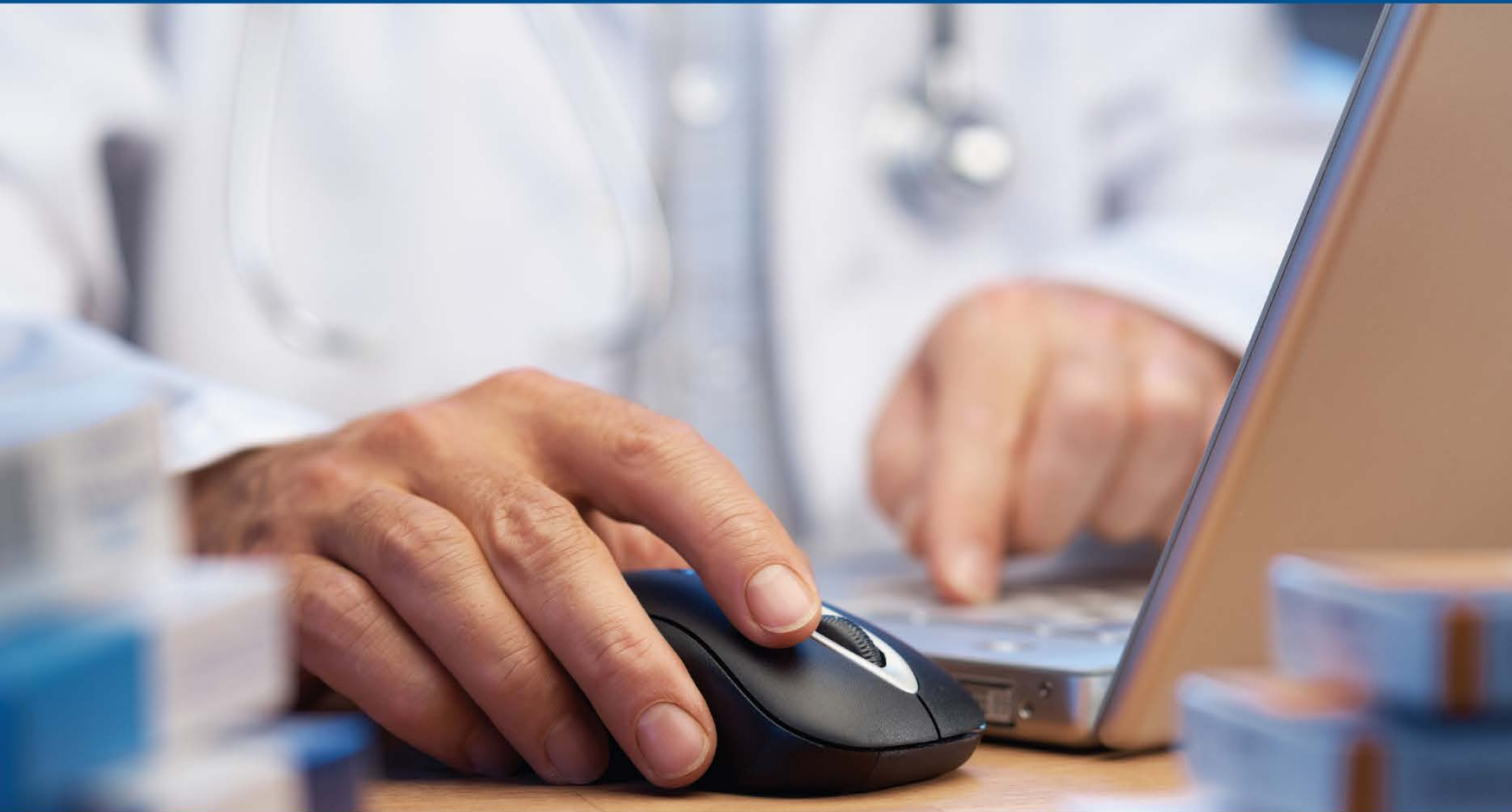# REPORT ON THE SAFE USE OF PICK LISTS IN AMBULATORY CARE SETTINGS:

Issues and Recommended Solutions for Improved Usability in Patient Selection and Medication Ordering

September 2016

Report on the Safe Use of Pick Lists in Ambulatory Care Settings

Issues and Recommended Solutions for Improved Usability in Patient Selection and Medication Ordering

Prepared for

Prepared by

Stephanie Rizk, MSc
Grace Oguntebi, MPH
Mark L. Graber, MD, FACP
Douglas Johnston, MTS
RTI International
3040 E. Cornwallis Road
Research Triangle Park, NC 27709

ACKNOWLEDGMENTS

This page intentionally left blank

CONTENTS

FIGURES

1. INTRODUCTION

Pick lists are ubiquitous features in every electronic health record (EHR) and order entry system. Also known as drop-down lists, pick lists are designed to save time and avoid typographical errors. Their use affects every aspect of clinical work, starting with the selection of the correct patient; pick lists facilitate the selection of tests, consults, orders, note titles, billing codes, and medication choices. The goal of pick list automation is to make selection of information more organized and straightforward. However, errors can be made even with automated pick lists; therefore, improvements in pick list development, implementation, and adoption can reduce the opportunity for medical errors and patient harm.

Pick list errors occur across all care settings, and have been observed in inpatient units, physicians' offices, pharmacies, and nursing homes. Examples of wrong-patient and wrong-medication pick list errors are found in reports submitted to the U.S. Food and Drug Administration's (FDA's) Manufacturer and User Facility Device Experience (MAUDE) database[1] as well sentinel events submitted to The Joint Commission.[2] The Joint Commission recently issued Sentinel Event Alert #54 in response to these findings, and the three examples highlighted in this alert focused on pick list errors.[3] Specific studies on the incidence of pick list errors have found that the number of wrong-patient medication orders range from 2 to 68 per 100,000 orders, depending on the methodology employed.[4] These unintentional errors involve a wide spectrum of stakeholders—from the vendors who develop and implement the technology, to the members of the health care team (hereby referred to as the providers) selecting the patient charts and placing the orders, to the patients receiving unintended care (or not receiving the intended care). In wrong-medication cases, pharmacists also become important stakeholders in the process.

In this report, we summarize the current state of knowledge regarding pick list errors, and provide recommendations for vendors, chief medical information officers (CMIOs), and end users—provider organizations and health care teams—on how to minimize the risk of pick list errors and facilitate detection of errors before patients are harmed. The discussion and recommendations in this report were developed with a focus on ambulatory care settings, and the resources provided as appendices focus on improving safe medication ordering processes primarily in outpatient care settings. However, these resources are also appropriate for consideration in other care settings as well.

This page intentionally left blank.

2. BACKGROUND ON PICK LIST ERRORS

In recent years, increased implementation of health information technology (IT) has helped to build a foundation for improving care and managing costs. Past evidence was inconclusive regarding the impact of health IT on patient safety,[5,6] but health IT has evolved rapidly and has continued to improve.[7] A linked series of four systematic reviews was published within the last decade, illustrating the change in health IT impact over time.[8-11] The findings demonstrated positive effects of health IT, such as increased adherence to clinical guidelines and protocols as well as benefits in medication safety. Other studies have shown that EHRs are effective in identifying adverse drug events in outpatient settings.[12,13]

Along with these benefits, multiple issues associated with the rapid adoption of health IT have surfaced. A central issue relates to the usability of EHRs, defined in general terms as the "effectiveness, efficiency, and satisfaction with which specific users can achieve a specific set of tasks in a particular environment."[14] The National Institute for Standards and Technology (NIST) has helped clarify the importance of usability when using health IT to improve overall safety in health care. Due to the variety and complexity of information, differences in clinical practices, and varying system interface needs in health care settings, it is particularly difficult to achieve a high level of usability within an EHR system. Most recently, NIST has provided guidance for how EHR usability issues can be assessed, understood, and managed.[15] Their guidelines name three major EHR usability domains that impact safety:

- Identification of information: Am I (the provider) in the right place and doing the right thing?

- Information presentation: How should information be displayed?

- Integrity of information: Is the information correct and do I have it all?

These three domains offer a structured approach to identify and address safety risks related to using EHRs in medication management processes and tasks.

In addition to NIST's work in the area of usability, substantial progress has also been made to improve the safety of medication management. The Institute for Safe Medication Practices (ISMP) released its initial "Call to Action" in 2000, pushing for the elimination of handwritten prescriptions within 3 years. Six years later, a major report by the Institute of Medicine (now the National Academy of Medicine) found that there was an unexpectedly high prevalence of medication errors and harm occurring at high cost to the nation, and provided a comprehensive approach to addressing the problem.[16]

A host of issues remain. Medication errors, defined as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer,"[17] are consistently the most

frequently encountered problem in every large study of patient safety events.[12,18,19] The same is true in studies that focus specifically on safety events involving health IT and EHRs.[20] For example, a recent review of malpractice claims found that medication-related errors accounted for the largest fraction of the 76 EHR-related errors overall (31%).[21] Almost half of those errors were related to medication ordering (46%), along with other errors associated with improper medication management (25%) and administration errors (16%). Ordering problems were the most frequent problem in all three settings of care: ambulatory, inpatient, and emergency.

Within the medication management cycle, pick lists are often used in the ordering and entering phases to first select a specific patient in the system and then to choose the desired medication and the prescription for its use. Based on an analysis of over 10,000 errors identified in the MEDMARX database over a 7-year period, Schiff and colleagues identified pick list errors as an especially common vulnerability (i.e., choosing the wrong patient or the wrong medication from a list). In total, they detected 302 "wrong drug" and 229 "wrong patient" selection errors, and many other prescription-related problems (e.g., wrong dose, wrong schedule) that could have resulted from pick list errors. It can be easy to accidentally select a wrong medication that is listed adjacent to the correct medication. Attempts to place order errors using a test scenario in 13 different EHR systems showed that look-alike, sound-alike (pick list adjacency errors) received the second lowest "ease of entry" score, a 1.83 (where a score of 1 = mistake easily made with no system protection/warnings, and a score of 5 = highest protection against error).[22]

When considering the usability of pick lists within a health IT system, one must also consider the role of human-computer interaction in minimizing potential errors associated with selections made from these lists. Human-computer interaction design applies principles to enhance effectiveness, efficiency, and user satisfaction, and to counteract "possible adverse effects of use on human health, safety, and performance."[14] Health IT systems have drastically reduced medication errors associated with illegible handwritten prescriptions or miscommunications due to verbal prescriptions. However, these systems have also introduced new types of errors attributed to poor design, implementation, and/or system configuration.

Medication ordering errors occur across all care settings. While medication errors in inpatient settings are well documented,[23-25] most prescriptions are written in ambulatory care settings. Discrepancies are one index of possible medication errors, and audits in ambulatory care show that 90 percent of active medication lists do not match what the patient is taking.[26] Medication lists for new patients and patients seen by multiple providers and specialists are especially prone to discrepancy errors.

What is a pick list error? An example of wrong medication selection

An elderly female was admitted for nursing home placement with a history of Parkinson's disease, hypertension, coronary artery disease, schizoaffective disorder, and dementia. In addition, the patient also complained of constipation. The physician meant to order lactulose for the constipation, usually given as 1–2 ounces every 4 hours. Instead, the physician inadvertently selected the adjacent item, Lamictal (lamotrigine), from the pull-down menu, an anticonvulsant.

```
XXXXXX
XXXXXX
LACTOBACILLUS CAPS, ORAL
LACTOBACILLUS GRANULES
LACTOBACILLUS TAB, CHEWABLE
LACTOSE TAB
LACTULOSE SYRUP
LAMICTAL (LAMOTRIGINE TAB, ORAL)
LAMISIL (TERBINAFINE HCL 1% CREAM, TOP)
LAMISIL (TERBINAFINE TAB)
LAMIVUDINE TAB
LAMIVUDINE SOLN, ORAL
XXXXXX
XXXXXX
```

The nurses did not recognize a problem with the order, and gave several doses of the wrong medication. None of the staff members (physician, pharmacist, or nurse) had ever used Lamictal and were not familiar with its indications.

