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Original Article

Use of clinical pathways integrated into the electronic health record to address the coronavirus disease 2019 (COVID-19) pandemic

Allison H. Bartlett MD, MS[1], Sonya Makhni MD, MBA[2], Samantha Ruokis BS[3], Mary Kate Selling MHA[4], Lauren Hall MPH[3], Craig A. Umscheid MD, MS[2] and Cheng-Kai Kao MD[2]

[1]Department of Pediatrics, University of Chicago, Chicago, Illinois, [2]Department of Medicine, University of Chicago, Chicago, Illinois, [3]Quality Performance Improvement, University of Chicago Medicine, Chicago, Illinois and [4]Data and Analytics, University of Chicago Medicine, Chicago, Illinois

Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic has required healthcare systems to meet new demands for rapid information dissemination, resource allocation, and data reporting. To help address these challenges, our institution leveraged electronic health record (EHR)–integrated clinical pathways (E-ICPs), which are easily understood care algorithms accessible at the point of care.

Objective: To describe our institution's creation of E-ICPs to address the COVID-19 pandemic, and to assess the use and impact of these tools.

Setting: Urban academic medical center with adult and pediatric hospitals, emergency departments, and ambulatory practices.

Methods: Using the E-ICP processes and infrastructure established at our institution as a foundation, we developed a suite of COVID-19–specific E-ICPs along with a process for frequent reassessment and updating. We examined the development and use of our COVID-19–specific pathways for a 6-month period (March 1–September 1, 2020), and we have described their impact using case studies.

Results: In total, 45 COVID-19–specific pathways were developed, pertaining to triage, diagnosis, and management of COVID-19 in diverse patient settings. Orders available in E-ICPs included those for isolation precautions, testing, treatments, admissions, and transfers. Pathways were accessed 86,400 times, with 99,081 individual orders were placed. Case studies demonstrate the impact of COVID-19 E-ICPs on stewardship of resources, testing optimization, and data reporting.

Conclusions: E-ICPs provide a flexible and unified mechanism to meet the evolving demands of the COVID-19 pandemic, and they continue to be a critical tool leveraged by clinicians and hospital administrators alike for the management of COVID-19. Lessons learned may be generalizable to other urgent and nonurgent clinical conditions.

Keywords: Decision support systems, clinical; electronic health record; information dissemination; COVID-19; clinical pathways

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Clinical pathways enable the translation of evidence into easily understood care algorithms, bridging the gap between science and clinical practice.[1,2] They can serve as accessible and streamlined resources for both clinical and logistical information.[3–6] Additionally, clinical pathways can facilitate adapting national guidance to local care environments, making them excellent roadmaps for guiding care delivery.[7] Thus, they are effective in promoting cost-effective care and reducing unwarranted clinical variation.[8]

Ideally, clinical pathways should seamlessly integrate into clinicians' workflows to augment their practice by providing high-yield information in easily followed algorithms available directly at the point of care.[9,10] At the University of Chicago Medical Center (UCMC), we have enhanced previously described approaches[1] to implementing clinical pathways at an institutional level by direct integration of pathways into the electronic health record (EHR). These EHR-integrated clinical pathways (E-ICPs) allow users to simultaneously follow evidence-based protocols, review previous test results, and place orders.

The aforementioned advantages make E-ICPs potentially critical tools in times of crisis, for example, to address the coronavirus disease 2019 (COVID-19) pandemic. In the early stages of the pandemic, healthcare providers were tasked with caring for high volumes of patients affected by a pathogen that was, at that time, poorly understood.[11] Epidemiologic information, clinical recommendations, and operational decisions were constantly changing, and accessibility of real-time updates became paramount.[12] Unprecedented demands to quickly disseminate this rapidly changing guidance challenged hospital systems to find innovative ways to adapt.[12]

Author for correspondence: Allison H. Bartlett, E-mail: abartlett@peds.bsd.uchicago.edu

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Check for updates

To rapidly consolidate information and provide a unified and comprehensive approach to COVID-19 management, our institution implemented a suite of E-ICPs to delineate COVID-19–specific care processes in different clinical settings. In this study, we describe the existing E-ICP infrastructure and the changes needed to enable the rapid creation of a suite of COVID-19–specific pathways. We also assessed the use and impact of these pathways.

Methods

Setting

The University of Chicago Medical Center (UCMC) is the flagship institution of University of Chicago Medicine, a not-for-profit academic healthcare system that serves communities throughout Chicagoland and northwest Indiana. UCMC includes an adult hospital with 811 inpatient beds including 169 intensive care beds and 33,705 admissions per year, plus a 45-bed emergency department with 74,578 visits per year; a free-leaning children's hospital with 172 inpatient beds and 5,000 admissions per year plus a 28-bed pediatric emergency department with 33,610 visits per year; and 5 multispecialty faculty ambulatory practice sites with >600,000 encounters per year.

The EHR-integrated clinical pathways (E-ICP) program at UCMC

Established in October 2018, UCMC's E-ICP program is an integral part of the institution's High Reliability program, which is a system-wide initiative to promote effective translation of evidence into clinical practice to promote high-value care. Figure 1 details the 5-step process, participants, and timeline for creating and implementing E-ICPs. The E-ICP program team, assembled by the chief medical officer (CMO), consists of the executive medical director for high reliability care, an associate chief medical informatics officer, the director of quality performance improvement (QPI), and a QPI project manager. The standard process takes at least 6 weeks from initiation to implementation; complex information technology (IT) changes and stakeholder availability often extend the timeline by several months. In the first 18 months of this program, we created and implemented 25 pathways.

