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Rapid Prototyping and Implementation of Electronic Order Sets for Critically Ill Adults with COVID-19 Admitted to a Children's Hospital

Nicole K. McKinnon[1,2,3] Shawna Silver[2,4] Sandra Pong[5] Winnie Seto[5] Phoebe Chan[5] Elaine Gilfoyle[1,2,6] Karim Jessa[2,4] Seth B. Gray[1,2]

[1] Department of Critical Care Medicine, Hospital for Sick Children, Toronto, Ontario, Canada
[2] Temerty Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada
[3] Neuroscience and Mental Health, Research Institute, Sickkids, Toronto, Canada
[4] Department of Paediatrics, Hospital for Sick Children, Toronto, Ontario, Canada

Address for correspondence Nicole K. McKinnon, MD, PhD, FAAP, Department of Critical Care Medicine, Hospital for Sick Children, Toronto, Ontario ON M5G 1 × 8, Canada (e-mail: nicole.mckinnon@sickkids.ca).

[5] Department of Pharmacy, Hospital for Sick Children, Toronto, Ontario, Canada
[6] Child Health Evaluative Science, Research Institute, Sickkids, Toronto, Canada

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Abstract

Objectives An eight-bed adult coronavirus (COVID-19) critical care (CC) unit was established within our pediatric CC unit (PCCU) when SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) variants increased the CC bed demand. Our objective was to rapidly implement electronic order sets (OSs) to facilitate computerized provider order entry (CPOE) for adult patients admitted within a children's hospital.

Methods OS development began from the assessment of OSs from seven adult CC units. Using a pre-existing PCCU admission template, we created two OSs: adult COVID-19 admission and ongoing care. We tested the prototypes in a multidisciplinary onsite–virtual hybrid tabletop simulation to evaluate usability within established workflows. Participants utilized role-specific profiles within the electronic health record (EHR) training environment which paralleled their computer interface, permitting charting and documentation. EHR analysts were present to gather change requests. Following implementation, we performed twice-daily huddles with end users to identify issues.

Results A total of 13 multidisciplinary bedside providers participated in simulation testing of the prototypes. Two safety issues were addressed before implementation. The electronic OSs were developed, tested, and implemented within 8 days. The postimplementation huddles identified one medication addition, and no deletions were necessary.

Conclusion Caring for adult COVID-19 patients within a freestanding children's hospital presents challenges and has the potential to introduce latent safety threats. Rapid development and implementation of electronic OSs within 8 days to facilitate CPOE and reduce health care provider cognitive burden relied on leveraging functionality within the EMR system, performing iterative testing with a tabletop simulation, integration into previously established workflows, and gathering post-implementation feedback for continuous improvement.

Keywords
- clinical decision support
- process management tools
- specific types
- clinical information systems, testing and evaluation
- general aspects

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Introduction

On March 11, 2020, the World Health Organization declared a global pandemic from the newly identified SARS-CoV-2 virus (severe acute respiratory syndrome coronavirus 2) and the disease named COVID-19 (coronavirus disease 2019).[1] By March 2021, new variants ignited another wave of infections and resulted in critical care (CC) demand exceeding bed capacity.[2,3] To assist the provincial-wide demand for increased CC services, our freestanding quaternary pediatric teaching hospital developed an eight-bed adult COVID-19 CC unit (CCU) embedded within the pediatric CCU (PCCU).[4] The unit was staffed by PCCU physicians, nurses, respiratory therapists (RTs), pharmacists, and ancillary support services. Adult intensivists were available for consultation when necessary.

Caring for both general PCCU patients and adults with COVID-19 housed within the same physical space has the potential to introduce latent medication safety threats.[5] Our priority was ensuring the safety and quality of care for both patient populations. Of particular concern was the risk for errors related to drug dosing differences between adults and children, such as infusions of inotropes/vasopressors, sedatives, analgesics, and antihypertensives, which are dosed by body weight in children (units/kg) as opposed to set standard doses for adults.[6,7] Implementation of computerized provider order entry (CPOE) systems has been demonstrated to reduce medication errors[8–11] and has become standard practice within electronic health record (EHR) systems.

Preparing to care for a new critically ill patient population also dramatically increases the cognitive burden on health care providers. In addition to differences in disease pathology and medication prescribing, standard protocols for CCU morbidity prophylaxis also differ between children and adults. Management of increased cognitive burden requires timely education, robust safety check mechanisms, and adequate clinical support.[12,13] Previous work has demonstrated that CPOE systems can provide point-of-care clinical decision support.[14] To this effect, a second priority was to integrate clinical decision support throughout established EHR workflows to decrease additional cognitive burden.