Fortunately, the patient suffered no harm. The error was discovered 48 hours later when a new pharmacist came on duty and began reviewing orders.

Regardless of care setting, the incidence of these errors is difficult to accurately quantify, as the available methods of error detection are imperfect. Errors that are voluntarily reported tend to underestimate the actual incidence and sometimes do not include near-miss errors.[27] An automated approach to identify errors would be more effective, but only recently have methods been developed to detect errors in electronic orders. In one study, researchers developed an automated trigger based on the abrupt cancellation of a medication, within 120 minutes of the initial order, followed by a quick reorder (within 5 minutes of cancellation) of the same medication by the same provider for a different patient.[27] This study resulted in an incidence rate of 0.064 percent for patient identification errors in inpatient medication orders. The researchers found this trigger to have a high level of specificity in detecting patient identification errors, although they were unable to evaluate sensitivity because of lack of a "gold standard" in error detection.

A similar study produced the "retract-and-reorder" (RAR) tool, which is very similar to the trigger described above. The automated tool identifies orders retracted within 10 minutes of the initial order and then reordered by the same provider for a different patient within 10 minutes of retraction. This study resulted in a comparable incidence rate of 0.058 percent for patient identification errors, representing an average of 14 errors per day.[4] These incidence rates represent near-miss errors, which were recognized and corrected by the providers prior to causing any adverse events. However, patient safety research has shown that near-miss errors share the same causal pathway with errors that cause harm.[28] Therefore, the tools and recommendations provided in this report to reduce the risk of near-miss errors should also prevent the wrong-patient and wrong-medication errors that could harm patients.

This page intentionally left blank

3. METHODS

Under contract to the Office of the National Coordinator for Health Information Technology (ONC), RTI International assembled a work group in late 2015 to develop recommendations for increased safety and usability of EHR systems in the ambulatory setting related to medication management errors. Convened as an operational test of the work group activities described in the Health IT Safety Roadmap,[29] the objectives were to: (1) **convene** a set of experts around a health IT safety topic; (2) **research** best practices, tools, and interventions provided by the group members and develop shared recommendations and/or tools based on the findings; and (3) **disseminate** developed solutions through targeted promotional activities. Figure 1 outlines how the activities of this work group mirror activities proposed in the Health IT Safety Roadmap.

Figure 1.   Operational Goals of the Health IT Safety Roadmap and Their Implementation in This Project
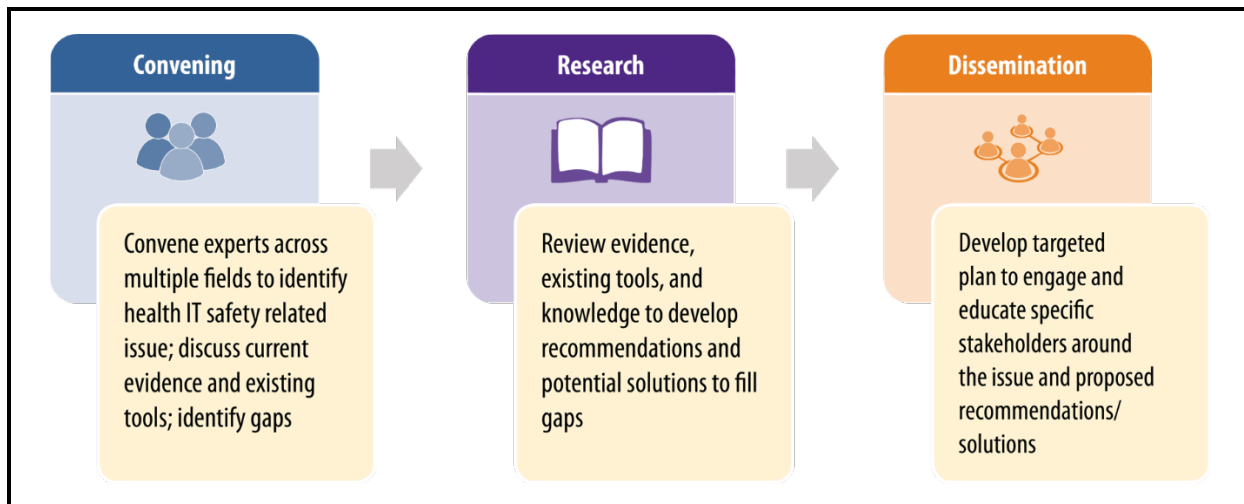
The members of the work group were selected by RTI with ONC advice as to balance of perspectives and expertise, and included representatives from provider and pharmacist organizations, standards monitoring and health IT safety-related groups, consumers, patient safety organizations (PSOs), and usability and human factors experts. A full listing of members is provided in **Appendix A**. At the outset, work group members were presented with an initial set of topics related to EHR usability within the medication management process identified by the project team, as indicated by recent research and considered as in line with the timeline, overall scope, and resources allocated for the project. Work group members chose the pick list error topic by consensus as representing a common, serious, and actionable problem.

Following topic selection, RTI staff conducted a scan of the evidence related to pick list errors. In total, RTI reviewed 66 sources related to medication management and usability of EHRs. Resources included journal articles, proceedings, case studies, private organization and federally funded reports, newsletters, guidelines, blog postings, and books.[a] Each resource was ranked with a designation of high, medium, or low relevance. The criteria for determining relevance included presence of evidence specific to pick lists and whether the content was current to the health IT systems, infrastructure, and policies available and widely used today. Research in both inpatient and outpatient settings was included, although more focus was given to evidence with high applicability to the ambulatory environment. Findings, lessons, and recommendations from these resources were then abstracted and summarized into factors that increase or decrease pick list-related errors.

Members of the work group reviewed then reviewed these factors and provided feedback, additional evidence, and suggestions regarding additional factors related to pick list errors. From the input provided, a set of recommendations was developed that were validated and supported by consensus of the work group members, and are described in this report.

---

[a] Keywords used included iterations on the following: pick list errors, electronic prescribing system, human factors, medication safety, usability, retract-and-reorder (RAR), wrong-patient errors, patient-identification errors, wrong-drug errors, and wrong-medication errors. Resources published more recently (2010–2016) were prioritized, although older references were included if they were deemed relevant. RTI's library services staff supported two rounds of searching using PubMed, Embase, and Web of Science databases. A third search was performed on non-health-related databases including ScienceDirect, Business Source Corporate, PsycINFO, and EBSCO Discovery Service. The search did not place restrictions on country of origin.

4. CONCURRENT WORK

An important consideration in developing recommendations was to establish clear communication with groups that are currently engaged in complementary initiatives to ensure that this work did not duplicate other health IT safety efforts. Two major initiatives were occurring in parallel with the work described here, and were identified as complementary but not overlapping: (1) the Patient ID Workgroup of the Partnership for Health IT Patient Safety convened by the ECRI Institute, and (2) the Draft Guidelines for the Safe Electronic Communication of Medication Information by the ISMP. Representatives from these initiatives participated in the work group and provided details about their ongoing work to ensure that RTI's recommendations supported, and did not duplicate, the work being done in the other organizations.

This page intentionally left blank

5. FINDINGS

5.1   Overview

When considering usability and medication management, one subset of challenges involves those relating to selection from pick lists. Also referred to as drop-down menus, these user interface design features facilitate a provider's experience and interaction with the system; however, they introduce the opportunity for error. Research has uncovered evidence related to pick list errors in two general categories: (1) those that occur when the wrong patient is chosen and (2) those that occur when the wrong medication is selected from a drop-down list. Although pick list errors might also be prevalent in tasks such as dosage, route, and medication administration scheduling, most of the evidence is related to patient identification and medication selection. We grouped the evidence into the two categories of wrong-patient errors and wrong-medication errors, and we identified factors that either increased or decreased the risk of each category of error.

5.2   Wrong-Patient Errors

Wrong-patient errors, sometimes referred to as patient-identification errors, occur when the electronic chart for the wrong patient is selected. When the wrong patient chart is selected, multiple adverse consequences can result, including but not limited to: entry of clinical documentation into the wrong patient's chart, and entry of unnecessary procedure or medication orders for the patient selected.

Review of the evidence indicated that the ability of the prescriber to view multiple patient charts simultaneously within the system is considered by physicians and CMIOs to predispose user to patient identification errors.[27] In one study of medication errors involving the wrong patient, 59 percent of those errors intercepted over a 6-year period occurred when the prescriber had both patients' charts open: the intended patient and the incorrect patient.[30] When a provider does have simultaneous access to both charts, such errors might be prevented by using visual clues in the chart that identify the patient. Simply limiting a provider's access to only one patient chart at a time is not a straightforward solution, as the consequences of such workflow restrictions create the potential for new errors.

Certain pick list design features can increase or decrease the risk of patient selection errors. Simply providing adjacent choices may, for instance, increase the risk of pick list errors; pick list length and organization of the items in the list have an important impact on user selections.

Following a thorough literature search, Sengstack et al. developed a computerized provider order entry (CPOE) design checklist useful for designing or evaluating a CPOE system from a medication error reduction standpoint.[31] Their checklist consisted of 46 best practice configuration guidelines grouped into five categories. The two categories relevant to pick

lists—order form configuration and human factors configuration—both included design suggestions for patient pick lists. Although the checklist compiles best practices from the CPOE literature for medication error reduction, the evidence is limited in its generalizability, and its effectiveness is dependent on how an organization chooses to configure and implement its system.

Sopan et al. also proposed a catalog of 27 distinct user interface techniques designed to reduce wrong-patient selection errors.[32] Techniques included personalizing the list of patients to those that the provider has seen and allowing for sorting, filtering, and/or grouping the patients into categories. All of these features result in a shorter list of patients from which the provider can select, thus increasing the likelihood of selecting the correct patient.

Another EHR feature that may effectively reduce wrong-patient errors is the requirement of active review of a patient's identification at the point of order entry or before finalizing the order. Two studies evaluated the use of patient verification screens implemented at the beginning of the ordering session to reduce wrong-patient orders.[4,33] Adelman implemented an alert that displayed the patient's name, gender, and age, which the provider had to acknowledge with a single click response to be able to proceed. Green used a similar strategy, displaying the patient's name, gender, and age, chief complaint, bed location, length of stay, and recent medication orders. In addition, a mandatory 2.5-second delay was added to prevent providers from clicking ahead without reviewing the information. Use of a simple patient verification screen was found to be effective, reducing wrong-patient orders by 16 percent in Adelman's study and 25 percent in Green's study.

An identification verification screen that also includes a photo of the patient has been shown to further decrease the risk of wrong patient selection. In one study, an order verification screen with the patient's photo positioned centrally on the screen was implemented at a children's hospital.[34] Following implementation of the intervention, there were no reports of unintended care received by any patient who had a picture in the EHR, and overall, there was a 75 percent decrease in ordering errors resulting in unintended care. This method is likely to be more efficient than other more interruptive interventions, but its effectiveness may vary. Some patients may appear very different from normal when hospitalized, or may appear similar to other patients when ill.[30] Also, there are operational expenses associated with providing digital cameras at every point of entry and ensuring that the photos are kept updated within the EHR.[34] However, once a patient's photo is in the EHR, a thumbnail version of the photo can also be used in the pick list of patient names to facilitate correct patient selection prior to entering the medication order.