Pathway content is developed and disseminated across our institution using a cloud-based platform (AgileMD, San Francisco, CA), which integrates with our EHR (Epic, Verona, WI). The pathway platform contains an author portal that facilitates asynchronous collaboration with stakeholders during the pathway development process. All clinical EHR users have access to E-ICPs by launching the interactive platform within a patient's EHR chart or by browsing the read-only pathway library on the hospital intranet. E-ICP access within the EHR allows users to view pathway content, to review selected data such as laboratory test results, and to place orders directly from the pathway (Fig. 2). E-ICPs also link to resources, including patient education materials. Using pathway enrollment orders, clinicians can alert all EHR users when patients are being managed on a pathway. Moreover, the platform provides a channel for pathway users to provide feedback to pathway owners at the point of care. Pathway views and orders placed through the pathways are monitored via a real-time analytics dashboard (Fig. 3) and can be analyzed down to the level of individual user and specific order.

Rapid development and updating of COVID-19 E-ICPs

In March 2020, the existing E-ICP program structure was modified to accommodate the unique needs presented by the COVID-19 pandemic. These changes allowed for rapid development of COVID-19–specific E-ICPs to enable implementation of federal, state, and city health department guidance within our local context (Fig. 1). Nearly all institutional projects under the CMO's office not directly related to COVID-19 were paused at this time, and all clinical and nonclinical teams that could be redeployed to support the COVID-19 response were, which allowed operational leaders and support teams to focus on COVID-19–related efforts, including E-ICP development.

Briefly, the time from identification of need to start of E-ICP build was shortened to 1 day. Infection control (IC) and infectious disease (ID) teams were clinical leads for all pathways; introductory meetings were converted to working meetings to prioritize pathway builds and draft outlines. The review with limited key stakeholders via videoconference was supplemented with an asynchronous review by a broader audience, and the review period was shortened to 1 day. Implementation was accelerated under the Hospital Incident Command System (HICS) structure. Using the emergency change control process, we circumvented the usual IT weekly update cadence, pushing pathways live daily as soon as testing was complete. Updates were communicated through daily HICS e-mail messages to UCMC healthcare workers. Following the initial deployment, the core pathway team met daily to review pathways: updating treatment recommendations from subject-matter experts; revising operational guidance; and incorporating end-user feedback. There were 3.5 full-time equivalents (FTE) on the core team (ie, 2 QPI project management FTE, 0.5 ID FTE, 0.5 IC FTE, 0.5 QPI director FTE) for 2 months, which decreased to 2.25 FTE (ie, 1.5 QPI project management FTE, 0.25 ID FTE, 0.25 IC FTE, 0.25 QPI director FTE) as needs diminished.

Pathway adoption

Institutional endorsement through HICS and restriction of COVID-19 testing orders to E-ICPs drove widespread pathway adoption. Daily e-mail communication from HICS to UCMC healthcare workers was the primary modality for communication from leadership and included information about new and revised pathway content. This communication was supplemented by a dedicated COVID-19 resource team staffed by hospital epidemiologists available to answer questions from frontline staff and to reinforce the use of E-ICPs. Existing E-ICP analytics dashboards (Fig. 3) tracked the number of users who accessed pathways and user type (ie, physician, nurse, pharmacist, medical assistant, etc), the number of times pathways were accessed, and the number of orders placed from pathways, including isolation precautions, severe acute respiratory coronavirus virus 2 (SARS-CoV-2) testing, imaging, and medications. This information was reviewed regularly by team members from ID, IC, clinical analytics, and informatics to inform priorities and daily operations changes and to estimate impact on process and outcome measures.

Study analysis

Data regarding COVID-19 testing at our institution were extracted from the EHR. We analyzed the number of patients who were tested for SARS-CoV-2 by polymerase chain reaction (PCR) at our medical center, the PCR platform used, urgency of test (routine