Objectives

Our aim was to rapidly develop and implement electronic order sets (OSs) to facilitate CPOE and provide clinical decision support for adult patients with COVID-19 pneumonia admitted to a PCCU within a freestanding children's hospital.

Methods

The rapid prototyping process began with gathering adult general CC admission and COVID-specific OS from six adult CCUs. Similarities and differences were summarized by a pharmacist and shared with PCCU stakeholder representatives including two physicians, three pharmacists, and a clinical informatics physician with expertise in clinical decision support tools. Using a pre-existing pediatric respiratory CC admission electronic OS template, the stakeholders combined the summarized recommendations and current evidence-based guidelines to create two adult-specific COVID electronic OSs, one for admission and the other one for ongoing care. The initial electronic OS prototypes were created within the EHR build environment and were verified by PCCU pharmacists.

To decrease cognitive burden on providers, we built clinical decision support into the OS, including auto-defaulting standard adult CCU care practices including venothromboembolism prophylaxis and a daily bowel regime. To prevent medication errors related to dosing differences between adults and children, the medications housed in the adult electronic OS were only available at adult standard doses if ordered from within the CCU EHR environment using the adult electronic OS and were not accessible for CPOE using the facility-wide general search function. Flowsheets were updated to accommodate adult ventilation strategies for acute respiratory distress syndrome including rows for plateau pressure, driving pressure, and a tidal volume calculation. The nutrition flowsheet was adapted to include an automated calculation for ideal body weight for assessment of daily caloric needs.

Following development of the electronic OS prototypes, we then conducted a multidisciplinary onsite–virtual hybrid tabletop simulation to evaluate usability and workflow integration. PCCU representatives from nursing, physicians, clinical trainees, RTs, pharmacists, clinical application analysts, and a clinical informatics physician participated in the tabletop simulation. Each group utilized role-specific profiles within the EHR testing environment, which paralleled their computer-work interface and permitted standard documentation. The four-part simulation described an evolving adult patient with COVID-19 pneumonia and started with admission, acute decompensation requiring intubation, complications of withdrawal and delirium, and finally hospital discharge. During the simulation, clinical trainees first placed orders using the adult COVID-19 electronic OS, followed by age and medication-dosing verification by pharmacists. Nursing and RTs then released the electronic orders and charted vital signs and medications/therapies using standard workflows. This evolving scenario provided functional assessment of the OS, including order entry, verification, and integration into nursing and RT workflows. The interaction was observed virtually by analysts and clinical informatics physician specialists. Participants self-reported workflow challenges and latent safety issues, which were then flagged for revision by the analysts in real time. An optional anonymous survey (►**Supplementary Survey S1**) evaluating the simulation and the electronic OS usability was provided to participants at the end, followed by a brief huddle to discuss the simulation.

Following the hybrid tabletop simulation, the electronic OS prototypes were revised and released for use. Staff education regarding the new OS was provided during a 1-hour didactic session prior to implementation. Postimplementation, two PCCU physicians and two nurses conducted twice-daily huddles with bedside providers to gather feedback regarding the prototypes, workflows, and EHR

