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Brief Communications

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The influence of integrating clinical practice guideline order bundles into a general admission order set on guideline adoption

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ABSTRACT

Objectives of this study were to (1) describe barriers to using clinical practice guideline (CPG) admission order sets in a pediatric hospital and (2) determine if integrating CPG order bundles into a general admission order set increases adoption of CPG-recommended orders compared to standalone CPG order sets. We identified CPG-eligible encounters and surveyed admitting physicians to understand reasons for not using the associated CPG order set. We then integrated CPG order bundles into a general admission order set and evaluated effectiveness through summative usability testing in a simulated environment. The most common reasons for the nonuse of CPG order sets were lack of awareness or forgetting about the CPG order set. In usability testing, CPG order bundle use increased from 27.8% to 66.6% while antibiotic ordering errors decreased from 62.9% to 18.5% with the new design. Integrating CPG-related order bundles into a general admission order set improves CPG order set use in simulation by addressing the most common barriers to CPG adoption.

Key words: user-centered design, clinical decision support, clinical practice guidelines, usability testing

LAY SUMMARY

For many diseases, there exists either national or institutional guidelines that can help physicians best manage and treat their patients based on the most up-to-date evidence and medical knowledge. These guidelines serve to standardize care for patients and have been shown to improve disease outcomes when used, particularly when coupled with order sets built into the electronic health record. Despite the proven benefits of these guidelines, there are barriers that prevent clinicians from using them for eligible patients. In this study, we determined that the most common barriers for clinicians at our institution were not knowing about or forgetting the guideline and associated order set. To address these barriers, we developed a new admission order set that integrated multiple available guideline order bundles aimed at improving guideline order set to use for eligible patients. When tested in a simulated environment, the new tool improved guideline order bundle use by 38.8% as well as decreased antibiotic ordering errors by 44.4%, suggesting that this intervention may be successful at improving guideline order set usage in a real-world environment in for eligible pediatric patients admitted to the hospital.

BACKGROUND AND SIGNIFICANCE

Clinical practice guidelines (CPGs) disseminate evidence-based practices to the bedside, leading to decreased variation in care and improved patient outcomes.[1–3] However, CPG adoption in many contexts remains suboptimal.[4,5] Clinical decision support (CDS) systems integrated into the electronic health record can improve CPG adoption.[6,7] For example, order sets allow physicians to place multiple evidence-based orders for a single diagnosis with a few keystrokes without searching individually for each order. This can reduce the work burden to follow guidelines by aggregating CPG-recommended therapies instead of relying on the physician's memory alone, making the "right" clinical decision easy.[6–8] The use of CPG-associated order sets has been shown to improve patient outcomes in sepsis, pneumonia, and many other diseases.[8–17]

It remains unknown what strategies best promote the use of CPG order sets. Many organizations use disease-specific admission order sets, but this approach requires the user to remember and solicit the CPG order set at the right time.[18] Additionally, order sets may not be adopted because they do not align with workflow[4] and are not monitored for ongoing optimization, reducing their clinical utility.[19] Including modular disease-specific order bundles into more commonly used admission order sets significantly improved adoption in one single-center study.[9] At our institution, a stand-alone pediatric hospital in an urban setting, we identified multiple CPGs for general pediatrics admissions where the appropriate order set was used in <50% of eligible encounters. CPG recommendations were also followed less often when the associated order set was not used, which can lead to lower-value care.

In this study, we employed user-centered design to (1) understand clinician barriers to CPG order set use and guideline adherence and (2) evaluate CDS prototypes addressing those barriers through formative and summative usability testing.

METHODS

We designed CDS to promote CPG adoption in three stages (1) identification of barriers and facilitators to CPG order set use, (2) development of a CDS prototype addressing these barriers through formative usability testing, and (3) evaluation of the CDS prototype through summative usability testing. In this study, formative usability testing was used to optimize the design of our CDS in the early stages of its development by highlighting useful design features as well as flaws. Changes to the design were made between participants, improving based on their qualitative feedback but precluding a direct comparison between designs. Subsequent summative usability testing then served to quantitatively evaluate the performance and usability of the final CDS design compared to the original EHR in order to estimate how the CDS would perform in a real production environment when compared with the current state.