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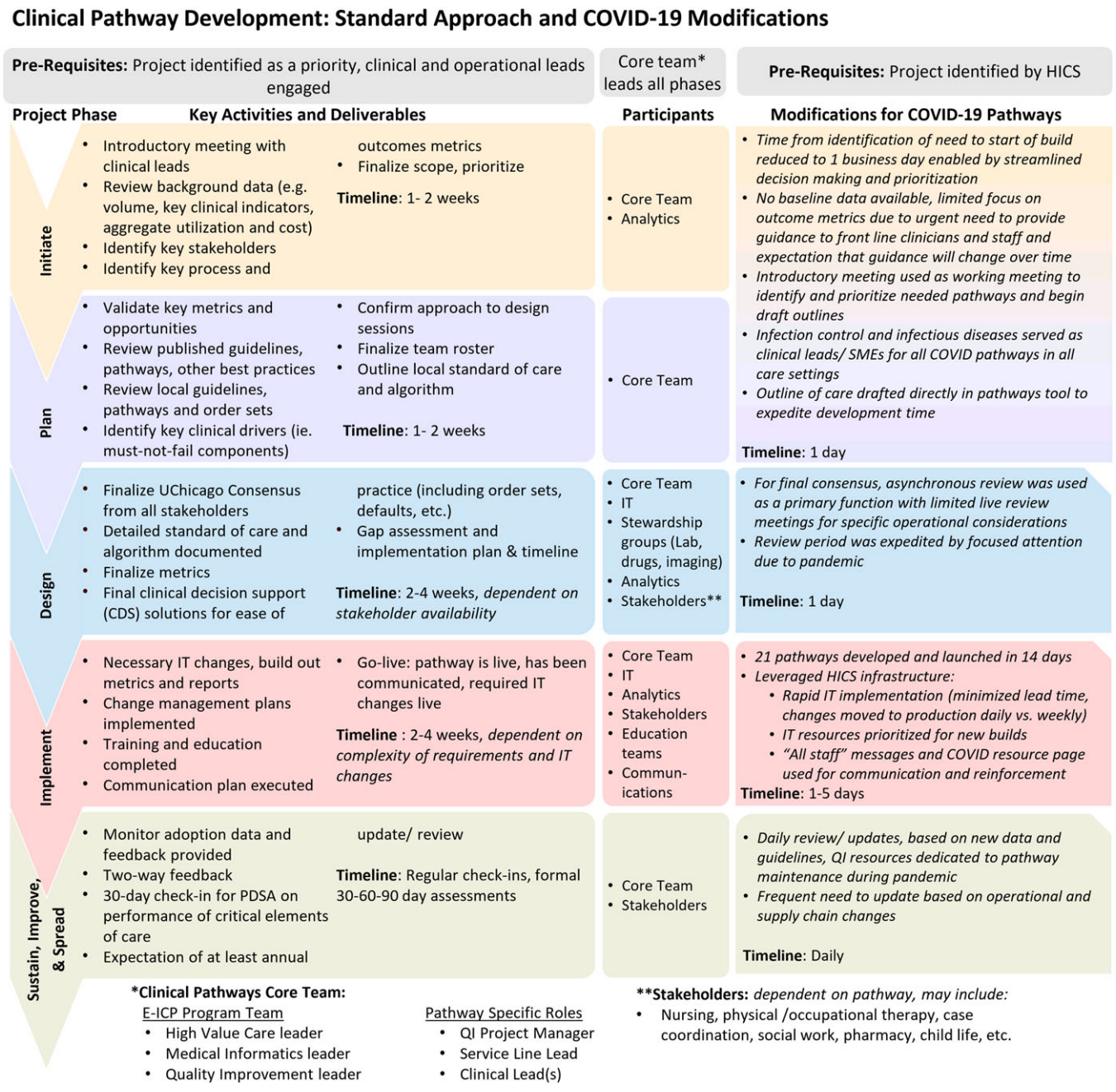

Fig. 1. Clinical pathway development: comparison of standard approach and COVID-19 modifications. Our E-ICP development projects are undertaken in 5 stages as outlined in this figure. The minimum time to complete the standard process is included, although we rarely achieved this timeline because of information technology system changes and difficulty scheduling in-person meetings. The key participants are listed in the middle column. Modifications to rapidly develop and implement COVID-19 pathways are detailed in the right-most column.

vs urgent), test result, location of patients at the time of testing (eg, curbside testing, ED, inpatient) and disposition (death or discharge) if admitted. Data regarding number of E-ICPs, date of E-ICP implementation, and number of revisions are collected centrally by the E-ICP program using the author tool in AgileMD. Volume of pages to the COVID Resource Pager was extracted from the paging system (spōk, Alexandria, VA). We defined the "COVID-19–specific pathways" as those developed and disseminated over a 6-month period (March 1–September 1, 2020), beginning 2 weeks before the COVID-19 national emergency was declared. We also examined the frequency of use of each pathway during the study period, including the number of views and orders placed through each pathway, as well as the numbers of unique users and user types. We also present case studies demonstrating E-ICP impacts on (1) speed of discontinuing isolation, (2) response to changing testing needs, and (3) internal and external tracking of patients by COVID-19 status.

Results

Of 15,516 inpatient admissions and 100,709 ambulatory clinic visits at UCMC during the study period, 5,303 patients were