Identification (ID) reentry is a method that goes one step beyond the requirement for active review of the patient's identification. In ID reentry, instead of presenting a simple patient

verification screen, the system presents a screen that requires the provider to reenter the patient's information (initials, gender, and age) prior to proceeding with the order. Use of the ID reentry screen prior to signing the order resulted in a 41 percent reduction in errors.[4]

Unfortunately, any intervention that requires a provider to take additional action, even as simple as a single click, can result in a decrease in efficiency and end-user satisfaction. In the Adelman study, an average of 0.5 additional seconds was spent for every ordering session, and 6.6 additional seconds for every ordering session with ID reentry. In the Green study, the mean viewing time for the patient verification screen was 4.2 seconds, including the 2.5 second delay, and 4.9 seconds when the provider realized that the order was placed for the wrong patient. Although these times appear short in the context of one order session, collectively they represent hundreds of hours of provider time over the course of a year.[4] Experts agree that it is preferable in terms of cost and effectiveness to address safety problems in the design of the technology, rather than by modifying the technology after system implementation.[35]

Additional human factors research has identified that information presentation and design issues affect the safe use of EHR systems, as does the reduction in cognitive load.[36] Other safety-critical industries have identified cognitive load as a key factor in committing errors in situations where interruptions are frequent.[37] Although requiring users to take additional steps to ensure that a task has been completed may lead to a reduction in errors, it may not be feasible in practice, causing unintended consequences such as delays and dangerous workarounds. Thus, as in all safety interventions, a balance between efficiency and effective safety must be carefully considered.

5.3   Wrong-Medication Errors

Wrong-medication errors occur when a provider selects the incorrect medication from the pick list during a medication order. As with wrong-patient errors, the incidence of these errors is difficult to quantify; however, the RAR method is also valuable for detecting the occurrence of this type of error.

Many of the factors that increase or decrease risks of selecting the wrong patient from a pick list may also impact the medication selection process. For example, the use of a summary review screen at the end of the ordering session, prior to signing the order, allows the provider to verify that the correct medications have been selected.

The length of the pick list is also important in medication selection, because there are thousands of medication options, and many medications with similar spellings.[38,39] One method to simplify and shorten the pick list is for the e-prescribing system to allow ordering providers to create lists of commonly prescribed medications that are subsets of the full medication list.[40] This approach is similar to creating patient lists that are limited only to the provider's patients. Also, if the system dynamically limits a medication list as a provider

enters a medication name, the resulting list contains far fewer options from which to select. An advanced e-prescribing system may be able to take advantage of a predictive algorithm that uses entries from the patient's list of established diagnoses to populate the pick list, so that the medications listed are only those that would be indicated for the patient's problems.[41] Auto-fill or auto-complete features such as these can lighten the provider's cognitive load, even if manual adjustments are sometimes needed for various scenarios, such as off-label prescribing.

Look-alike/sound-alike (LASA) drugs are easily confused, to the point that current Joint Commission accreditation standards require health organizations to develop and maintain a list of the LASA drugs that they stock.[42] Pick lists that are arranged in alphabetical order create LASA opportunities by their very nature. This is especially problematic for drugs with the exact same root name, but different variants or formulations (e.g., long acting versus short acting). A strategy for mitigating errors associated with LASA drugs is the use of Tall Man lettering, a textual format that involves displaying the confusing parts of LASA drug names in uppercase and sometimes bolding those distinguishing letters as well (e.g., aceta**ZOLAMIDE** versus aceto**HEXAMIDE**). Although some studies did not find any significant reduction in LASA-related errors after implementation of Tall Man lettering,[43] a greater body of evidence has established that Tall Man lettering does improve accuracy in the perception of drug names.[44] Moreover, Tall Man lettering continues to be highly endorsed by multiple regulatory and accreditation organizations, including ISMP and the Joint Commission.[31,45,46]

Several pick list design considerations affect medications specifically. The ISMP developed guidelines for safely communicating medication information electronically.[47] The guidelines focus on the correct selection of medications from pick lists, and promote consistency in the display of medications throughout the EHR. Many EHRs and e-prescribing systems, however, are not standardized in the ways they display medications. Systems vary in their display of brand names and/or generic names, in the number of characters allowed prior to truncation of medication names, in the abbreviations used for various medication terms, and in the use (or nonuse) of suffixes to indicate the delivery method for the medication.[31,40,48] These inconsistencies stem from the flexibility allowed for medication names in various drug databases, in vendor EHR and e-prescribing software, and across health care systems. In November 2015, the National Council for Prescription Drug Programs (NCPDP) released updated SCRIPT Implementation Recommendations, which outline implementation requirements for complying with Prescription Model Act when transmitting NCPDP SCRIPT transactions.[49] Specifically, they outline recommendations for drug knowledgebase compendia organizations (such as First DataBank, Wolters Kluwer MediSpan, Cerner Multum, among others), and EHR/e-prescribing vendors. Implementation of these standards would reduce the considerable variation in drug nomenclature that currently exists within the industry, and potentially reduce pick list errors as well.

Another strategy for mitigating the selection of wrong medications from a pick list is the use of a clinical decision support (CDS) tool that compares the selected medication against the medications that are applicable to the patient's known problems.[48] If the medication is not indicated for any of the diagnoses on the patient's problem list, an alert is displayed for the provider prior to signing the order. Although this intervention is interruptive, one study showed that indication alerts intercepted 1.4 medication errors per 1,000 alerted orders.[50] Thoroughly researched and implemented indication-based alerts promise to prevent both wrong-patient and wrong-medication errors, and could also result in improvement of the patient's problem list.

This page intentionally left blank

6. RECOMMENDATIONS

Based on the findings presented above, the work group members put forward the following recommendations to improve the safe use of pick list functionality related to medication ordering in EHR systems. Figure 2 outlines a series of risk factors across stakeholders associated with wrong-patient and wrong-medication pick list errors, and the major stakeholders who are responsible for implementing solutions that help address these risk factors. These recommendations are related to actions that each stakeholder can take in areas such as system design, usability, workflow redesign, and local policy development.

Between the risk factors associated with local implementation staff in provider organizations (for example, CMIOs, practice managers, IT staff, etc.) and providers, red arrows highlight the most crucial areas for development of new designs and practices to reduce the risk of pick list-related errors. These overlapping areas of accountability indicate that neither providers nor provider organizations are solely responsible for enacting solutions. For example, providers may be responsible for managing the various distractions experienced in clinical practice, but provider organizations are responsible for developing support structures that reduce provider workload and stress. Development of and adherence to solutions in these areas require close collaboration among all stakeholders.

Figure 2.   Cause-and-Effect Diagram of Ways that Various Factors Contribute to Pick List Errors
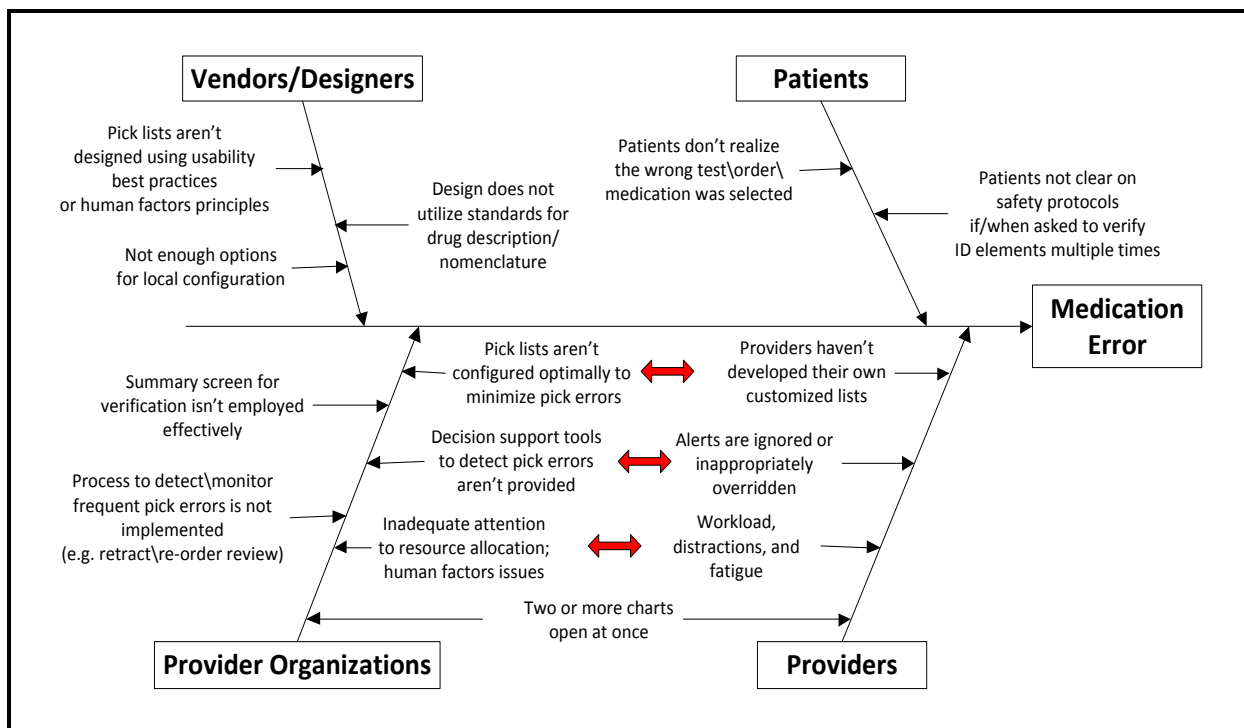
A high-level summary of the recommendations developed by the work group, each intended to alleviate and reduce the risk factors associated with selecting both wrong patients and wrong medications as described in this report, are provided below. The resources, planning, and coordination required to implement each of these six recommendations may differ by type of stakeholder and by recommendation. Generally, however, implementation will require vendors, practice managers, information officers, and providers to work together to ensure that system functionality, training and organization policies, and end-user practices all align. Accordingly, guidance on how to implement these recommendations specific to stakeholders is provided in *Appendix B* (Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations), *Appendix C* (Self-Assessments for Practice Leaders to Use in Support of Pick List Best Practices), and *Appendix D* (Reducing Pick List Errors in Medication Ordering for Providers).

The six recommendations below are organized according to a general medication order workflow—identifying and selecting a patient, developing and implementing pick lists, searching for and picking a medication, completing an order, and so forth. Each summary also lists stakeholders directly affected by or involved in implementing the recommendation.

1. **Use specific design features to reduce wrong-patient pick list errors; in particular, include a patient's photograph in the record.**

   Summary: Evidence showed that providers often experience heavy cognitive load and frequent disruptions that increase the likelihood of a wrong-patient error. Emerging evidence-based functionality, such as adding a photo to the patient record to facilitate provider recall, should be used to reduce wrong-patient errors. The implementation of such functionalities in the EHR must be done within the technical constraints of the system so as not to slow performance, and must be supported with training and ensuring adherence to best practices. *Appendix D* provides a tool for bridging the gap between policy and practice in reducing wrong-patient and wrong-medication errors for providers using EHRs. Specific design features shown to reduce patient ID errors are also included in the *Appendix B* tool.