Identifying barriers and facilitators

We developed a list of potential barriers using Miller et al's application of Nielsen's design heuristics to CDS.[20] We then identified encounters from October 16, 2019 through January 1, 2020 in which patients were eligible for a CPG based on pre-existing computable population definitions but where the appropriate order set was not used. A board-certified pediatrician (JM) performed manual chart reviews to confirm CPG eligibility. Within two weeks of the patient's admission date, we contacted clinicians who signed the admission order for these patients. We provided the admitting clinician the patient's medical record number, the date of the relevant encounter, and the CPG for which the patient was eligible. We asked them to (1) select reasons for CPG nonuse from the pre-defined list (or add categories as needed) and (2) provide narrative comments.

CDS prototype and formative usability testing

We developed a candidate CDS system based on the most commonly identified barriers and iteratively improved the prototype through formative usability testing with pediatric residents in their usual workroom. Participants were instructed to describe their goals, thoughts, and actions out loud[21] as they placed admission orders for simulated patients using a test EHR environment with functionality identical to the production environment except for the presence of the new CDS prototype. Ordering activities were observed by a pediatric hospitalist and human factors engineer with special attention to the use of CPG order groups. At the end of each scenario, we elicited qualitative feedback from participants to inform CDS design and iteratively adjusted based on common errors.

Summative usability testing

We compared the new CDS design with the current state in summative usability testing (Figure 1) with pediatric residents, family medicine residents, and pediatric hospital medicine attendings. Testing was performed in the same simulated environment as formative testing. Participants were randomized to either the original or the integrated admission order set and asked to place orders in a test EHR environment for three standardized scenarios described verbally by the interviewer. We measured the use of the appropriate order bundle, adherence to CPG recommendations, rate of ordering errors, and time to complete the task. Definitions of ordering errors are outlined in Supplementary Appendix 1. Participants were then asked to complete a postsimulation quiz focused on CPG knowledge. Finally, they switched order set designs for a fourth simulation to provide context for a subjective comparison of the original design and integrated order set. Subjective comparison survey questions were adapted from the Technology Acceptance Model (Supplementary Appendix 1) focusing on constructs of perceived usefulness and ease of use, which are associated with individual behavioral intention to use a system.[22] Participants were randomized based on their training level in blocks of two.

Data analysis

Continuous variables were compared between CDS and current usability testing using two-sample *t* tests. Categorical variables were analyzed using chi-square tests (or Fisher's exact tests where expected cell counts were less than 5). Analyses were conducted using R Statistical Software (Foundation for Statistical Computing, Vienna, Austria).

This study was deemed by the Children's Healthcare of Atlanta Institutional Review Board to be nonhuman subjects research as a quality improvement study.

Figure 1. Summative usability testing study design. TAM: Technology Acceptance Model.

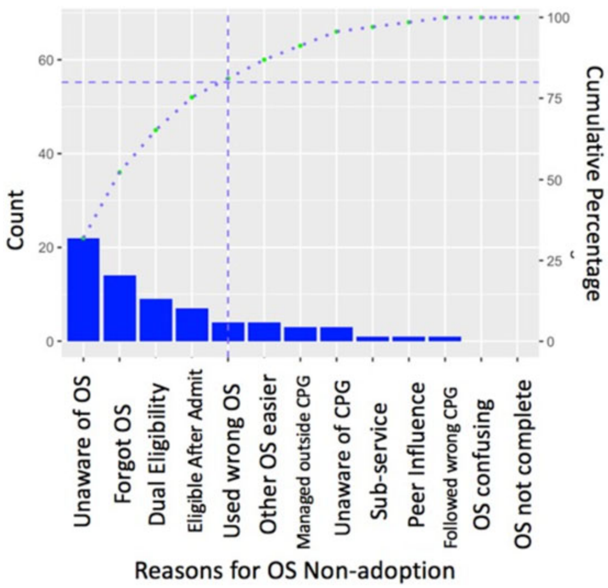

Figure 2. Pareto plot of reasons for Clinical Practice Guideline order set nonadoption. CPG: clinical practice guideline; OS: order set.