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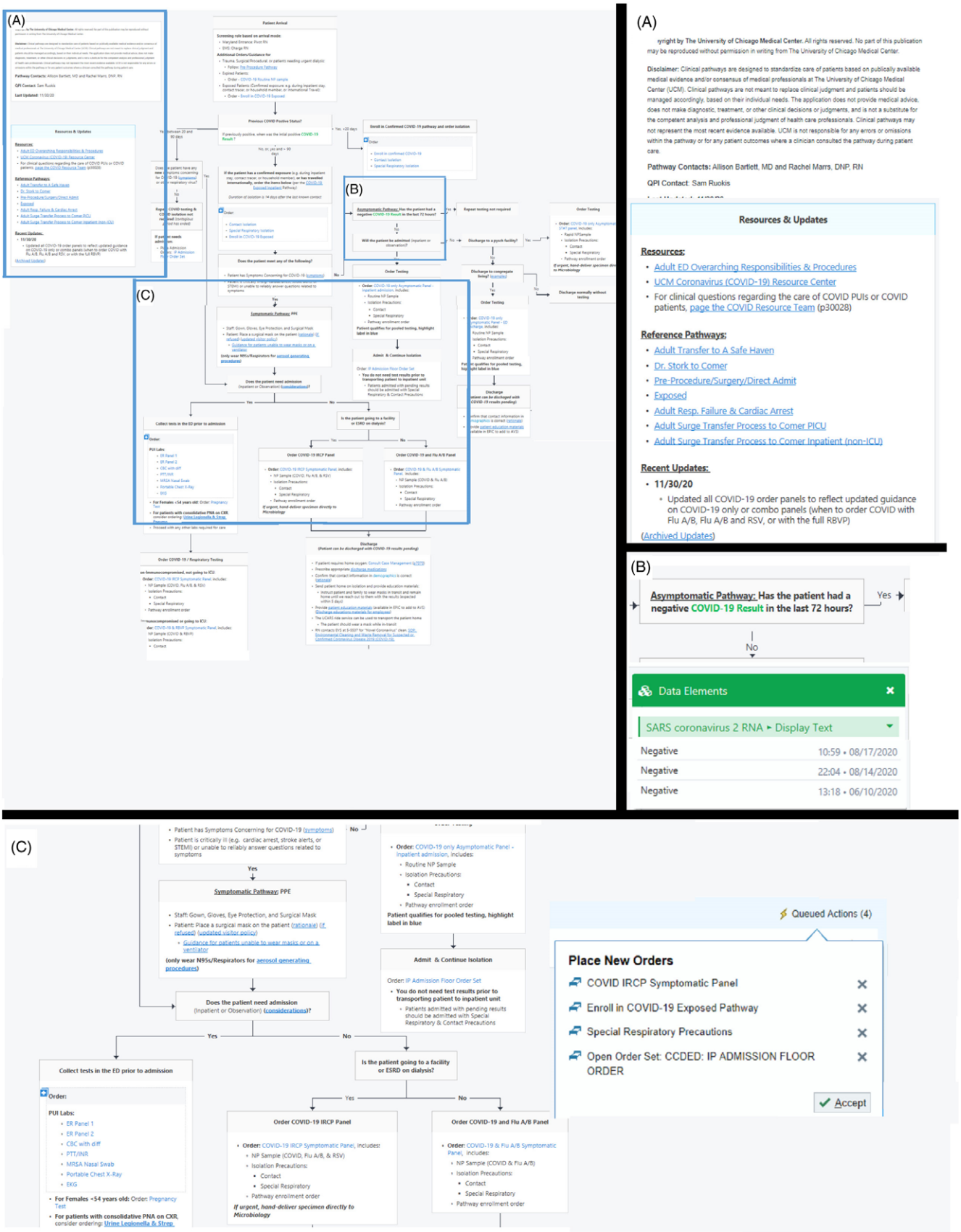

Fig. 2. Example of our institution's COVID-19 adult emergency department pathway, with specific recommendations embedded within the pathway's branching logic. View of entire pathway. (A) Enlarged view of the pathway's Resources & Updates section. Each pathway contains contextual information regarding resources, references, archival data of prior pathway modifications, and contact information for the pathways' contributors. (B) Enlarged view of data elements. Data from the EHR can be embedded in the E-ICPs. When users click on the green "COVID-19 Result" text, the data element is displayed as a pop-up so users do not need to interrupt their workflow. (C) Enlarged view of additional features that allow users to interact with the EHR directly. E-ICPs are fully integrated into the EHR, allowing users to place orders, obtain additional details (eg, a list of aerosol-generating procedures) and to access external links (eg, patient education materials).

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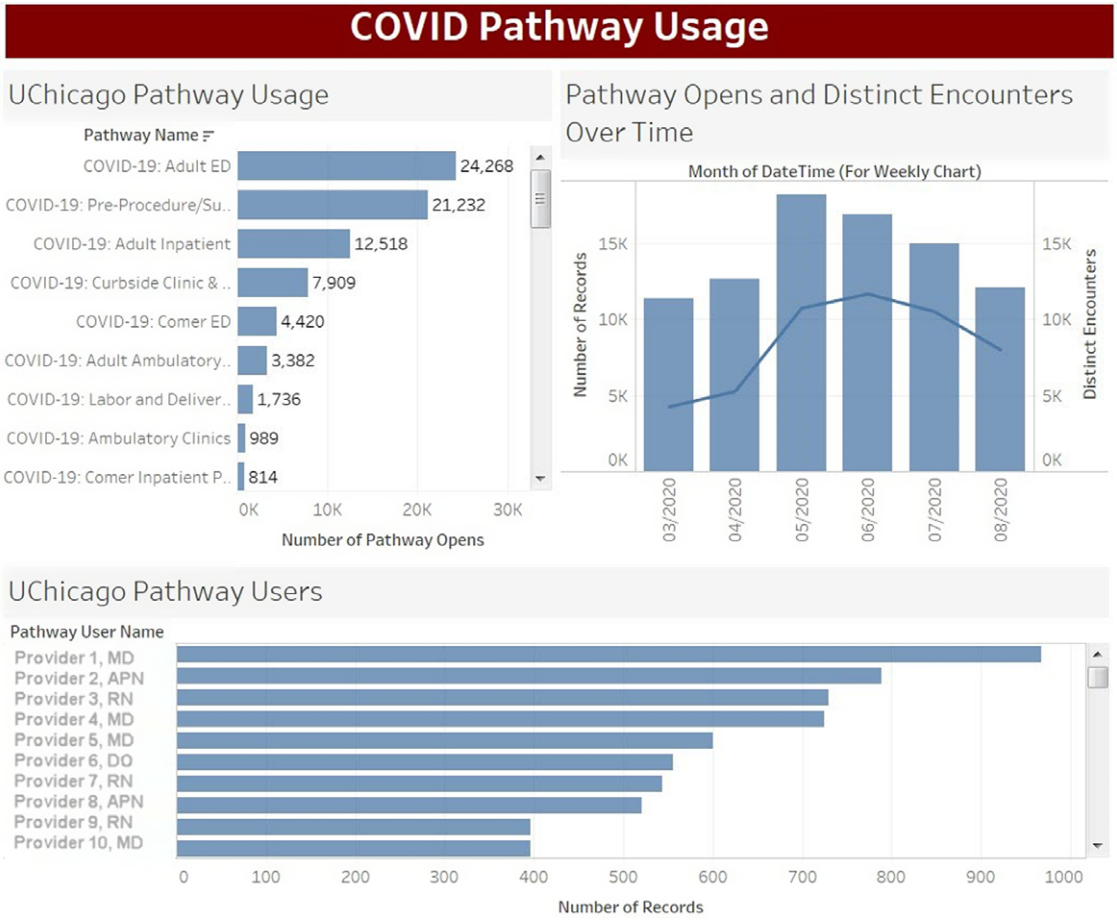

