

The results of this study demonstrate that utilizing a systematic, multidisciplinary approach to identify and select low-risk, high-volume medications within the ED for autoverification can significantly reduce the number of orders that require pharmacist intervention while maintaining safety. Autoverification went live on April 28, 2020, and May 6, 2020, at the academic hospital ED and community hospital ED, respectively. This is the first report to evaluate the safety of autoverification of select medications in the ED population. Medication orders in the ED are most often single doses or of limited duration, which minimizes the risks to patient safety. Lack of meaningful improvement in patient outcomes with NUPOR supports the need to stratify medication orders based on their relative risk to the patient.[10,12]Click or tap here to enter text. The high-risk environment of the ED contributes to medication errors, with many medications ordered, dispensed, and administered at the point of care. By reducing the need to verify low-risk, high-volume medications and thus not restricting pharmacists to a computer terminal, opportunities increase for pharmacists to be at the bedside at point of care, especially during high-risk situations (eg, rapid-sequence intubation, cardiac arrest). Notably, most interception of medication errors by EM pharmacists occurs during the prescribing phase. Click or tap here to enter text.[12] However, in the ED, prescribing in the most critical of situations often occurs at the bedside, with order entry occurring after or concurrently with medication administration.

In this report, we show how the EHR can be leveraged to safely decrease the number of medication orders pharmacists need to review. We demonstrated that 41% of medications can be safely autoverified and that time previously

devoted to verification can safely be repurposed for more acute ED needs. Selective autoverification using technology within the EHR allows the filtering of orders presented to pharmacists for review and only displays orders with the highest potential for intervention.

Notably, the majority of the 18 PAM orders modified by a pharmacist in the verification queue would not have been autoverified. Most orders did not fall within the parameters of the EHR ruleset due to dose warnings being triggered or the corresponding patient having an assigned admitting primary team (boarder patients). Other modifications by the pharmacist included simple timing changes, medication dispensing prioritization, and formulation changes.

Of the 2 orders identified during manual review needing clinical intervention that would have met criteria for autoverification, the first was for a patient with acute kidney injury prescribed morphine 4 to 8 mg intravenously every 20 minutes as needed. This medication was discontinued by the provider 6 minutes after entry without pharmacist verification. The second was a patient with low platelet count and a concern for bleeding who was prescribed ketorolac by a resident physician. Ketorolac was discontinued 1 minute after entry by the attending EM physician, and the medication was not verified or administered to the patient. In the first case, it is very possible that the EM pharmacist intervened on this order, given the timeframe in which the order was discontinued. In the second case, given the very short timeframe from order entry to discontinuation, it is unlikely that the EM pharmacist intervened on this order. It is more likely that the attending physician reviewed the resident's order and discontinued it.

Implementation of autoverification was not a completely linear process. An in-depth knowledge of medication warning functionality is necessary to ensure orders are not inappropriately autoverified. A final table of our autoverification rules illustrates this in Figure 3. Additional customized parameters were added to both ketorolac and lidocaine orders, as well as excluding the "other" route from autoverification, based on postimplementation review and clinical pharmacist feedback. Medi-Span dose warnings consist of a prespecified dosing regimen range with dose thresholds. Dose warnings are triggered if the ordered dose exceeds the threshold. This was tested in dose thresholds for ketorolac. Dose thresholds for ketorolac are dependent on a patient's renal function. Many ED patients do not have serum creatinine levels and/or weight documented for the EHR to calculate the creatinine clearance. In these patients without a creatinine clearance value available for dose checking, no dose warning fired on ketorolac orders, regardless of how large the dose was. This required a custom rule to prevent any intravenous ketorolac order of greater than 30 mg. Institution-specific quirks within the EHR can also cause issues with autoverification. A medication route of "other" is allowed on medication orders at the hospital involved in this study. After implementation, we added a rule to prevent any order with a route of "other" from being autoverified so that a pharmacist could assess the intent of the order. Ongoing continuous review of all patient safety reports within the department occurs to assess and enhance safety related to autoverification.

There were several limitations to the study. The study was a retrospective study at a single health system, which limits the external validity of the results. However, orders were included from both an academic and community hospital ED, and 97% of PAMs were prospectively verified by different practicing EM pharmacists. Additionally, autoverification was only applied to ED patients and may not be generalizable to other populations.

Figure 3. Autoverification rules. IV indicates intravenous. An asterisk indicates that extra safety parameters for lidocaine and ketorolac were built within the original rule as maximum dosing error found within alert functionality.

Auto-verification rules
[medications in grouper]
[order warning]
[mixture grouper]
[dispensing pharmacy]
[patient ID: age years]
[admit orders]
[lidocaine grouper]*
[IV route] *
[ketorolac grouper]
[dose > 30 mg]
[route = other]

Conclusion

Low-risk, high-volume medications can be strategically targeted for autoverification in the ED by using a systematic approach to selecting appropriate orders. Medications deemed appropriate for autoverification through this method demonstrate significant decreases in verification volume without compromising patient safety.

