COVID-19 pandemic preparedness: A practical guide from clinical pharmacists’ perspective

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Purpose. To describe our hospital pharmacy department’s preparation for an influx of critically ill patients during the coronavirus disease 2019 (COVID-19) pandemic and offer guidance on clinical pharmacy services preparedness for similar crisis situations.

Summary. Personnel within the department of pharmacy at a medical center at the US epicenter of the COVID-19 pandemic proactively prepared a staffing and pharmacotherapeutic action plan in anticipation of an expected surge in admissions of critically ill patients with COVID-19 and expansion of acute care and intensive care unit (ICU) capacity. Guidance documents focusing on supportive care and pharmacotherapeutic treatment options were developed. Repurposing of non–ICU-trained clinical pharmacotherapy specialists to work collaboratively with clinician teams in ICUs was quickly implemented; staff were prepared for these duties through use of shared tools to facilitate education and practice standardization.

Conclusion. As challenges were encountered at the initial peak of the pandemic, interdisciplinary collaboration and teamwork was crucial to ensure that all patients were proactively assessed and that their respective pharmacotherapeutic regimens were optimized.

Keywords: clinical pharmacy, COVID-19, pandemic, pharmacist, pharmacotherapy

The pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has challenged all health systems to adapt and expand clinical care, including pharmacy services, to manage patients with coronavirus disease 2019 (COVID-19). SARS-CoV-2 is transmitted after entering the respiratory tract and may cause a severe systemic inflammatory response resulting in acute respiratory disease syndrome (ARDS), multiorgan failure, and sometimes distributive shock. The exponential spread of the SARS-CoV2 virus in the tristate area (New York, New Jersey, and Connecticut) led to escalating healthcare resource utilization, resulting in a burden on acute care resources, including hospital beds, personal protective equipment (PPE), ventilators, dialysis machines, and medications often used in the management critically ill patients.

After our initial observance of hospital admissions of patients with COVID-19 and in anticipation of a larger surge in numbers of critically ill mechanically ventilated patients, the department of pharmacy services at New York University Langone Health (NYULH), a large tertiary academic medical center, formed and commissioned its “COVID-Rx” team. This team consisted of clinical pharmacy managers, clinical pharmacotherapy specialists, and operational pharmacy managers. The COVID-Rx team was charged with implementing an adaptive COVID-19 preparedness and response strategy to address our patients’ pharmacotherapeutic needs. This strategy included but was not
limited to the following: developing pharmacotherapeutic guidance documents; training on limiting utilization of PPE; redeploying clinical pharmacotherapy specialists to work with subject matter experts and assist with an increased volume of critically ill patients; and navigating daily critical drug shortages. This articles adds to the literature on pharmacy response during a pandemic, with a focus on clinical pharmacy services and practice in the United States.5,4 We outline our experience—at a hospital in the US epicenter of the pandemic—in leveraging a clinical pharmacy presence on inpatient units during unprecedented circumstances to improve patient care. We plan to detail our operational pharmacy experience during the pandemic in a future publication.

Repurposing clinical pharmacotherapy services

NYULH is an 825-bed academic medical center in New York, NY, whose capacity was expanded to accommodate a surge of patients admitted during the COVID-19 pandemic. As part of the pandemic response, intensive care unit (ICU) capacity was increased by 160 beds and 136 additional acute care beds were created. At NYULH, providing clinical pharmacy services is an established practice throughout various departments, including critical care, cardiology, adult medicine, infectious diseases, transplant, hematology/oncology, emergency department, and pediatrics units. These services are provided by 20 clinical pharmacotherapy specialists, all of whom have completed postgraduate residency training and are board certified. They provide rounding clinical pharmacy services at the patient bedside, including selection of therapy, dosing, dosage adjustments, therapeutic drug monitoring, and education. Further, all clinical pharmacotherapy specialists perform antimicrobial stewardship and antithrombotic/hemostatic stewardship activities on their respective care teams.

In order to prepare for the surge of patients with COVID-19, our clinical pharmacotherapy specialists were assigned clear roles and responsibilities in order to minimize duplication of efforts while maintaining a high level of bedside care and avoiding gaps in coverage. These roles consisted of, but were not limited to, dedicated clinical pharmacy support of all COVID patient units, off-hours staffing to assist with the increased operational needs of the pharmacy, and prospective review of high-cost, low-supply off-label and investigational COVID-19-directed pharmacotherapies. All clinical pharmacotherapy specialists were repurposed to assist with clinical pharmacotherapy coverage for patients admitted with COVID-19 in addition to their normal job responsibilities.

COVID-19 guidance document

First, a shared document was developed to communicate COVID-specific pharmacotherapy options and workflow recommendations. After reviewing information from multiple sources, including primary literature and international and medical society guidelines, clinical pharmacotherapy specialists synthesized that information in a single document, which was kept up to date as new data became available to empower the entire pharmacy department to assist with optimal pharmacotherapy selection. This document included a wide range of information: contact information for on-call pharmacists; standardized dosing recommendations for possible COVID-19 pharmacotherapy agents, including antivirals and immunomodulatory agents; a list of open clinical trials of agents targeted to COVID-19, with a description of each investigational agent; and newly implemented medication ordering restrictions for treatment of patients with COVID-19. In the early stages of the pandemic response, the document was made available daily for revision by all clinical pharmacy services teams and then uploaded to the internal NYULH website by an assigned clinical pharmacotherapy specialist each day at 4 pm to share updates with the entire pharmacy team and provide a resource for all clinicians. Thereafter, updates were completed as needed, 1 to 3 times per week. Pharmacotherapy managers continuously discussed pharmacotherapy options with key stakeholders within the institution, including nurses and physicians, to rapidly assess available COVID-19 treatment options (all hospital committee activities, including pharmacy-related activities, had been suspended due to the surge in patient volume). Up-to-date information on all options was disseminated virtually through various channels.