Fig. 3. Pathway utilization dashboard illustrating all COVID-19 pathway usage and top users over time. (Top left) Pathway usage. Total number of times each pathway was opened within the EHR during the study period. (Top right) Pathway opens and distinct encounters over time. Bars graph indicates "number of records," or the total number of times pathways were opened each month. Multiple episodes of pathway usage for single patient are counted separately. Line graph indicates "distinct encounters," or the number of individual patient encounters that had a pathway opened. Each patient encounter (eg, admission to hospital or clinic visit) counts as 1 distinct encounter, regardless of how many times E-ICPs were used during the encounter. (Bottom) Pathway users: number of times pathways were accessed by individual user name and role.

documented SARS-CoV-2 positive, including 1,165 adult and 38 pediatric inpatient admissions and 4,138 patients identified in ambulatory clinic evaluations. There were 101 COVID-19–related deaths, and 1,048 COVID-19–positive inpatients were discharged home. At the peak of the pandemic on April 22, 2020, 155 COVID-19–positive patients were hospitalized at UCMC; 38 of these patients received care in the ICU.

We developed and implemented 45 COVID-19–specific pathways, 21 of which were created within the first 2 weeks, covering the triage, diagnosis, and management of COVID-19 in the adult and pediatric ambulatory, ED, inpatient, and intensive care settings, as well as labor and delivery (Supplementary Table 1 online). Over time, some E-ICPs were consolidated; for example, emergency department (ED) screening, admission, and discharge pathways were combined into single ED pathway. Also, some E-ICPs were archived, for example, "adult surge process transfer to PICU." Read-only pathways were made publicly available.[13] E-ICPs also included links to patient education resources, definitions, symptoms lists, previous SARS-CoV-2 test results, contact information for new COVID-19 response teams from a variety of disciplines (eg, IC, social work, and environmental services), and documentation of pathway revisions and updates (Fig. 2). COVID-19–related orders, including SARS-CoV-2 tests and admission and transfer order sets, were only available through pathways.

Pathways were viewed 86,400 times by 3,310 users: 1,328 registered nurses (40.1%), 1,283 attending and house staff physicians (38.8%), 321 advanced practice providers (9.7%), 132 medical students (4.0%), 93 medical assistants (2.8%), 54 pharmacists (1.6%) and others (3.0%). In total, 99,081 orders were placed via pathways: 60,441 SARS-CoV-2 test orders (61.0%), 15,579 isolation precaution orders (15.7%), 9,764 referral orders for curbside testing (9.9%), 5,292 pathway enrollment orders (5.3%), 3,279 order sets (3.3%), 1,142 medication orders (1.2%), and others (3.6%). Our peak daily pathway utilization overall occurred on March 20, 2020, with 856 views of COVID-19 pathways. Utilization varied by location, patient population, and patient volume (Supplementary Table 1 online). The average number of patient encounters touched by an E-ICP increased from 383 per month before the pandemic to 8,545 per month during the pandemic study period (Supplementary Fig. 1 online). Calls to the COVID-19 Resource Pager peaked in mid-March, averaging 96 pages per day, and these calls decreased over time to <10 per day as pathway use increased, driven in part by the resource team reminding callers to check pathways first and updating pathways to address frequently asked questions (Fig. 4).