Disclosures

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Previous affiliations

At the time of project implementation, Dr. Bienvenida was a postgraduate year 2 emergency medicine resident at University of Wisconsin Health, Madison, WI. At the time of project data collection, Dr. Kroll was a postgraduate year 2 emergency medicine resident at University of Wisconsin Health, Madison, WI.

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Appendix A—Modified high-alert medication checklist

Primary Questions	Primary Question Scoring	Frequently Asked Questions
DRUG NAME: OVERALL SCORE:	**Yes = 1 point** **No = 0 points**	
1) Does this medication exist on the ISMP High Alert Medication List?		What is the definition of ISMP high-alert medication? *A. High-alert medications are drugs that bear a heightened risk of causing significant patient harm when they are used in error. Although mistakes may or may not be more common with these drugs, the consequences of an error are clearly more devasting to patients.* [15]
2) Does this medication exist on the institution's own High Alert Medication List?		What is the definition of your institution's high-alert medication list? *A. A medication that bears heightened risk of causing significant harm to an individual when used in error. The high-alert medication list is maintained by the institution's Pharmacy and Therapeutics Committee, which provides oversight of all policies involving the medication use process. P&T considers adverse drug events and ensures establishment of medication safety.*

3) Does this medication exist on the institution's own Restricted List?	How does your institution choose what medications exist on your restricted medication list? *A. The P&T committee maintains processes for all additions, deletions, medication and restrictions to the drug formulary that maximize safe, efficient, evidence-based,rational drug use.*
4) Does the project committee consider this medication high risk?	What were other questions posed by the workgroup committee that differed from questions 1 through 3? *A. This committee initially started a list of potential medications to be placed on auto-verify by clinical expert opinion. The workgroup committee assessed logistical considerations in the ED in addition to medication safety concerns. For example, risk benefit of "ONCE" orders in the ED.*
5) Is this medication considered safe after retrospective review by a pharmacist?	What did additional review by a single pharmacist yield? *A. A retrospective review of medications administered prior to pharmacist review of the preselected low-risk medications in a month's period was evaluated. Any medication orders were counted if a pharmacist intervention would have been required to prevent error.*

Abbreviations: ED, emergency department; ISMP, Institute for Safe Medication Practices; P&T, Pharmacy & Therapeutics.

Appendix B—Final list of autoverified medications

Medication	Route
Acetaminophen	Oral, suppository
Acetaminophen/codeine #3	Oral
0.083% albuterol sulfate nebulizer	Inhaled
0.5% albuterol nebulizer	Inhaled
Aluminum and magnesium hydroxide/simethicone	Oral
Bacitracin zinc ointment	Topical
Bacitracin/polymyxin β ointment	Topical
Bisacodyl	Suppository
Calcium carbonate antacid	Oral
Carboxymethylcellulose sodium drops	Ophthalmic
Dermabond (Ethicon) topical adhesive	Topical
Fentanyl	Intravenous, intranasal
Fleet enema	Suppository
Fluorescein	Ophthalmic strip
Glucose vitamin C chew tablet	Oral
Glycerin suppository	Suppository
Hydrocodone/acetaminophen	Oral
Heparin sodium lock flush	Intravenous
Hydromorphone	Intravenous, oral
Ibuprofen	Oral
Iohexol solution	Oral
0.02% ipratropium bromide nebulizer	Inhaled
Ipratropium albuterol nebulizer	Inhaled
Ketorolac injection	Intravenous

Lactated Ringer's solution bolus	Intravenous
Nonintravenous lidocaine	Intradermal, intramuscular, nasal, subcutaneous, topical, urethral
Lidocaine/epinephrine solution	Intradermal, subcutaneous
4%/0.5%/1:2,000 lidocaine/tetracaine/epinephrine compound gel	Intradermal, subcutaneous
4% lidocaine/transparent dressing external kit	Topical
Loperamide	Oral
Magnesium citrate	Oral
Menthol lozenge	Oral
Morphine sulfate	Intravenous
Multivitamin	Oral
Ondansetron	Oral, intravenous
Oxycodone	Oral
Oxycodone/acetaminophen	Oral
0.05% oxymetazoline HCl	Intranasal
PEG 3350/KCl/NaCl	Oral
Phenazopyridine	Oral
Polyethylene glycol 3350 pack	Oral
0.5% proparacaine HCl	Ophthalmic strip
Racepinephrine HCl 2.25 nebulizer	Inhaled
Sennosides/docusate	Oral
0.9% sodium chloride solution bolus	Intravenous
0.9% sodium chloride bacteriostatic injection solution	Intravenous
Sterile water for injection solution	Subcutaneous
White petroleum jelly gel	Topical
Zinc oxide ointment	Topical