   Stakeholders: EHR support/training staff, CMIOs, practice managers, providers, vendors

2. **Use e-prescribing drug name concepts that adhere to common guidelines, which focus on improving safety, when developing medication pick lists.**

   Summary: The NCPDP has determined that lack of standardization in the development of e-prescribing drug names raises patient safety risk.[49] Each drug compendium organization uses different criteria to develop its proprietary clinical terminologies. Moreover, EHR vendors, health care systems, and individual physician practices may have their own editorial policies, further fracturing the ability to standardize around best practices for safe electronic display of medication information. Drug compendia organizations should update their editorial policies and create "E-Prescribing Preferred Drug Description Name (EPN)" concepts as recommended by NCPDP for EHR and pharmacy system vendors to implement and adopt. In doing so, compendia organizations must ensure that their drug description concepts adhere to known safety-related guidelines, such as those provided by the ISMP. In 2015, the ISMP released its *Draft guidelines for the safe electronic*

communication of medication information,[46] which provide extensive and detailed specifications for the safe presentation of drug nomenclature and dosing. The guidelines are currently under review and finalization, and provide a number of specifications related to the development of medication-related pick list functionality that improve usability and reduce errors. In addition, the NCPDP has outlined specific elements that compendia should use to develop EPNs. Specific guidelines that should be considered in the development of EPNs are provided in ***Appendix B***, organized by evidence regarding impact on pick list safety, with specific references to supporting evidence and visual representation of examples when applicable.

Stakeholders: Drug knowledgebase compendia development organizations, EHR vendors, EHR implementers/selection committees

3. **Implement best practices for organization, design, and configuration of all pick lists, including use of e-prescribing drug names provided by compendia.**

   Summary: Building on the previous recommendation, all EHR vendors developing medication-related pick list functionality should implement and adopt the EPN concepts provided by the compendium. When designing the pick list, fundamental usability recommendations for contrast, font size, color, and spacing should always be considered. Reliance on well-established guidelines, such as those developed by the ISMP, should serve as a reference for the safe design and display of medications in all EHR systems. Advanced features to support pre-population or narrowing the lists of likely patients and medications will streamline selection and reduce scrolling through long lists of items. However, significant consideration must be given to the rules that underlie this type of functionality. Poorly displayed lists without proper validation and decision support checks can lead to an increase rather than a decrease in errors. In addition, human factors considerations must be taken into account when site-specific customizations and policies are being made. How and when providers are instructed on creating a list of "favorites," for example, can be just as essential to safety as the display of medication-related information. Specific references to design features and best practices for local configurations by practice staff can be found in ***Appendixes B*** and ***C***.

   Stakeholders: Vendors, EHR implementers/selection committees

4. **Display a summary review screen prior to completion of a medication order.**

   Summary: Evidence throughout the literature shows that requiring ordering providers to pause and review a summary of an order prior to submission greatly reduces the risk of many types of errors, including those related to choosing the wrong patient or the wrong medication from a pick list. While many EHR systems provide this functionality, which is required by entities such as Surescripts to participate in their e-prescribing network, studies have shown that providers often fail to adequately use the summary screen to review and check for errors. Clinician work group members *strongly* advised against including functionality that required ordering providers to reenter patient information (name, age) to verify the patient as a last step in the medication order. Instead, they stressed using design strategies to prevent errors earlier in the ordering process. In addition, work group members supported including indications (diagnoses, problems) as part of the information in a summary review screen. Evidence strongly shows that medication-related errors are reduced when EHR systems use CDS to verify that medications chosen from a pick list are indicated by the diagnoses noted in the patient's problem list. This functionality is particularly effective in reducing errors from selecting look-alike medications from a pick list. Even with the use of off-label prescribing, this method

provides an important safeguard against unintended errors. Specific references to design features and best practices for local configurations by practice staff can be found in **Appendixes B** and **C**.

Stakeholders: Providers, EHR implementation support staff, CMIOs, practice managers

5. **Provide easy-to-use retract-and-reorder (RAR) functionality, as well as functionality to track and identify potential design errors through regular review of RAR information.**

Summary: The use of RAR functionality is emerging as a common methodology not only to reverse medication order errors, but also to study incidence and root cause of errors that occur during the medication ordering process, including pick list-related errors. This recommendation is two-pronged. First, RAR functionality, whether built-in to the EHR or provided by a third party, would benefit prescribers when an erroneous order is identified. Prescribers should be able to easily cancel or modify the order as needed in the EHR and to have that information relayed immediately to the pharmacy receiving the order to ensure patient safety. Current NCPDP SCRIPT standards include functionality to link the separate "discontinue" <CancelRx> and "new order" <NewRx> messages and to communicate the nature of the order change to the pharmacist.[49] Second, EHR systems should build upon the existence of the RAR functionality to produce regular reports available to practice staff to support monitoring and quantifying the occurrence of orders canceled; the reports should include specific reasons for cancellation, such as "wrong patient," or "wrong medication." Emerging evidence strongly supports the benefits of regularly reviewing these data to identify patterns or frequencies of events and determine if adjustments need to be made to reduce the likelihood of error.

Stakeholders: EHR support staff, CMIOs, practice managers, providers, vendors

6. **Provide patients with lists of their current medications, including indications for each medication.**

EHR systems that are certified under the ONC Certification Program provide access to an electronic summary of each visit, which includes an updated medication list, ongoing diagnoses, and other standard items. Both the Joint Commission and the Centers for Medicare & Medicaid Services (CMS) require the provision of an after-visit summary as part of the protocol for compliance with their programs. Although adherence to this policy is increasing rapidly, patients may not always understand the importance of reviewing the after-visit summary, or may not be fully engaged or empowered to ask follow-up questions if the information—including active medications and their relationship with diagnoses—is unclear or differs from their understanding. The information included on the patient summary should reiterate and support the details discussed as part of the "teach back" portion of an office visit, a requirement of the National Patient Safety Goal.[51] In the "teach back," a provider reviews with the patient a summary of the discussions and decisions made during the encounter to ensure understanding. If the patient has been given the wrong medication or administration due to a pick list error, careful review of the after-visit summary by the patient is perhaps the most important step in identifying and rectifying the error.

Stakeholders: Practice managers, providers, patients

6.1 Supporting Documents

To support the implementation of RTI's six recommendations, the project team developed a series of supporting documents with input, review, and approval from the work group members. These include: (1) Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations, (2) Self-Assessments for Practice Leadership to Use in Support of Pick List Best Practices, and (3) Best Practices for Providers: Reducing Pick List Errors.

Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations. This document outlines specific EHR system functionality that supports the recommendations put forward by the work group. The document provides vendor development and user experience teams the ability to compare their systems' current functional capabilities against each of the major recommendations, and provides references to sources of additional detail. Understanding that there are multiple demands on the decision-making process for development cycles, the document distinguishes between core and suggested functionalities. Core functionalities are the most critical with the strongest evidence base, while suggested functionalities have strong evidence but are less critical. See ***Appendix B***.

Self-Assessments for Practice Leadership to Use in Support of Pick List Best Practices. Care sites using an EHR system should have clear and enforceable policies to support end users in safe medication ordering, including use of pick lists. Designated staff members should be responsible for communicating with the vendor to solve problems with system design or usability. This document includes two distinct assessments. The first allows practice staff to determine the status of organizational policies and procedures for reducing pick list-related errors. The second provides a set of EHR design features and functions that support best practices for reducing pick list-related errors, which staff may use to assess their current EHR or a system that they may be considering for implementation. See ***Appendix C***.

Best Practices for Providers: Reducing Pick List Errors. This document provides a brief synopsis of the responsibilities of front-end users of EHR systems in reducing the potential for both wrong-patient and wrong-medication pick list errors. Providers should feel confident that their EHRs support them in providing the safest care possible, and should know with whom they should discuss concerns if they identify potential hazards or feel that the system or policies are overly burdensome. See ***Appendix D***.

This page intentionally left blank

7. FUTURE CONSIDERATIONS

In reviewing the research on factors that decrease the likelihood of pick list errors in the medication ordering process, certain topics lacked sufficient evidence to support a specific recommendation. These topics require additional research to better understand the underlying factors that increase the risk of medication error and which strategies are effective in addressing these factors.

First, more research is needed in understanding and managing interruptions during the medication ordering process. The body of literature on the human factors elements that lead to pick list errors indicates that interruptions are a significant factor, but one for which specific, workable solutions either in policy, practice, or supportive technological functions have not been widely established. Adding steps to a provider's workflow or including more alerts has not been shown to uniformly decrease the risk of errors; instead, these approaches may increase the burden on providers who are already working in busy, time-sensitive environments. Understanding why interruptions occur and how they lead to pick list-related errors, especially in the ambulatory environment, need further research before specific recommendations can be made.

Second, applied research regarding the use of CDS to develop automated inferences related to diagnoses and other information in the EHR—which would support the population of a tailored list of possible medications for a patient—needs to be more robust, and best practices must be published. Today's EHR systems have the ability to support advanced analytic and decision support, allowing providers to choose from a smaller list of appropriate medications, thereby reducing the likelihood of choosing the wrong medication from a larger list.[52,53] This practice may also reduce wrong-patient errors through a tacit alert when the medication the provider is looking for does not appear on the "smart" list. However, these system capabilities are just now emerging and have not been fully optimized; therefore, their effectiveness in practice is not fully established, which raises the risk of unnecessary delays or even additional unintended errors. EHR vendors and health care systems may be willing to share components of their decision support systems that use inference to delimit medication pick list choices; wider adoption of these techniques would allow greater standardization around safety-critical functionality. Such collaboration could be a high-priority topic for the proposed Health IT Safety Collaborative, where issues could be discussed in a shared but protected manner and further validated through scientific research and external testing.

Third, work group members agreed that sharing diagnosis information with pharmacy staff would provide an important additional quality check at the site where medication is dispensed. A 2013 pilot study indicated that the impact of including diagnosis information with prescription orders could lead to improved patient safety and workflow by providing pharmacists information to contextualize the orders they are filling.[54] Findings

substantiating the reduction of confusion and incorrect ordering by including diagnosis information have been reported in systems elsewhere in the world.[55] A study expanding on the initial pilot is currently underway to provide further evidence that could lead to future recommendations regarding the role of pharmacy staff play in improving safety of medication ordering, including the possibility of catching pick list-related errors. Additional research in this area is currently being conducted under an Agency for Healthcare Research and Quality (AHRQ)-funded grant that is convening stakeholder expert panels, building a working prototype, and formally testing the prototype's effect on the usefulness and safety of incorporating indication into the order for both pharmacists and patients.[56] A number of work group members suggested that this is an essential area for additional research and funding.

Finally, the members of the work group considered the benefits of tracking pick list-related errors, specifically in reports of medication errors provided to PSOs. The ability to track the source of a medication error through review of RAR data, as recommended in this report, is important at the practice level, but an additional vital step toward improving our understanding of these issues would be to report the root cause (including possible pick list issues) to PSOs. To encourage this level of detail, it may be possible to leverage the AHRQ Common Formats for medication-related adverse event reporting. The Common Formats for Community Pharmacy and for Hospital settings would need to be changed to capture such information in a useful way. As a public–private entity with engagement from various PSOs and Federal representatives, including AHRQ staff, the proposed Health IT Safety Collaborative would be an ideal forum for advancing work in this area.