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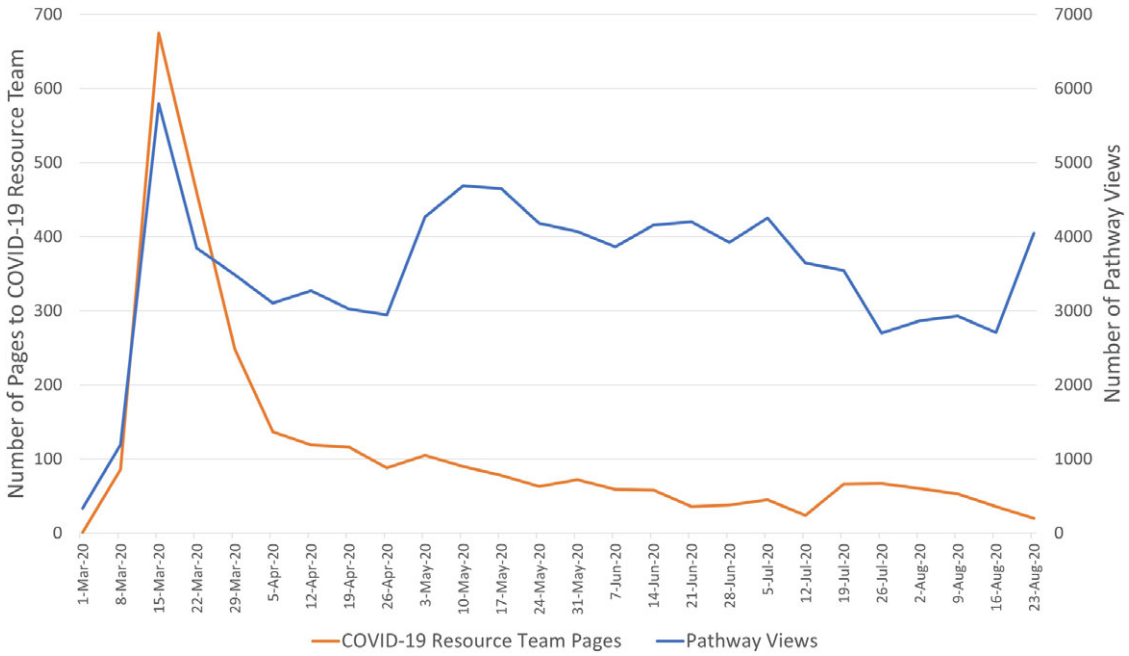

Fig. 4. Number of pages to the COVID-19 resource team and E-ICP pathway views. The COVID-19 Resource Team pager was created on March 5, 2020. The number of pages to the COVID-19 Resource Team peaked mid-March, averaging 96 pages per day. The increase in pathway views in May corresponded to implementation of admission COVID-19 testing for all patients. Members of the COVID-19 Resource Team reinforced pathway use by reminding callers that information was available on E-ICPs. Additionally, information to address frequently asked questions was added to pathways to improve their utility.

Case studies describing impact

Using E-ICPs to expedite the COVID-19 isolation clearing process and to support stewardship of resources

Before the pandemic, our standard process for respiratory viral infections bundled testing and isolation orders but did not restrict who could discontinue isolation nor audit adherence to recommended isolation duration. To optimize healthcare worker safety in the face of evolving understanding of the mechanism and timing of SARS-CoV2 transmission, we needed a more stringent process for ensuring appropriate patient isolation. E-ICPs bundled respiratory isolation orders and SARS-CoV2 testing and included specific PPE recommendations. To prevent premature discontinuation of isolation, we initially restricted the ability to discontinue respiratory isolation precautions to a dedicated 'COVID-19 clearing team' consisting of 3 ID specialists who, at the height of the pandemic, each worked >4 hours per day to support the clearing requests. We later developed EHR-based clinical-decision support (CDS) aligned with the E-ICPs, which allowed frontline clinicians and nurses to discontinue isolation orders when the appropriate clearing criteria were met. These criteria were reviewed and revised as institutional protocols evolved. The E-ICPs reduced the duration of isolation precautions by 24.8 hours on average (75.9 hours vs 51.1 hours; $P < .0001$ by t test), which improved clinical efficiency, restored provider autonomy, and preserved PPE while ensuring appropriate isolation. As a result of the CDS intervention, the COVID-19 clearing team was decommissioned and the ID specialists resumed patient-care duties.

Using E-ICPs to drive optimal COVID-19 testing strategy

The clinical, operational, and regulatory requirements for SARS-CoV-2 testing evolved frequently and had to be balanced with ever-changing supply and reagent shortages. We had 2 testing platforms (1 for urgent tests and 1 for routine tests), and we used several combinations of nasal and nasopharyngeal swabs and viral transport media depending on supply availability. To optimize the testing strategy and to ensure compliance, the SARS-CoV-2 tests could only be ordered within the E-ICPs. To ease the burden of the ordering providers, we customized defaults within order panels to align with location on E-ICP algorithms, identifying patients as symptomatic or asymptomatic, and sending tests as routine or urgent according to institutional protocols. This became particularly important when implementation of admission testing for all patients coincided with a shortage of reagents for urgent testing. The order defaults in E-ICPs were modified to allocate urgent tests for specific situations (eg, laboring women, symptomatic admissions from the ED, discharge from the ED to a group living setting). Without additional messaging and disturbance of provider workflow, the changes in the E-ICP successfully drove the desired testing resource allocations immediately and effectively (Fig. 5).