RESULTS

Identifying barriers and facilitators

We identified 142 encounters eligible for CPGs based on computable population definitions where the corresponding CPG order set was not used. Of these, we excluded 65 (46%) after manual chart review indicated the patient did not meet CPG eligibility criteria. We contacted the clinician who placed the admission order for 77 encounters, of whom 69 (90%) responded. Nearly, all (96%) respondents were pediatric residents; 77% were interns. The most common reasons for the nonuse of CPG order sets were lack of awareness or forgetting to use the CPG (Figure 2), which accounted for 52%. Eligibility for multiple CPGs (13%), becoming eligible for a CPG later in the hospital stay (10%), and use of a similarly named order set that was not the intended CPG order set (6%) were the next most common reasons for nonadoption.

CDS prototype and formative usability testing

Based on the most commonly identified barriers, we integrated CPG order bundles into a single general pediatrics admission order set. Order bundles were added to a section entitled 'Common General Pediatric Clinical Practice Guidelines' (Figure 3). Orders in each CPG order bundle were identical to the existing standalone CPG-associated order sets. Within each order bundle, embedded hyperlinks referenced the published CPG and relevant literature from which recommendations were made. For order bundles that recommended empiric first-line antibiotics, common target disease pathogens were referenced to help facilitate learning. The integrated order set allowed for the selection of multiple CPG order bundles within the order set, for patients that may qualify for multiple CPGs.

Formative usability testing was completed with 5 residents (3 interns and 2 senior residents) from 2 specialties with a total of 16 scenarios administered. The senior residents searched for and utilized the appropriate CPG order set in 5 out of 6 scenarios (83%). Interns searched for the generic general pediatrics admission order set in 5 out of 10 scenarios (50%). Interns selected CPG order bundles through the general pediatrics order set in 4 of 5 of these scenarios (80%) when using the new system. All interns commented that they did not know initially that an order set existed for those scenarios until being prompted by the new CDS tool. All 5 residents reported that the combined order set was more usable than the current state, particularly in scenarios with patients eligible for multiple CPGs. One recurring problem was that patients eligible for multiple CPGs would have duplicate orders placed for a regular diet, intravenous fluids, and vital signs. We subsequently removed these orders from the CPG-specific order bundles unless CPG-specific instructions existed and kept them in the main order set. No other specific adjustments were made.

Summative usability testing

Summative usability testing was performed with 18 clinicians (Table 1). The proportion of scenarios in which an appropriate CPG order bundle was used increased from 27.8% to 66.7% (+38.9%, 95% CI +4.2–+83.0%, $P = .015$) with the new integrated design (Table 2). Participants randomized to the integrated order set also made fewer errors (−29.7%, 95% CI −0.5% to −58.7%, $P = .056$) including wrong or under-dosed antibiotics based on institutional recommendations (−44.4%, 95% CI −17.3% to −71.5%, $P = .002$). There was no significant difference in average time to complete scenarios or post-scenario quiz grade. In the subjective comparison survey, 94% of participants favored the new CDS and reported that they agreed the new system was easy to use and that they were satisfied with the new system. Additionally, 94% reported that it was easier to remember to use a CPG order set with the new system. Finally, 78% agreed that the new system was efficient to use with the remaining 28% feeling neutral, suggesting the efficiency of the new CDS was equivalent or better than the current state for all participants.