Appendix A:
List of Work Group Members

Rob Anthony
Quality Measurement and Value-Based Incentives Group (QMVIG)
Centers for Medicare & Medicaid Services (CMS)

Jeff Belden
Usability Consultant
Independent provider; Too Many Clicks

Barbara Boockholdt
Chief of Policy, Evaluation, and Analysis
U.S. Drug Enforcement Administration (DEA)

Gerry Castro
Project Director, The Joint Commission, Office of Patient Safety
The Joint Commission

Simon Choi
Senior Science Health Advisor- Digital Health
U.S. Food and Drug Administration (FDA)

Michael Cohen
President
and
Allen Vaida
Executive Vice President
Institute for Safe Medication Practices (ISMP)

Ajit Dhavle
Vice President, Clinical Quality
Surescripts

Jesse Ehrenfeld
Member, Board of Trustees
American Medical Association (AMA)

Ellen Flynn
Assistant Vice President, Safety and Accreditation Programs
Vizient, Inc.

Tejal Gandhi
President & CEO
National Patient Safety Foundation (NPSF)

Andrew Gettinger
Chief Medical Information Officer
Office of the National Coordinator for Health Information Technology (ONC)

Joe Graedon and Terry Graedon
Founders
Society for Participatory Medicine and The People's Pharmacy

David Kibbe
Senior Advisor, Health IT
American Academy of Family Physicians (AAFP)

Rich Landen
Director, Regulatory Affairs, QuadraMed
Representing the HIMSS Electronic Health Record Association (EHRA)

Edwin Lomotan
Chief of Clinical Informatics
and
David Rodrick
Health Scientist Administrator
Center for Quality Improvement and Patient Safety (CQuIPS)
Agency for Healthcare Research and Quality (AHRQ)

Svetlana Lowry
Usability Scientist, Lead NIST Health IT Usability Program
National Institute of Standards and Technology (NIST)

Taramarie Modisett
Executive Director
Alliance for Patient Medication Safety

James Owen
Vice President, Practice and Science Affairs
American Pharmacists Association (APhA)

Raj Ratwani
Scientific Director, National Center for Human Factors in Healthcare
and
Zach Hettinger
Medical Director, National Center for Human Factors in Healthcare
MedStar Institute for Innovation
Jeanie Scott
Director, Informatics Patient Safety
U.S. Department of Veterans Affairs (VA)

Ronni Solomon
Executive Vice President and General Counsel
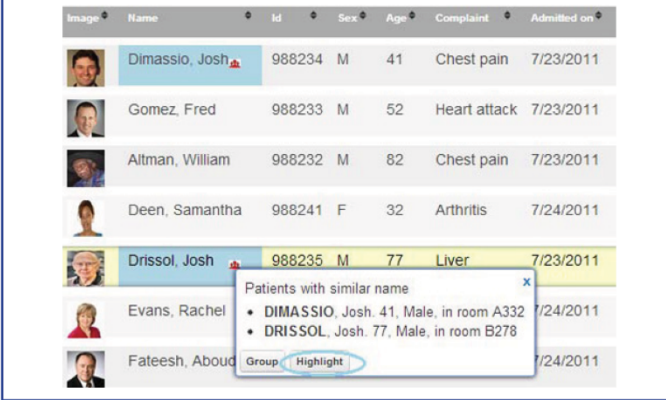ECRI Institute

Appendix B:
Features to Reduce Pick List-Related Medication Order Errors
for Compendia and Vendor Organizations

Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations

Recommendation 1:
Design functionality to improve pick list-related patient identification error

Implemented by:
Vendors

Straightforward EHR functional design can greatly reduce the likelihood of a wrong-patient error

	CORE FUNCTIONALITY	REFERENCES
1	The ability to recognize a **picture of the patient** and to have the photo displayed in the record at the time of medication order submission reduces the likelihood of errors related to selecting the wrong patient.	Galanter[50]; Hyman and Redmond[34]; Sopan[32]; SHARPC: NCCD[57]
2	**Provide clues that similar names exist**. For example, a small icon next to the name if there are other patients with similar names. Hovering the cursor over the icon reveals the list of similar names and additional information about those patients.	Sopan[32]; SHARPC: NCCD[57]
3	**Always show patient's full name**, as identified by the patient. If a name in the list is unusually long, it should be wrapped inside the cell using a double height row.	Sopan[32]; SHARPC: NCCD[57]

	SUGGESTED FUNCTIONALITY	REFERENCES
1	Ability to **view multiple patient charts at once increases the likelihood of wrong-patient error** in medication ordering. Systems should be capable of implementing local configurations on restrictions or notifications regarding multiple patient charts open at one time based on organizational policies.	Levin[26]

Core functionalities are those that have highest support in the evidence for reducing pick list-related errors and are considered essential for the upcoming development cycle. **Suggested functionalities** are those supported by evidence to reduce pick list-related errors, but not as critical to include in immediate development cycles.

28

Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations

Recommendation 2:
Adhere to a set of common guidelines to standardize the safe identification of medications when developing e-prescribing drug names

Implemented by:
Compendia Developers

List of medications appearing in a drop-down menu, demonstrating best practices for nomenclature

	CORE FUNCTIONALITY	REFERENCES
1	**Do not abbreviate drug names or truncate information** on the display. (e.g., MTX for methotrexate has been misunderstood as mitoXANtrone; MSO4 for morphine sulfate has been misinterpreted as magnesium sulfate).	ISMP[46]; NIST[15]; FDA[48]; NCPDP[49]; Sengstack[31]
2	List all medication-related products by **generic name using all lowercase** letters as the primary expression of drug nomenclature, ensuring that each matches FDA-approved nomenclature so that electronic medication records agree with all package labels.	ISMP[46]
3	**Avoid information being truncated on the display** (e.g., medication names and doses in pick list menu displays should be accurate and complete and distinguishable from other items in the pick list).	ISMP[46]; FDA[48]; Belden et al.[41]; NIST[15]; NCPDP[49]; Sengstack[31]
4	**Standardize the expression of suffixes** that are part of the drug name (e.g., SR, CD, CR) within both the generic name field and the brand name field (e.g., diltiazem CD, Cardizem CD).	ISMP[46]; NCPDP[49]; FDA[48]

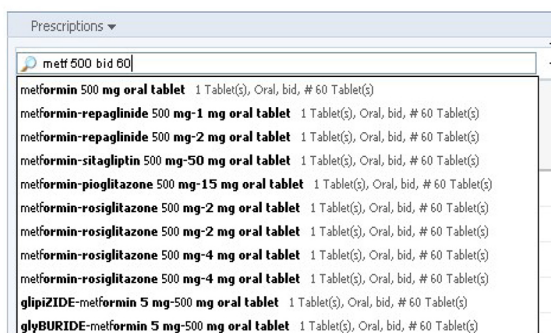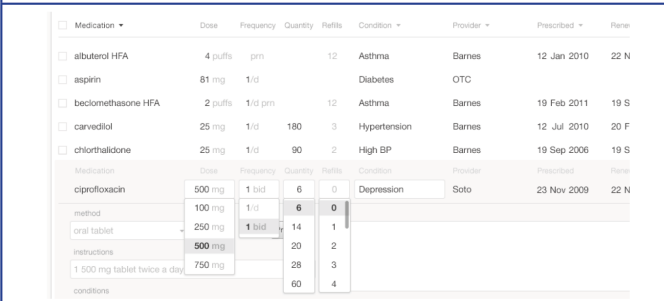|	SUGGESTED FUNCTIONALITY	REFERENCES
1	**Do not include the salt of the chemical** when expressing a generic drug name unless there are multiple salts available (e.g., prednisone hydrochloride and prednisone pamoate). If the salt is used as part of the name (e.g., US Pharmacopeial Convention [USP]-approved abbreviations such as K [potassium], Na [sodium], HBr [hydrobromic acid], and HCl [hydrochloric acid]), it should follow the drug name, not precede it.	ISMP[46]; FDA[48]
2	**Avoid using drug protocol acronyms** (e.g., CVP) without defining the protocol (cyclophosphamide, prednisone) at least once within the electronic communication.	ISMP[46]; FDA[48]
3	As appropriate, **list associated brand names** in a requisite field using an **uppercase first letter** (unless using tall man letters). Although the use of all uppercase letters is a standard convention for trademarks, mixed-case and lowercase letters are more unique and distinguishable than all block-like uppercase letters, which look similar especially in low lighting. Trademark symbols (e.g., TM, ®) should not be used.	ISMP[46]
4	**Avoid the use of known error-prone abbreviations**, symbols, and dose designations, including those on the ISMP List of Error-Prone Abbreviations, Symbols, and Dose Designations (www.ismp.org/Tools/errorproneabbreviations.pdf), which may cause confusion in electronic formats.	ISMP[46]; NCPDP[49]

Core functionalities are those that have highest support in the evidence for reducing pick list-related errors and are considered essential for the upcoming development cycle. **Suggested functionalities** are those supported by evidence to reduce pick list-related errors, but not as critical to include in immediate development cycles.

Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations

Recommendation 3:
Implement best practices for organization, design, and configuration of all pick lists

Implemented by:
Vendors

Screenshot of a set of medication-ordering drop-down menus that demonstrate best practices

	CORE FUNCTIONALITY	REFERENCES
1	**Use easy-to-read, larger size fonts** not densely compressed when expressing electronic text. Familiar sans serif fonts without embellishments are preferred, although using serifs is not problematic as long as the font style is not extreme or unusual.	ISMP[46]; NIST[15]; Belden et al.[41]
2	**Adhere to tested, evidence-based guidelines when utilizing color.** Color should be used sparingly. It should be specifically used to draw attention, communicate organization, indicate status changes, and establish relationships. **Utilize established human factors data to select the appropriate character, text, and colors to accompany electronic displays of information.** For example, the contrast ratio for alphanumeric characters/text to the self-luminous computer screens or displays should not be below 7:1. Never display pure red text on a pure blue background or vice versa; never use pure blue or red text on a black background; and never use pure blue for text or fine details on electronic displays.	Belden et al.[41]; ISMP[46]; NIST[15]
3	**Provide adequate space for items in data fields** used to communicate drug names, dosing units, routes of administration, and frequencies. Two or three character fields force the use of potentially dangerous abbreviations.	ISMP[46]
4	Utilize Tall Man bolded letters (e.g., **DOBUT**amine and **DOP**amine) to distinguish between medications that look alike on the screen.	ISMP[46]; Naunton[58]

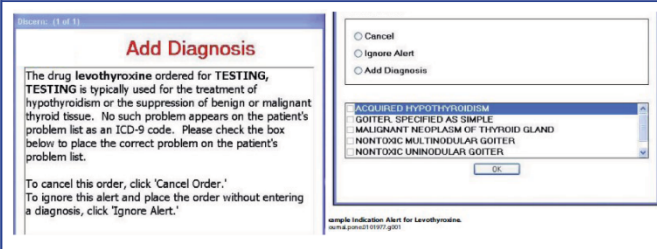|	SUGGESTED FUNCTIONALITY	REFERENCES
1	EHR vendors are strongly encouraged to **use a commercial compendium** source, and to use the compendium's recommended e-prescribing drug name, which is not to be modified, so that information sent to the pharmacy on prescriptions minimizes confusion and possible patient harm. EHR systems should support timely and accurate updates for drug files.	NCPDP[49]
2	EHRs may choose to support local drug names on "favorites" or "quick pick lists," but **free text drug descriptions should not be used**. The information should be presented in these list in the same way it appears in the final review and the transmission of the e-prescribing drug name, and should always follow safety-related recommendations outlined by ISMP and NCPDP (see also recommendation 4, core functionality 1).	NCPDP[49]
3	**Drop-down lists can be designed to improve accuracy and reduce time burden on clinicians** by properly implementing the following functionalities: • **Typing Causes the List to Prepopulate**—User favorites can jump to the top of the list. • **Typing More Characters Produces a Closer Match**—Additional details (tablet strength "500") may be added to the search string. • **Allow Users to Type a Portion of the Drug Name, and Then Skip to Additional Details**—Allowing the physician to add the dosing frequency "bid" after the right medication appears in the list reduces the number of correct choices without having to type the complete medication name or scroll through all of the dosing options.	Belden et al.[41]
4	**Provide users with the ability to search by brand name, generic name, short name, or mnemonic**, and link all means of accessing a name to default to a generic name. Also, organize generic and brand names by dosage form in look-up tables (e.g., multiple gentamicin products should be organized by parenteral injection, ophthalmic solution, cream, and other dosage forms).	ISMP[46]

Core functionalities are those that have highest support in the evidence for reducing pick list-related errors and are considered essential for the upcoming development cycle. **Suggested functionalities** are those supported by evidence to reduce pick list-related errors, but not as critical to include in immediate development cycles.

Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations

Recommendation 4:
EHR systems should institute a summary review screen prior to completion of an order, with appropriate training and policies to ensure proper uses

Implemented by:
Vendors; Local Configurator

Example of an alert about a wrong-medication pick list error that may have occurred because the medication chosen is not indicated by the patient's problem list

Add Diagnosis

The drug **levothyroxine** ordered for TESTING, TESTING is typically used for the treatment of hypothyroidism or the suppression of benign or malignant thyroid tissue. No such problem appears on the patient's problem list as an ICD-9 code. Please check the box below to place the correct problem on the patient's problem list.

To cancel this order, click 'Cancel Order.'
To ignore this alert and place the order without entering a diagnosis, click 'Ignore Alert.'

○ Cancel
○ Ignore Alert
○ Add Diagnosis

☐ ACQUIRED HYPOTHYROIDISM
☐ GOITER, SPECIFIED AS SIMPLE
☐ MALIGNANT NEOPLASM OF THYROID GLAND
☐ NONTOXIC MULTINODULAR GOITER
☐ NONTOXIC UNINODULAR GOITER

[OK]

	CORE FUNCTIONALITY	REFERENCES
1	Use the following to display information in a summary review of the medication order prior to submission: • Use the typical smaller **font for fractions** (i.e., ½ not 1/2) to express a partial tablet. • When the drug name, strength, dosage form, and dosage units appear together, list the **generic name first, followed by brand name**, strength, dose (if different than strength), and the dosage form (e.g., timolol [Timoptic if brand dispensed] 0.5% ophthalmic solution; diazepam 5 mg tablet). **When the strength and dose differ, also list the amount needed for the dose** (e.g., propranolol 5 mg [½ x 10 mg] tablet) on the electronic medication administration record (eMAR). • When the drug name, strength/dose, and the unit of measure appear together, **require a space between the drug name and strength/dose** (e.g., propranolol20 mg has been misread as 120 mg), and between the dose and unit of measure (10Units has been misread as 100 Units). • **Include the name(s) of the drug and the patient-specific dose** (not just the strength dispensed) on the same line/entry on eMARs. Avoid entries where the name of the drug and available dosage strength are on the first line and the patient-specific dose is on the next line.	ISMP[46]
2	**System checks diagnosis/problem list against:** • look-alike products (www.ismp.org/Tools/confuseddrugnames.pdf) that are known to be problematic (few look-alike name pairs are used for the same purpose); • medications that have different dosing based on the indication (e.g., desmopressin for hemophilia or diabetes insipidus) or have multiple indications not included in the approved labeling (e.g., most prescriptions for gabapentin are for off-label uses such as neuropathic pain syndrome, generalized anxiety, social phobia, and migraine therapy).	ISMP[46]; Galanter[50]

	SUGGESTED FUNCTIONALITY	REFERENCES
1	**Allow Physicians to Modify the Display Quickly by Offering the Most Common Detail Choices for a Particular Medication**—These include strength, instructions, quantity, and number of refills.	Belden et al.[41]; Sweidan et al.[40]
2	The system should **allow association of a diagnosis or chronic problem and association of one or more diagnoses per medication**. Automatically assigning a therapeutic class is not an appropriate substitution for this functionality. Knowing that a drug is a beta-blocker (the therapeutic class) is not sufficient, because a beta-blocker might be used for any of these diagnoses: hypertension, angina, coronary artery disease, atrial fibrillation, supraventricular arrhythmias, tremor, migraine, and portal hypertension. The therapeutic class will often be meaningless to the patient.	Belden et al.[41]

Core functionalities are those that have highest support in the evidence for reducing pick list-related errors and are considered essential for the upcoming development cycle. **Suggested functionalities** are those supported by evidence to reduce pick list-related errors, but not as critical to include in immediate development cycles.

Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations

Recommendation 5:
EHR systems should provide easy-to-use Retract-and-Reorder functionality and ability for staff to review data regularly

Implemented by:
Vendors; Local Configurator

Example of a medication cancellation screen which includes erroneous entry as a reason for the retraction

	CORE FUNCTIONALITY	REFERENCES
1	**Ability to easily retract and/or reorder (RAR) medication if an error is discovered is a crucial factor in reducing errors**. This functionality is also emerging as essential for tracking and investigating wrong-medication and wrong-patient errors, which can lead to the formation of new best practices in medication ordering.	Adelman[4]; Green[33]

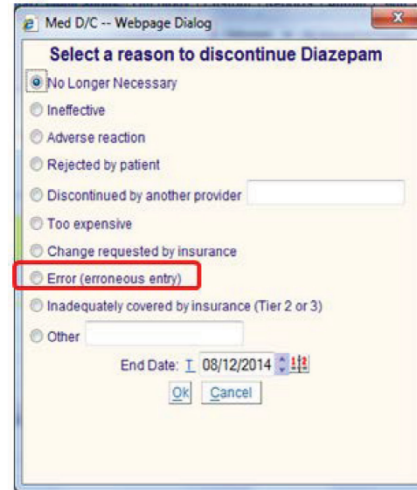No suggested functionality for this recommendation

---

Core functionalities are those that have highest support in the evidence for reducing pick list-related errors and are considered essential for the upcoming development cycle. **Suggested functionalities** are those supported by evidence to reduce pick list-related errors, but not as critical to include in immediate development cycles.

Features to Reduce Pick List-Related Medication Order Errors for Compendia and Vendor Organizations

Recommendation 6:
Visit summaries provided to patients should clearly indicate which medications are indicated for which diagnoses

Implemented by:
Vendors; Local Configurator

Example of clinical summary which includes description of both diagnoses and the medications prescribed to treat the issue.

Final Report

Ambulatory Patient Depart Summary (Verified)

UNIVERSITY PHYSICIANS – SOUTH PROVIDENCE FAMILY MEDICINE GOLD
University of Missouri Health Care
South Providence Medical Building
551 E Southampton Drive
Columbia, MO 65201

Patient: xxxx
Date of Birth: xxxx
Sex: Male
Race: White
Ethnicity: Not Hispanic or Latino or Spanish Origin
Diagnosis or Problem(s) Addressed at this Visit: Erectile dysfunction; Osteoarthritis; Basal cell carcinoma of face; Hyperlipemia (target LDL)

Date/Time of Visit: 06/20/16 01:20pm
Preferred Language: English
Primary Care Provider: Belden MD, Jeffery L
Attending Physician: Belden MD, Jeffery L
Actual Physician: Belden MD, Jeffery L

Vital Signs, Results, and Measurements

Blood Pressure: 147/84 mmHg
Heart Rate: 57 beats per min.
Temperature: 97.9F (36.6 C)
Respiratory Rate: 16 breaths per min.
Smoking Status: Former smoker quit longer than 12 months

Height: 5 ft. 8 in. (173.1 cm)
Weight: 166.56 lbs (75.55 kg)
Body Mass Index: 25
Glucose:

Problem List

Printed by: xxxxxxx
Printed on: 06/22/2016 12:53
Actinic keratosis; Basal cell carcinoma of face; Colon polyps; Erectile dysfunction; History of nonmelanoma skin cancer; Hyperlipemia (target LDL)

Medication Instructions

NEW, CHANGED or REFILLED prescriptions this visit	Special Instructions
lisinopril (Lisinopril 20 mg) 20 mg = 1 Tablet(s) Oral Daily *Sent to Tolson Drug Inc – Jefferson City, M*	Purpose: high by Instructions: New dose as of 6/20/16
meloxicam (meloxicam 15 mg) 15 mg – 1 Tablet(s) Oral Dailey *Sent to Tolson Drug Inc – Jefferson City, M*	Purpose: Osteoarthritis
sildenafil (Viagra 100 mg) 100 mg = 1 Tablet(s) Oral as needed for erectile dysfunction *Printed prescription will be given to you*	Purpose: ED Instructions: 1 hour before sexual activity

CONTINUE TAKING the following medications	Special Instructions
aspirin (aspirin 325 mg) 325 mg = 1 Tablet(s) Oral Daily **Patient/Caregiver states: Still taking, as prescribed**	Instructions: for DVT ppx

	CORE FUNCTIONALITY	REFERENCES
1	EHR certification criteria for Meaningful Use Stage 1 and beyond for clinical summaries require the presence of: (a) problem list/current conditions, (b) medication list, (c) diagnostic test/lab results, and (d) patient instructions. Providing this information to the patient in a format that **easily associates each medication prescribed with a condition/diagnosis** at the end of each visit allows the patient to review and catch potential patient ID or medication order errors. Clinicians would need to associate the diagnosis to the medication in some cases.	National Learning Consortium[59]

No suggested functionality for this recommendation

Core functionalities are those that have highest support in the evidence for reducing pick list-related errors and are considered essential for the upcoming development cycle. **Suggested functionalities** are those supported by evidence to reduce pick list-related errors, but not as critical to include in immediate development cycles.

This page intentionally left blank

Appendix C:
Self-Assessments for Practice Leaders to Use in Support of Pick List Best Practices

Overview: This document provides ambulatory facility staff responsible for setting policies and end-user training (CMIOs, practice managers, EHR selection committees) assessments of items that should be established to prevent pick list-related errors. This tool allows practice leaders to determine the state of their organization in terms of best practices for pick lists and to then recommend any changes to their policies and procedures as necessary.

Two assessments are included: (1) policies and procedures for reducing pick list-related errors; and (2) a set of EHR design features and functions that support best practices for reducing pick list-related errors. These resources focus on improving safe medication ordering processes primarily in outpatient care settings, but are also appropriate for consideration in other care settings.

Pick List–related Policies and Procedures Assessment

Instructions: Review the policies and procedures below and mark whether they are strongly established, used but not firmly established, or not in place. If not firmly established or not in place, consider developing and disseminating policies, and providing the necessary training on procedures to support reductions in wrong-patient and wrong-medication order errors. Mark N/A for any items that are not applicable.

Who should complete this Assessment?

This assessment is intended to be completed by ambulatory facility staff responsible for setting policies and end-user training (CMIOs, practice managers, EHR selection committees). The results of this assessment should be used by practice leaders to facilitate discussion with your team about developing new policies and procedures specific to assessment, training, measuring, reporting, and responding to health IT-related safety events, in particular those related to use of pick lists in medication ordering.