Using E-ICP enrollment orders to enhance patient triage, and external and internal reporting

Over the course of the pandemic, significant effort was needed to meet everchanging reporting requirements for COVID-19 patient volumes and outcomes as well as SARS-CoV-2 testing volumes and results. Externally, data were sent to the Illinois Department of Public Health and the federal government, initially to the Centers for Disease Control and Prevention (CDC) through existing data feeds using the National Healthcare Safety Network (NHSN) and then to the Department of Health and Human Services through an alternative mechanism (Teletraking). Internally, data were used to determine appropriate allocation of medication (eg, remdesivir), to forecast PPE supply needs, and to feed predictive models projecting ICU bed and ventilator needs.

To better specify the patient's COVID-19 status for triage, appropriate bed placement and reporting, we created COVID-19 pathway enrollment orders to allow patients to be categorized

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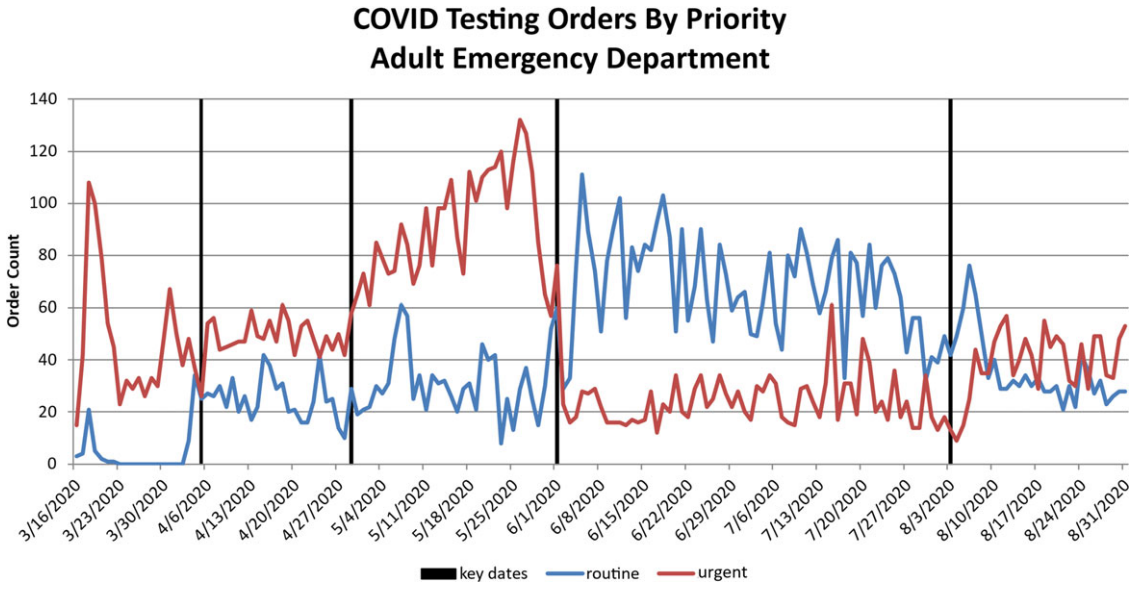

Fig. 5. Number of routine versus urgent SARS CoV-2 test orders in the adult emergency department over time, with dates reflecting critical pathway changes relevant to testing. The number of tests overall and the relative proportion of routine versus urgent tests varied over time based on clinical recommendations and supply availability, which informed pathway testing changes. (1) April 5, 2020: The lower age limit for symptomatic testing decreased from 60 years to 50 years based on CDC recommendations. (2) April 29, 2020: Testing began on all patients being admitted to the hospital, regardless of symptoms. (3) June 1, 2020: Due to the shortage of reagents for urgent testing, strict limits were placed on populations allowed to receive rapid testing. (4) August 3, 2020: Urgent testing reagent availability was increased and restrictions for urgent testing were removed.

by frontline clinicians as 'COVID-confirmed,' 'person under investigation (PUI),' or 'COVID-exposed.' These enrollment orders, bundled with SARS-CoV-2 tests in the corresponding pathways, automatically changed the patient's COVID-19 status in the EHR header visible to all clinical users. If the SARS-CoV-2 test result came back positive, it triggered an EHR alert to notify the clinicians to enroll the patient in the confirmed COVID-19 pathway. Patients with known COVID-19 or SARS-CoV-2 exposure prior to arrival at our institution were appropriately isolated in advance based on their history, rather than waiting for admission test results.

The integrity of these data was maintained by the management of the orders available in the COVID-19 E-ICPs. When new data needs were identified, new questions were added within the orders, and default answers were set accordingly in different E-ICPs to ease the provider burden for data entry. In this way, we created a seamless user experience while keeping the integrity of the data high, enabling the HICS team to track testing volumes and positivity rate by population (eg, asymptomatic pre-procedure, symptomatic, contact tracing). The data analytics team was able to leverage the utilization of E-ICPs as a key identifier of the COVID-19 population (PUI vs confirmed), even as the definitions within the pathways evolved over time with new protocols.

Discussion

The urgent need to provide guidance during a pandemic was not suited to our existing pathway development process. With the support of HICS, and united by an institution-wide, single-minded focus on the COVID-19 pandemic, we streamlined our process. The end result was a suite of COVID-19–specific E-ICPs representing easily accessible, reliable, actionable information upon which our clinicians, healthcare administrators, data analysts, and, ultimately, our patients could rely.