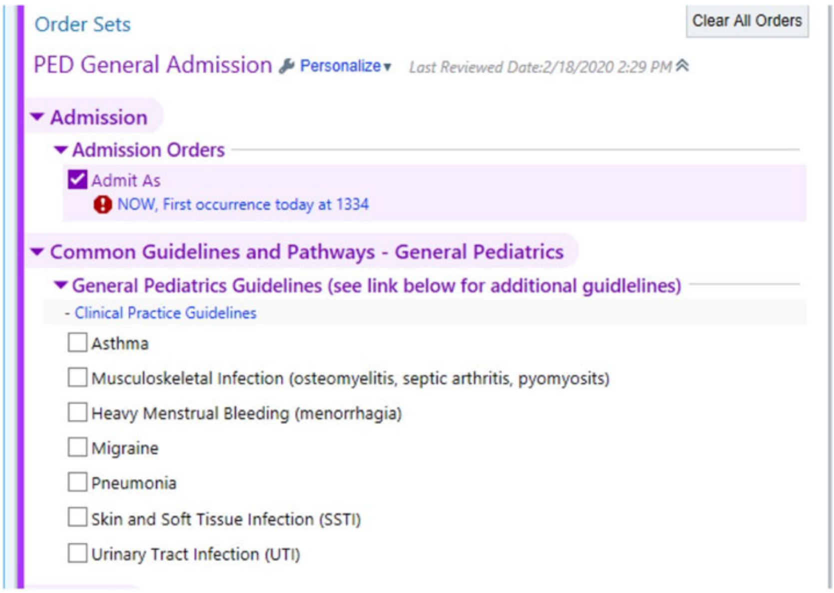

Figure 3. Clinical Practice Guideline order bundles incorporated into a General Pediatrics Order Set.

Table 1. Summative usability testing participant baseline characteristics

	Overall ($N = 18$)	Original ($n = 9$)	Redesign ($n = 9$)
Role			
Resident	12 (66.7%)	6 (66.7%)	6 (66.7%)
Attending	6 (33.3%)	3 (33.3%)	3 (33.3%)
Specialty			
Family medicine	1 (5.6%)	1 (11.1%)	0 (0.0%)
Pediatrics	17 (94.4%)	8 (88.9%)	9 (100%)
Training level			
PL—1	6 (33.3%)	3 (33.3%)	3 (33.3%)
PL—2	2 (11.1%)	1 (11.1%)	1 (11.1%)
PL—3	4 (22.2%)	2 (22.2%)	2 (22.2%)
Attending	6 (33.3%)	3 (33.3%)	3 (33.3%)
Years of ordering experience (includes residency)			
<1	5 (27.8%)	3 (33.3%)	2 (22.2%)
1–2	3 (16.7%)	1 (11.1%)	2 (22.2%)
3–4	4 (22.2%)	2 (22.2%)	2 (22.2%)
5–9	3 (16.7%)	2 (22.2%)	1 (11.1%)
10 +	3 (16.7%)	1 (11.1%)	2 (22.2%)

DISCUSSION

User-centered design incorporating CPG order bundles into an integrated general pediatrics admission order set improved CPG adoption and reduced ordering errors in simulation-based testing without increasing time on task. This approach addressed the most commonly cited barriers to CPG order set to use, providing decision support through a format that reduced the cognitive burden for users to remember to search for a CPG order set at the time of admission. Participants randomized to the redesigned order set were more likely to select guideline-concordant orders, especially related to antibiotic choice and dose. Finally, participants found the redesigned order set to be more usable than the existing system.

During formative usability testing, we identified that dual CPG eligibility was a common frustration for clinicians, suggesting that this may play a larger role in CPG nonadherence than clinicians often recall. In pediatrics, dual eligibility is a common scenario, particularly for respiratory diseases such as asthma, bronchiolitis, and pneumonia. Vendor EHR systems may allow merging of order sets, but unless the original order sets are designed with merge capabilities, the resulting merged order sets may not be usable. For example, one of the simulated scenarios in this study detailed a patient admitted with both asthma exacerbation and community-acquired pneumonia. In the current state, a clinician could not open both of these CPG simultaneously, often leading to the nonuse of one of the CPG order sets due to disruption of workflow and time constraints. A modular disease-specific order bundle design can help address this barrier but may result in duplicate orders that users must correct. Furthermore, while this study was able to demonstrate significant improvement in guideline order-set usage, 33.3% of scenarios still did not have the appropriate CPG utilized. This highlights a remaining gap between eligibility and order set usage that this CDS tool did not address. Future research into the nonadoption of CPG order bundles may address other potential drivers such as diagnostic uncertainty, cultural barriers, or training.

While CPGs and associated order sets can disseminate evidence-based practices to the bedside,[23–26] it remains challenging to promote the correct order set in the right context. Combining alerts with order sets can improve usage in specific contexts but requires developing disease-specific logic and risks alert fatigue.[27,28] Order suggestions driven by machine-learned patterns of order use based on user and patient characteristics have been shown to drive ordering behavior[4,12,29] but may reflect existing practice patterns instead of evidence-based recommendations. Both of these approaches are more resource-intensive than the design produced in this study.