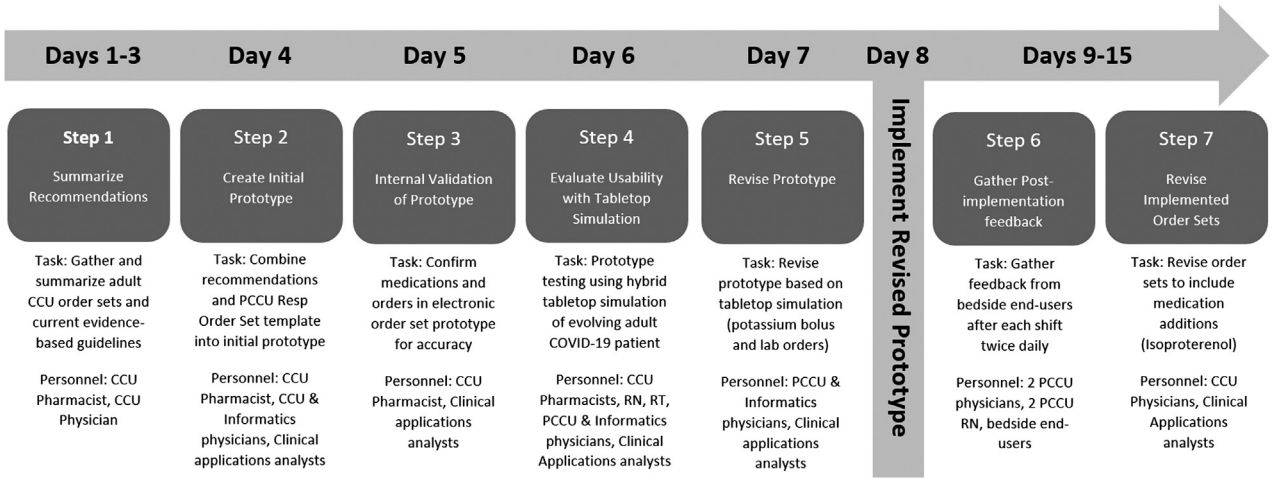

Fig. 1 Timeline of adult COVID-19 electronic order-set prototyping and implementation including multidisciplinary onsite–virtual hybrid tabletop simulation (Step 4) and postimplementation feedback sessions (Step 6).

interfaces, and modification requests were prioritized and submitted (►**Fig. 1**).

Results

We generated two adult COVID-19 electronic OSs for CPOE in the PCCU (►**Supplementary Tables S1** and **S2**, available in the online version). Thirteen multidisciplinary providers and three application analysts participated in a 60-minute hybrid tabletop simulation during the iterative testing phase, including nurses ($n=4$), RTs ($n=2$), clinical pharmacists ($n=2$), PCCU trainees ($n=2$), PCCU physicians ($n=2$), application analysts ($n=3$), and a clinical informatics physician ($n=1$). The simulation identified two safety issues. The first was related to electrolyte repletion for hypokalemia. OS from outside institutions suggested a single potassium bolus of 40 mmol over 1 hour. A potassium repletion solution is made in the pharmacy as a 25 mmol 50 mL syringe, thus requiring one full 50 mL syringe and 30 mL from a second. During the tabletop simulation, the participants identified this as a latent safety threat if the second syringe was not stopped after the administration of 30 mL. We modified the OS to a single 25 mmol (one syringe) bolus followed by a repeat serum potassium, after which a second bolus could be ordered. The second safety issue related to daily laboratory orders. The initial OS prototypes included a laboratory frequency nursing communication in both the admission and ongoing OSs, and it was identified that this would result in duplicate and potentially discrepant orders. As such, we removed the nursing communication from the ongoing OS and continued with our current practice of making daily adjustments within the previously ordered nursing communication.

A postsimulation assessment survey was completed by 11/16 (69%) of participants (►**Table 1**). In total, 81% reported that they would be interested in participating in future simulation exercises, and 91% stated they would recommend the exercise to a colleague. Notable is that all participants strongly agreed that the session was beneficial to their practice, and that the exercise would help with patient safety. Fifty-five percent of the participants stated they felt the initial prototype OSs were accurate, and the tabletop simulation identified and addressed the gaps.

Table 1 Simulation participant responses to adult COVID-19 order-set prototypes and hybrid tabletop simulation experience

Survey statement	Strongly agree, *N* (%)	Somewhat agree, *N* (%)	Do not agree, *N* (%)
The session was beneficial to my practice	11 (100)	0	0
I am better prepared to use these order sets on adult patients	11 (100)	0	0
I am more confident in using these tools	11 (100)	0	0
This exercise will help with patient safety	11 (100)	0	0
Instructions were clear	6 (55)	5 (45)	0
Screens were easy to understand	10 (91)	1 (9)	0
The orders were accurate	6 (55)	5 (45)	0
The flowsheets were intuitive to use	10 (91)	1 (9)	0
The MAR was easy to understand	10 (91)	1 (9)	0

Abbreviation: MAR, medication administration record.

The total time between starting the development process and implementation of the electronic OS was 8 days. The postimplementation huddles with bedside providers identified one medication for addition to the electronic OS, and there were no deletions necessary. The two OSs were used to care for 35 adult patients treated over a 12-week time period, with no serious safety events reported through our anonymous online system related to medication dosing or the OS. The admission OS was used on all 35 adult patients, as well as 3 adolescents weighing over 50 kg admitted to the PCCU with COVID pneumonia. No child under 50 kg had an order unintentionally placed from either adult OS. The ongoing OS was utilized 435 times in the care of adult patients.