Our pathway functionality was not static; it evolved throughout the pandemic, incorporating additional clinical decision support to decrease provider cognitive burden and workload, and allowing dissemination and rapid implementation of the most up-to-date recommendations. The rapid implementation and frequent revisions of E-ICPs provided important lessons about the optimal design of pathways to increase usability, including the physical layout, color choices, and flow of decision support.

Instead of making SARS-CoV-2 testing freely orderable in our EHR, we restricted ordering to E-ICPs. By requiring clinicians to interact with pathways for SARS-CoV-2 test ordering and updating our pathways in real time, we ensured just-in-time operational guidance was available and current. We believe mandating test ordering through E-ICPs translated into the high utilization and impact described in this evaluation.[14,15]

The large-scale deployment and use of COVID-19 pathways generated enthusiasm for how E-ICPs could be leveraged to promote high-value care and decrease unwarranted clinical variation for many other clinical conditions. As a result, we witnessed increased interest in E-ICP development for non–COVID-19 diseases from multiple clinical departments and service lines. Between March 2020 and October 2021, we implemented 67 non–COVID-19 pathways ranging from neonatal hypoglycemia to cardiac valve disease.

This study had several limitations. First, this observational study was performed at a single, urban, academic, medical center, which might limit the generalizability of these results. Second, we did not have a control group (eg, clinical areas that do not use COVID-19 E-ICPs for guidance) with which to compare effectiveness. Third, we had to create robust downtime procedures in case the E-ICP system went down, including posting updated PDF files of pathways on the intranet with each pathway revision and creating a COVID-19 testing order panel in the EHR for downtime use only. Finally, once clinicians become accustomed to using E-ICPs, they tended to spend less time reviewing changes to pathways and

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go straight to placing orders, which is also a known consequence of clinical decision support.[16]

In conclusion, E-ICPs provide a flexible and unified mechanism to meet the evolving demands of the COVID-19 pandemic. These highly utilized pathways offer direct guidance to frontline clinicians and serve as a valuable resource for hospital administrators. Lessons learned about the use of E-ICPs in the context of COVID-19 may be generalizable to other urgent and nonurgent clinical conditions.

Supplementary material. For supplementary material accompanying this paper visit https://doi.org/10.1017/ice.2022.64

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

References

1. Flores EJ, Mull NK, Lavenberg JG, *et al.* Using a 10-step framework to support the implementation of an evidence-based clinical pathways programme. *BMJ Qual Saf* 2019;28:476–485.
2. Lawal AK, Rotter T, Kinsman L, *et al.* What is a clinical pathway? Refinement of an operational definition to identify clinical pathway studies for a Cochrane systematic review. *BMC Med* 2016;14:35.
3. Kinsman L, Rotter T, James E, *et al.* What is a clinical pathway? Development of a definition to inform the debate. *BMC Med* 2010;8:3.
4. *Institute of Medicine (US) Roundtable on Evidence-Based Medicine. The Learning Healthcare System: Workshop Summary*. Olsen L, Aisner D, McGinnis JM, eds. Washington, DC: National Academies Press; 2007.
5. Guise JM, Savitz LA, Friedman CP. Mind the gap: putting evidence into practice in the era of learning health systems. *J Gen Intern Med* 2018;33:2237–2239.
6. Jabbour M, Newton AS, Johnson D, *et al.* Defining barriers and enablers for clinical pathway implementation in complex clinical settings. *Implement Sci* 2018;13:139.
7. Osheroff JA, Teich JM, Levick D, *et al. Improving Outcomes with Clinical Decision Support, An Implementer's Guide,* Second *Edition.* Chicago: Healthcare Information and Management Systems Society; 2012.
8. Rotter T, Kinsman L, James E, *et al.* Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs. *Cochrane Database Syst Rev* 2010;3:CD006632.
9. Flores EJ, Jue JJ, Giradi G, *et al.* AHRQ EPC series on improving translation of evidence: use of a clinical pathway for *C. difficile* treatment to facilitate the translation of research findings into practice. *Jt Comm J Qual Patient Saf* 2019;45:822–828.
10. Du Z, Sun X. Clinical pathway for the community-level management of patients with type 2 diabetes. *Int J Health Plann Manage* 2019;34:975–985.
11. Polak SB, Van Gool IC, Cohen D, *et al.* A systematic review of pathological findings in COVID-19: a pathophysiological timeline and possible mechanisms of disease progression. *Mod Pathol* 2020;33:2128–2138.
12. Reeves JJ, Hollandsworth HM, Torriani FJ, *et al.* Rapid response to COVID-19: health informatics support for outbreak management in an academic health system. *J Am Med Inform Assoc* 2020;27:853–859.
13. Clinical Pathways Program. University of Chicago Medicine Center for Healthcare Delivery Science and Innovation. https://hdsi.uchicago.edu/clinical-pathways-program/. Accessed October 25, 2021.
14. Halpern SD, Ubel PA, Asch DA. Harnessing the power of default options to improve health care. *N Engl J Med* 2007;357:1340–1344.
15. Patel MS, Volpp KG, Asch DA. Nudge units to improve the delivery of health care. *N Engl J Med* 2018;378:214–216.
16. Campbell EM, Sittig DF, Ash JS, *et al.* Types of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc* 2006;13:547–556.