	This is strongly established in our organization	This is in formative stages, not firmly established	We do not have or need specific procedures or solutions for this issue
EHR Functionality Assessment			
Content and design of pick lists assessed regularly (see Assessment 2: Pick List Functionality)			
There is an established line of communication with EHR vendor about upgrades and improvements if pick list functionality requires adjustment			
Training			
Documentation and training are available to ensure that end users are comfortable with the content and design of pick list functionality in medication ordering process			
Clear policies/procedures that establish responsibility for verification of patient ID prior to placing a medication order			
Importance of using a summary review screen for all medication orders is incorporated into training and continuing education for end users			

	This is strongly established in our organization	**This is in formative stages, not firmly established**	**We do not have or need specific procedures or solutions for this issue**
EHR end users are aware of policies and procedures for reporting safety-related concerns about the functionality of the EHR system, including pick lists			

Measurement and Reporting

A system is in place for reporting and tracking resolution to health IT-related safety issues, including specific pick list concerns			
EHR system allows for tracking and reporting on individual and aggregate retract-and-reorder occurrences.			
Retract-and-reorder occurrences are reviewed on a regular basis to identify potential problems.			
System for reporting health IT safety issues includes the ability to share narrative information with a reporting organization (for example, free text of the medication names that were used in the erroneous orders).			

Responding

My organization has clear policies and procedures for responding to health IT-related safety issues, including specific pick list functionality concerns.			
Response policies clearly delineate responsibility for addressing a reported health IT-related safety issue. Policy includes procedures for contacting and working with vendors, risk managers, and safety organizations in addressing issues, as appropriate.			

Pick List Configuration

Staff responsible for EHR configuration and use are familiar with the ONC Collaborative report on pick list errors			
End users are involved in designing pick list configurations, data presentation, and usage parameters			

Pick List Functionality Assessment

Instructions: Review the list of EHR system functions shown to reduce the potential for pick list-related wrong-patient or wrong-medication errors below against your current EHR system or a new system you are considering. For items marked in the middle column as not currently provided but desired, contact your EHR vendor to discuss the current or future availability of the functionality.

Who should complete this Assessment?

This assessment is intended to be completed by ordering clinicians and EHR system users involved in the ordering process. To ensure accuracy and completeness of results, this assessment should be completed by multiple care team members. The results of this assessment should be used by ambulatory facility staff responsible for EHR vendor relationships to facilitate discussion about the current or future availability of the functionality included in the assessment. If using this assessment to inform purchase of a new EHR system, you may apply it to multiple systems under consideration and use results to compare system functionality.

	My EHR has this feature	**My EHR does not have this feature but I would like it**	**My EHR does not have this feature, nor do I want it**
Safe Presentation of Medications in Pick List			
Medication products listed by generic name using all lowercase letters, unless Tall Man letters are indicated to distinguish known look-alike/sound-alike (LASA) drug pairs			
The salt of the chemical is not included in generic drug names unless there are multiple choices available, in which case it is abbreviated following the drug name, not before			
Associated brand names are listed in a separate field using an uppercase first letter (unless Tall Man letters are indicated to distinguish known LASA drug pairs)			
Suffixes associated with medications are listed in both generic name fields and brand name fields			
Drug names are never abbreviated in drop-down lists			
Drug protocol acronyms are not used in the drop-down list, but are described separately in the electronic communication			

	My EHR has this feature	My EHR does not have this feature but I would like it	My EHR does not have this feature, nor do I want it
Tall Man **bolded** letters (e.g., **DOBUT**amine and **DOP**amine) are used to distinguish between medications that look alike on the screen			
The information presented in the drop-down list is not truncated (each medication and dose is complete and distinguishable in the pick list)			
Pick List Design			
I can easily read the items in the drop-down lists provided when ordering a medication (font size, type, color are all sufficient)			
Medication drop-down lists in my EHR prepopulate when I begin typing to shorten the list of possible choices			
The list of choices given when the drop-down list begins to prepopulate is tied to the diagnosis and/or problem list of that specific patient; flexibility to order a medication for an off-label use is still available			
The EHR system warns me if I have ordered a drug that is not associated with the specific patient's problem list			
The medications provided to me in the medication pick list are organized in a way that makes sense to me			
I can create a list of "favorites" to auto-fill in a medication drop-down list when ordering			
The EHR system populates medication names using drug information from compendia or from my institution			
Free text medication names when ordering are not allowed			
General EHR Design and Functionality			
The EHR provides a summary review of the medication order prior to submission, which allows me to double check the drug name, strength, dose, and units			
When opening a new patient record, my EHR allows me to pick from a list that is limited to the patients assigned to me.			

	My EHR has this feature	My EHR does not have this feature but I would like it	My EHR does not have this feature, nor do I want it
The EHR provides a summary review of the medication order prior to submission that requires me to verify the identity of the patient to ensure the order is being submitted for the right individual			
The EHR allows me, if necessary, to easily retract-and-reorder a medication order that I have submitted if an error is discovered			
The EHR system provides real-time information on the formulary, to inform decision making about medications covered under the patient's insurance			
The EHR system allows me to add a photo of the patient, which is displayed before the medication is ordered to support verification of patient identity			
The EHR system always shows the patient's full name in drop-down lists and summary screens			
The EHR system will let me know if there are other patients in the system with similar names			

Appendix D:
Best Practices for Providers: Reducing Pick List Errors

LAMICTAL (LAMOTRIGINE) FOR CONSTIPATION?

An elderly female was admitted for nursing home placement with a history of Parkinson's disease, hypertension, coronary artery disease, schizoaffective disorder, and dementia. Incidentally, the patient also complained of constipation.
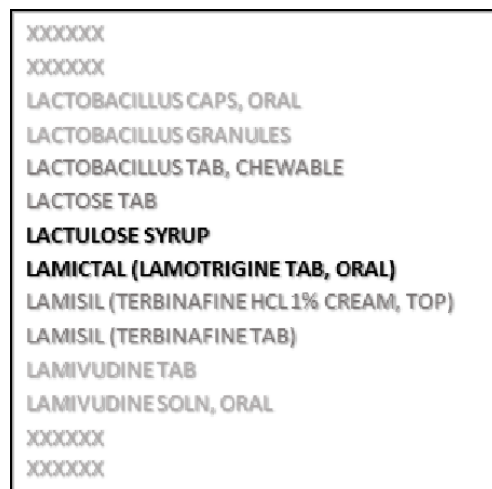
The physician meant to order Lactulose for the constipation, usually given as 1–2 ounces every 4 hours. Instead, the physician inadvertently selected Lamictal from the pull-down menu, an anticonvulsant with serious side effects. The suggested dose was 25 mg, so the doctor ordered this every 4 hours until resolution of the constipation.

An 'alert' appeared about the lamotrigine order, but the physician ignored it. The pharmacist didn't recognize that the order didn't make sense, and didn't realize anything was wrong from the alert either. The nurses didn't recognize a problem with the order, and gave several doses of the wrong medication. None of the staff (physician, pharmacist, or nurse) had ever used Lamictal and were not familiar with its indications.

Fortunately, no harm was done, but the constipation persisted. The error was discovered 48 hours later when a new pharmacist came back on duty and was reviewing orders.

"Pick lists" (drop-down lists) are a feature of every electronic health record (EHR) system, originally designed to save you time and make certain jobs easier. Instead of having to write out the name of your patient, a test, or a medication, you can select these items from pre-constructed menus.

```
XXXXXX
XXXXXX
LACTOBACILLUS CAPS, ORAL
LACTOBACILLUS GRANULES
LACTOBACILLUS TAB, CHEWABLE
LACTOSE TAB
LACTULOSE SYRUP
LAMICTAL (LAMOTRIGINE TAB, ORAL)
LAMISIL (TERBINAFINE HCL 1% CREAM, TOP)
LAMISIL (TERBINAFINE TAB)
LAMIVUDINE TAB
LAMIVUDINE SOLN, ORAL
XXXXXX
XXXXXX
```

Sometimes, however, pick lists create the potential to choose the WRONG patient, test, or prescription. Many of these errors arise in selecting an adjacent item on a list, or when multiple records are open at the same time—or are the result of inevitable distractions and interruptions.

Based on recommendations from a health IT safety work group convened by RTI under its contract to the Office of the National Coordinator for Health IT (ONC), who reviewed the best available evidence, a set of recommendations for improving the safe use of pick lists in clinical practice are included below:

Best Practices for Using Pick Lists

✓ Ensure that you've selected the correct patient record; take advantage of any tools your electronic health record/medical record (EHR/EMR) system offers to verify patient identity (e.g., the patient's picture, two forms of identification).

✓ Work on just one chart at a time, if possible.

✓ Pay special attention to summary review screens for orders: they are designed to catch mistakes. Double-check medication orders for the correct drug and its prescription.

✓ If your EHR/EMR can be customized, create your own lists of patients and favorite medications ('quick lists' or lists of 'my favorites').

✓ Report concerns about the content or design of a pick list to the health IT safety staff that manages your EHR. "Near misses" should always be reported to your practice IT staff, so that they can be reported to the vendors and/or patient safety organizations that, in turn, will determine whether potential safety issues are more widespread.

✓ Ideally, pick lists should be organized in a way that makes sense to you, rather than just being presented in alphabetical order, for example. Medications might be listed by major indication, or by symptom being treated. Patient lists can often be restricted to just the patients assigned to you, or patients being seen in a specific location.

✓ Give patients a list of their current medications and, if possible, a description of what each one is for during the "teach back" process at the end of each visit. Patients can be an important safety net in catching errors.

✓ Your EHR/EMR may issue alerts that can help detect important errors. Pay attention to these alerts and work with your EHR/EMR safety staff to design alert protocols that minimize unimportant alerts.

References

1.   Magrabi F, Ong MS, Runciman W, Coiera E. Patient safety problems associated with heathcare information technology: an analysis of adverse events reported to the US Food and Drug Administration. *AMIA Annu Symp Proc.* 2011;2011:853-857.

2.   Castro GM, Buczkowski L, Hafner JM. The contribution of sociotechnical factors to health information technology-related sentinel events. *Jt Comm J Qual Patient Saf.* 2016;42(2):70-76.

3.   The Joint Commission. Sentinel event alert #54: Safe use of health information technology. 2015; http://www.jointcommission.org/assets/1/18/SEA_54.pdf.

4.   Adelman JS, Kalkut GE, Schechter CB, et al. Understanding and preventing wrong-patient electronic orders: a randomized controlled trial. *J Am Med Inform Assoc.* 2013;20(2):305-310. 10.1136/amiajnl-2012-001055: 10.1136/amiajnl-2012-001055.

5.   Institute of Medicine (IOM). *Health IT and patient safety: Building safer systems for better care.* Washington, DC: The National Academies Press; 2011.

6.   Hydari MZ, Telang R, Marella WM. Saving patient Ryan—Can advanced electronic medical records make patient care safer? 2014; Available at SSRN: http://ssrn.com/abstract=2503702 or http://dx.doi.org/2503710.2502139/ssrn.2503702.

7.   Banger A, Graber ML. *Recent evidence that health IT improves patient safety.* Research Triangle Park, NC: RTI International; February 2015.

8.   Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med.* 2006;144(10):742-752.

9.   Goldzweig CL, Towfigh A, Maglione M, Shekelle PG. Costs and benefits of health information technology: new trends from the literature. *Health Aff (Millwood).* 2009;28(2):w282-293. 10.1377/hlthaff.28.2.w282: 10.1377/hlthaff.28.2.w282.

10.   Buntin MB, Burke MF, Hoaglin MC, Blumenthal D. The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health Aff (Millwood).* 2011;30(3):464-471. 10.1377/hlthaff.2011.0178: 10.1377/hlthaff.2011.0178.