Three months following initial implementation, we provided an additional anonymous survey (►**Supplementary Survey S2**) to the PCCU trainees regarding use of the electronic OS. The survey was completed by 25% (4/16). Of the respondents, three out of four indicated that both the adult COVID-19 admission and ongoing care electronic OS were "extremely useful." Three out of four respondents indicated that pharmacy "rarely" or "never" called to confirm a medication for an adult patient when ordered from within the OS, and two respondents indicated that pharmacy called "daily" to confirm medications when ordered on adult patients without using the OS.

Discussion

Rapid expansion of adult CC services through adaptation of existing PCCU beds during the COVID-19 pandemic required extensive resource allocation and multidisciplinary team involvement. CPOE with clinical decision support has been shown to reduce errors[8–11] and was utilized to mitigate potential safety threats related to medication dosing differences between children and adults through development of adult COVID-19 electronic OSs. Restriction of standard adult medication ordering to the adult COVID-19 OSs provided an additional safety mechanism against accidental prescription of adult medication doses for pediatric patients.

Preparing to care for a new critically ill patient population may also increase cognitive burden placed upon PCCU staff, particularly regarding differences in medication dosing and CC morbidity prophylaxis protocols. It is standard practice within our institution to utilize problem-specific admission OSs to aid CPOE and provide clinical decision support, and the adult COVID-19 OS also helped alleviate cognitive burden on health care providers as they cared for a new patient population. Documentation of clinical data including vital signs, ventilation parameters, and safety checks is performed using EHR flowsheets, and integration of adult documentation flowsheets into previously established workflows facilitated accurate communication of care provided.

Utilizing a hybrid tabletop simulation for rapid prototype testing ensured that key end users could participate while simultaneously maintaining social distancing and adhering to gathering restrictions. Standard role-specific EHR computer interfaces allowed high-fidelity testing of the electronic OSs and EHR flowsheets.[15] The presence of application analysts and clinical informatics physician experts during the tabletop simulation allowed for discussion and clarification of modification requests as they were identified. This process allowed us to circumvent our standard workflow for submitting EHR modification requests, thus saving valuable time as we worked to meet our deadline of 8 days from project initiation to implementation.

The postimplementation assessments of the adult COVID-19 electronic OSs provided insight into usability and end-user experience. By performing twice-daily huddles with bedside providers for 7 days postimplementation, we identified necessary changes and streamlined modification requests to the analysts in a timely manner. Only one medication was identified for addition to the OSs during the huddles, highlighting the utility of analyzing and integrating other adult units' admission orders and the preimplementation simulation testing. Restricting the EHR modification requests to a limited group of individuals allowed for request prioritization and consistent communication between the information technology department and clinician end users.

Limitations to our rapid prototyping and implementation process include significant personnel and resource allocation necessary to develop, test, and implement the OS within a short timeframe. The electronic OSs were also developed to integrate within the workflows of a single hospital and would likely need to be adapted if implemented in other institutions. Further limitations include a low response rate and an unclear question in the postimplementation survey. Only 55% of respondents stated that the instructions for the OS were clear; further discussion identified that the respondents answered that question in regard to the tabletop simulation as opposed to the OS prototypes. Given that no party had previously participated in a hybrid tabletop simulation, we expected and planned for this; however, it was not accurately captured in our survey results. Finally, given the short timeframe to implementation and system constraints during a pandemic, we did not collect formal usage data although intend to do so if the electronic OS is utilized in the future.

Conclusion

Caring for critically ill adult COVID-19 patients within a freestanding children's hospital has the potential to introduce latent medication safety threats. Our group was able to rapidly prototype and implement electronic OS for critically ill adults with COVID-19 pneumonia through a combination of a preimplementation hybrid tabletop simulation and postimplementation feedback. Active engagement of a multidisciplinary team of health care providers and application analysts can facilitate rapid development and implementation of electronic OS.

Clinical Relevance Statement

The COVID-19 pandemic highlighted the need to be able to rapidly increase CC bed capacity, including having flexibility to admit adult patients to children's hospitals. Future situations may evolve when similar flexibility is required and this article describes the rapid development,

testing, and implementation of electronic OSs to facilitate CPOE and provide clinical decision support for non-standard patients, with a focus on patient safety and decreasing caregiver cognitive burden.

Protection of Human and Animal Subjects

We reviewed this case report with our quality improvement specialists, and they deemed this case report to not meet criteria of human subject research.

Funding

None.

Conflict of Interest

None declared.

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