This study has several limitations. First, this single-center study focused on a single service may not be generalizable to different contexts, organizational cultures, or institutions with different EHR vendors. Second, as the CDS was evaluated in simulation, results may differ once incorporated into a real-world production environ-

Table 2. Comparing outcomes between participants randomized to the original and redesigned order sets

Outcome	Original	*n*	Redesign	*n*	Difference (95% CI, *p*-value)
Average time per scenario, s (SD)	258.9 (106.6)	9	259.8 (107.7)	9	−0.9 (−108.0, +106.8); $p = .68$
Scenarios in which all appropriate CPG order sets were used	5 (27.8%)	18[a]	18 (66.7%)	27[a]	+38.9% (+4.2%, +83.0%); $P = .015$
Scenarios with ordering errors	18 (66.7%)	27	10 (37%)	27	−29.7% (−0.5%, −58.7%); $P = .056$
Scenarios with wrong or under-dosed antibiotics	17 (62.9%)	27	5 (18.5%)	27	−44.4% (−17.3%, −71.5%); $P = .002$
Average quiz grade (%)	64.8 (21.2)	9	57.4 (14.7)	9	−7.8% (−11.1%, +25.7%); $P = .41$

[a]In one of the standardized scenarios, there did not exist a standalone CPG order set, but a new order bundle was created in the redesign. These scenarios were therefore not counted for participants randomized to the original design since they could not select an appropriate CPG order set.

ment. In particular, the CDS was optimized for specific admission scenarios and may not adapt to cases of diagnostic uncertainty or when CPG eligibility is established later in the admission. Alternative approaches such as EHR phenotypes for CPG eligibility triggering CDS may be more flexible, but such an approach requires more resources to build, test, and validate and is more difficult to scale across CPGs. Third, our CDS prototype does not include an exhaustive list of available CPGs. As the list expands, the benefits of adding CPG order bundles to a single integrated order set may diminish if they are harder to find.

CONCLUSIONS

User-centered design of CPG-related order bundles integrated into a generic admission order set improves CPG order to set use in simulation by addressing the most common barriers to CPG adoption. Users rated the integrated order set as more usable than the original admission order set and felt that it facilitated recognition of available CPGs. In simulation, using an integrated order set reduced the rate or ordering errors, particularly related to antimicrobial selection and dosing. Further work will establish the impact of an integrated order set once implemented in production environments on CPG adoption and subsequent clinical outcomes.

CLINICAL RELEVANCE STATEMENT

Clinical practice guidelines (CPGs) help disseminate evidence-based practices to improve patient outcomes. Clinical decision support through disease-specific order sets can improve the adoption of CPGs. However, many patients eligible for CPGs are not managed in concordance with CPG recommendations. In this study, we demonstrated that incorporation of CPG order bundles into an integrated general pediatrics admission order set improved the adoption of CPG orders in simulation. This strategy could improve the use of evidence-based management strategies and improve patient outcomes in general pediatrics and other settings.

HUMAN SUBJECTS PROTECTIONS

This study was deemed by the Children's Healthcare of Atlanta Institutional Review Board to be nonhuman subjects' research as a quality improvement study.

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AUTHOR CONTRIBUTIONS

JM, SK, CS, DR, and EO conceptualized and designed the project. JM performed chart review and surveyed clinicians for barriers to guideline adherence. JM, SK, and EO planned and carried out usability testing. ID and SG performed statistical analysis and contributed to interpretation of results. All authors discussed the results and conclusions from the study. JM wrote the manuscript with contribution and input from all authors.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *JAMIA Open* online.

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CONFLICT OF INTEREST STATEMENT

EWO is a cofounder of and has equity in Phrase Health©, a clinical decision support analytics company. He receives no direct revenue from this relationship. All authors declare there was no support from any organization for the submitted work, no financial relationships with any organizations that might have an interest in the submitted work and no other relationships or activities that could appear to have influenced the submitted work.

DATA AVAILABILITY

De-identified data underlying this article will be shared on reasonable request to the corresponding author.

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