11.   Jones SS, Rudin RS, Perry T, Shekelle PG. Health information technology: an updated systematic review with a focus on meaningful use. *Ann Intern Med.* 2014;160(1):48-54. 10.7326/M13-1531: 10.7326/M13-1531.

12.   Gandhi TK, Weingart SN, Borus J, et al. Adverse drug events in ambulatory care. *N Engl J Med.* 2003;348(16):1556-1564. 10.1056/NEJMsa020703: 10.1056/NEJMsa020703.

13.   Gandhi TK, Seger AC, Overhage JM, et al. Outpatient adverse drug events identified by screening electronic health records. *J Patient Saf.* 2010;6(2):91-96. 10.1097/PTS.0b013e3181dcae06: 10.1097/PTS.0b013e3181dcae06.

14.   International Standards Organization (ISO). *ISO 9241-210:2010 Ergonomics of human-system interaction—Part 210: Human-centered design for interactive systems.* Geneva, Switzerland: ISO.

15.   Lowry SZ, Ramaiah M, Taylor S, et al. *Technical evaluation, testing, and validation of the usability of electronic health records: Empirically based use cases for validating safety-enhanced usability and guidelines for standardization.* National Institute for Standards and Technology Interagency/Internal Report (NISTIR) 7804- 2015.

16.   Institute of Medicine (IOM). *Preventing medication errors: Quality chasm series.* Washington, DC: The National Academies Press; 2006.

17.   National Coordinating Council for Medication Error Reporting and Prevention. About medication errors. 2016; http://www.nccmerp.org/about-medication-errors. Accessed May 27, 2016.

18.   Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events. Implications for prevention. ADE Prevention Study Group. *JAMA.* 1995;274(1):29-34.

19.   Bates DW, Slight SP. Medication errors: what is their impact? *Mayo Clin Proc.* 2014;89(8):1027-1029. 10.1016/j.mayocp.2014.06.014: 10.1016/j.mayocp.2014.06.014.

20.   Nebeker JR, Hoffman JM, Weir CR, Bennett CL, Hurdle JF. High rates of adverse drug events in a highly computerized hospital. *Arch Intern Med.* 2005;165(10):1111-1116. 10.1001/archinte.165.10.1111: 10.1001/archinte.165.10.1111.

21.   Graber ML, Siegal D, Riah H, Johnston D, Kenyon K. Electronic Health Record-Related Events in Medical Malpractice Claims. *J Patient Saf.* 2015. 10.1097/PTS.0000000000000240: 10.1097/PTS.0000000000000240.

22.   Schiff GD, Amato MG, Eguale T, et al. Computerised physician order entry-related medication errors: analysis of reported errors and vulnerability testing of current systems. *BMJ Qual Saf.* 2015;24(4):264-271. 10.1136/bmjqs-2014-003555: 10.1136/bmjqs-2014-003555.

23.   Gleason KM, McDaniel MR, Feinglass J, et al. Results of the Medications at Transitions and Clinical Handoffs (MATCH) study: an analysis of medication reconciliation errors and risk factors at hospital admission. *J Gen Intern Med.* 2010;25(5):441-447. 10.1007/s11606-010-1256-6: 10.1007/s11606-010-1256-6.

24.   Cornish PL, Knowles SR, Marchesano R, et al. Unintended medication discrepancies at the time of hospital admission. *Arch Intern Med.* 2005;165(4):424-429. 10.1001/archinte.165.4.424: 10.1001/archinte.165.4.424.

25.   Bell CM, Brener SS, Gunraj N, et al. Association of ICU or hospital admission with unintentional discontinuation of medications for chronic diseases. *JAMA.* 2011;306(8):840-847. 10.1001/jama.2011.1206: 10.1001/jama.2011.1206.

26.   Coletti DJ, Stephanou H, Mazzola N, Conigliaro J, Gottridge J, Kane JM. Patterns and predictors of medication discrepancies in primary care. *J Eval Clin Pract.* 2015;21(5):831-839. 10.1111/jep.12387: 10.1111/jep.12387.

27.   Levin HI, Levin JE, Docimo SG. "I meant that med for Baylee not Bailey!": a mixed method study to identify incidence and risk factors for CPOE patient misidentification. *AMIA Annu Symp Proc.* 2012;2012:1294-1301.

28.   Aspden P, Corrigan JM, Wolcott J, Erickson SM, for the Committee for Data Standards for Patient Safety, Institute of Medicine, eds. *Patient safety: Achieving a new standard for care.* Washington, DC: The National Academies Press; 2004.

29.   Office of the National Coordinator for Health Information Technology. Health IT Safety Center Roadmap: Collaborate on solutions, informed by evidence. 2015; www.healthitsafety.org. Accessed July 21, 2016.

30.   Galanter W, Falck S, Burns M, Laragh M, Lambert BL. Indication-based prescribing prevents wrong-patient medication errors in computerized provider order entry (CPOE). *J Am Med Inform Assoc.* 2013;20(3):477-481. 10.1136/amiajnl-2012-001555: 10.1136/amiajnl-2012-001555.

31.   Sengstack P. CPOE configuration to reduce medication errors. *J Healthc Inf Manag.* 2010;24(4):26-34.

32.   Sopan A, Plaisant C, Powsner S, Shneiderman B. Reducing wrong patient selection errors: exploring the design space of user interface techniques. *AMIA Annu Symp Proc.* 2014;2014:1056-1065.

33.   Green RA, Hripcsak G, Salmasian H, et al. Intercepting wrong-patient orders in a computerized provider order entry system. *Ann Emerg Med.* 2015;65(6):679-686 e671. 10.1016/j.annemergmed.2014.11.017: 10.1016/j.annemergmed.2014.11.017.

34.   Hyman D, Laire M, Redmond D, Kaplan DW. The use of patient pictures and verification screens to reduce computerized provider order entry errors. *Pediatrics.* 2012;130(1):e211-219. 10.1542/peds.2011-2984: 10.1542/peds.2011-2984.

35.   Wears RL. "Just a few seconds of your time..." at least 130 million times a year. *Ann Emerg Med.* 2015;65(6):687-689. 10.1016/j.annemergmed.2015.02.006: 10.1016/j.annemergmed.2015.02.006.

36.   Zahabi M, Kaber DB, Swangnetr M. Usability and safety in electronic medical records interface design: a review of recent literature and guideline formulation. *Hum Factors.* 2015;57(5):805-834. 10.1177/0018720815576827: 10.1177/0018720815576827.

37.   McDonald JD, Durso FT. A behavioral intervention for reducing postcompletion errors in a safety-critical system. *Hum Factors.* 2015;57(6):917-929. 10.1177/0018720815584232: 10.1177/0018720815584232.

38.   Westbrook JI, Baysari MT, Li L, Burke R, Richardson KL, Day RO. The safety of electronic prescribing: manifestations, mechanisms, and rates of system-related errors associated with two commercial systems in hospitals. *J Am Med Inform Assoc.*

2013;20(6):1159-1167. 10.1136/amiajnl-2013-001745: 10.1136/amiajnl-2013-001745.

39.   Coiera E. Technology, cognition and error. *BMJ Qual Saf.* 2015;24(7):417-422. 10.1136/bmjqs-2014-003484: 10.1136/bmjqs-2014-003484.

40.   Sweidan M, Williamson M, Reeve JF, et al. Identification of features of electronic prescribing systems to support quality and safety in primary care using a modified Delphi process. *BMC Med Inf Decis Making.* 2010;10:21. 10.1186/1472-6947-10-21: 10.1186/1472-6947-10-21.

41.   Belden J, Patel J, Lowrance N, et al. *Inspired EHRs: Designing for Clinicians.* MO: The Curators of the University of Missouri; 2014.

42.   Frandzel S. Hi-tech tools boost savings, safety. *Pharmacy Practice News.* July 1, 2013.

43.   Zhong W, Feinstein JA, Patel NS, Dai D, Feudtner C. Tall Man lettering and potential prescription errors: a time series analysis of 42 children's hospitals in the USA over 9 years. *BMJ Qual Saf.* 2016;25(4):233-240. 10.1136/bmjqs-2015-004562: 10.1136/bmjqs-2015-004562.

44.   Grissinger M. Tall man letters are gaining wide acceptance. *Pharm Ther.* 2012;37(3):132-148.

45.   Naunton M, Gardiner HR, Kyle G. Look-alike, sound-alike medication errors: a novel case concerning a Slow-Na, Slow-K prescribing error. *Int Med Case Rep J.* 2015;8:51-53. 10.2147/IMCRJ.S78637: 10.2147/IMCRJ.S78637.

46.   Institute for Safe Medication Practices. *Draft guidelines for the safe electronic communication of medication information: Safe presentation of drug nomenclature and dose expressions.* n.d.

47.   Institute for Safe Medication Practices (ISMP). ISMP Medication Safety Alert! Acute Care (ISSN 1550-6312). 2015; http://www.ismp.org/tools/guidelines/SCEMI/SCEMIGuidelines.aspx.

48.   Schiff G, Wright A, Bates DW, Salazar A, Amato MG, Slight SP. Computerized prescriber order entry medication safety (CPOEMS): Uncovering and learning from issues and errors. US Food and Drug Administration. 2015; http://www.fda.gov/downloads/Drugs/DrugSafety/MedicationErrors/UCM477419.pdf.

49.   NCPDP. *Script implementation recommendations, Version 1.34.* Scottsdale, AZ: National Council for Prescription Drug Programs, Inc.; 2015.

50.   Galanter WL, Bryson ML, Falck S, et al. Indication alerts intercept drug name confusion errors during computerized entry of medication orders. *PLoS One.* 2014;9(7):e101977. 10.1371/journal.pone.0101977: 10.1371/journal.pone.0101977.

51.   The Joint Commission. 2016 National Patient Safety Goals. Ambulatory Health Care Accreditation Program. 2016. Accessed July 21, 2016.

52. Wright A, McCoy A, Henkin S, Flaherty M, Sittig D. Validation of an association rule mining-based method to infer associations between medications and problems. *Appl Clin Inform.* 2013;4(1):100-109. 10.4338/ACI-2012-12-RA-0051: 10.4338/ACI-2012-12-RA-0051.

53. Wright A, Pang J, Feblowitz JC, et al. A method and knowledge base for automated inference of patient problems from structured data in an electronic medical record. *J Am Med Inform Assoc.* 2011;18(6):859-867. 10.1136/amiajnl-2011-000121: 10.1136/amiajnl-2011-000121.

54. Warholak TL, Rupp MT, Leal S, Kurniawan G, Patel N. Assessing the effect of providing a pharmacist with patient diagnosis on electronic prescription orders: a pilot study. *Res Social Adm Pharm.* 2014;10(1):246-251. 10.1016/j.sapharm.2013.04.010: 10.1016/j.sapharm.2013.04.010.

55. Li W, Zhou Q. Patient diagnosis on electronic prescription orders: a key element for appropriateness review by pharmacists. *Res Social Adm Pharm.* 2013;9(4):493-494. 10.1016/j.sapharm.2013.06.005: 10.1016/j.sapharm.2013.06.005.

56. Schiff G. Indications-Based Prescribing. 2015; https://sites.google.com/site/indicationsrx/home/panel-1 Accessed July 21, 2016.

57. SHARPC: NCCD. *Reducing wrong patient selection errors.* Houston, TX: The University of Texas Health Science Center at Houston; 2013.

58. National Learning Consortium. Fact sheet: providing patients in ambulatory care settings with a clinical summary of the office visit. 2012; https://www.healthit.gov/providers-professionals/implementation-resources/fact-sheet-providing-patients-ambulatory-care. Accessed May 27, 2016.