Presence on patient care units

Given the impact of the pandemic on patient volume at NYULH, all clinical pharmacy services were repurposed to assist with pharmacotherapy coverage of patients admitted with COVID-19. Our group deployed pharmacists to round in all dedicated COVID-19 ICUs and provided remote clinical pharmacy support to COVID-19 acute care and “person under investigation” (PUI) units. In addition, postgraduate year 1 and postgraduate year 2 pharmacy residents were incorporated into the ICU rounding schedules. Specific attention was focused on in-person ICU rounding to maintain a clinical pharmacist...
presence and to allow close collaboration with physicians, advanced care practitioners, and nurses; however, this practice had to be balanced with efforts to avoid entering patient rooms in order to minimize utilization of PPE and personal exposure to SARS-CoV-2. This rounding approach was in contrast to experiences described in some other published reports on providing pharmacy services during a pandemic, but we felt this strategy was necessary to understand the factors driving clinical decisions, provide valuable education about pharmacotherapy options for COVID-19, and assist with dissemination of clinical guidelines, as well as drug shortages and alternative regimens, to all healthcare professionals providing ICU care on a dynamic and day-to-day basis. In our ICUs, we believed, remote clinical pharmacy support would not have been as effective because of the surge in numbers of critically ill patients, the complexities of patient care for COVID-19, the need for rapid point-of-care decisions in the ICU setting, and the influx of clinical personnel from various non-critical care disciplines who were assigned to assist in the care of critically ill patients with COVID-19.

As the numbers of COVID-19–dedicated ICUs and mechanically ventilated patients grew, healthcare teams increasingly consisted of providers from practice specialty areas other than critical care, including surgery, cardiology, and anesthesiology. We took a similar approach and repurposed clinical pharmacotherapy specialists from cardiology, adult medicine, transplant, and infectious diseases teams to assist with rounding in higher-acuity units. To provide guidance and support to these pharmacy specialists, the critical care pharmacotherapy team at NYUH developed multiple "quick-tip" guidance documents from existing internal protocols and policies (eg, a sedation, analgesia, and paralysis guide to assist with recommendations for patients with ARDS; guidance documents on corticosteroid therapy, airway clearance strategies, shock management, and renal replacement modalities) to aid in bedside decision making.

The deployment of pharmacists in ICUs provided an opportunity to strengthen the clinical team environment at the hospital. The availability of pharmacists in these units facilitated communication amongst all members of the healthcare team, which included acute care travel nurses, physicians, and advanced practice providers from other specialties. Pharmacists were available to review dose titrations of continuously infused medications and scheduling of medications, evaluate medication infusion pump settings for accuracy, facilitate missing medication requests, and (from outside patient rooms) assist in management of acute medical emergencies, including intubations and cardiopulmonary arrests. Lastly, our pharmacists were able to observe the acute needs of nursing staff, provide feedback on the implementation of drug management strategies (including concurrent administration of compatible medications to minimize PPE use), and anticipate the future needs of nursing staff based on evolving clinical scenarios.

**Structured pharmacotherapy plan reviews**

For non-ICU, acute care COVID-19–dedicated inpatient units, clinical pharmacotherapy specialists from transplant, hematology/oncology cardiology, adult medicine, and infectious diseases teams provided detailed pharmacotherapy plan reviews remotely within the hospital. They used secure messaging functions within the electronic health record (EHR) to communicate directly with clinical teams, and they assisted with transitions of care for patients discharged home to self-isolate or to rehabilitation facilities. A stepwise guide to remote pharmacy review for use in PUI for COVID-19 cases and confirmed COVID-19 cases was developed by the clinical pharmacotherapy team (Figure 1). Activities in this area included reviewing the results of SARS-CoV-2 polymerase chain reaction (PCR) assay testing; symptom onset prior to presentation to the hospital; patient respiratory status, including the need for supplemental oxygen; laboratory parameters for hyper-inflammation and severity of illness; criteria for potential use of antiviral or investigational therapies; venous thromboembolism prophylaxis; home medications; antimicrobial selection (if there was a concern for superinfection); and supportive care therapy options. Close attention was paid to keeping medication prescribing in line with the aforementioned COVID-19 pharmacotherapy guidance document. Recommended ICU supportive care strategies included preferential use of metered-dose inhalers if a closed ventilator circuit could not be maintained and nebulizers for patients with a closed ventilator circuit.

During the period described in this article, pharmacotherapies used for treatment of patients with COVID-19 at NYUH included remdesivir, hydroxychloroquine (plus zinc sulfate), ritonavir/lopinavir, and nitazoxanide. Specific attention was paid to navigating significant drug-drug interactions with ritonavir/lopinavir, such as interactions with direct oral anticoagulants and P2Y<sub>12</sub> receptor inhibitors. In addition, given the concerns for secondary hemophagocytic lymphohistiocytosis and cytokine release syndrome, clinical pharmacotherapy specialists were asked to review the records of all patients on COVID-19 units for documented elevations of inflammatory markers, including C-reactive protein, D-dimer, interleukin 6 (IL-6), and ferritin, to evaluate the appropriateness of therapies such as off-label tocilizumab or potential enrollment into open clinical trials of anti–IL-6 monoclonal antibodies at our institution. If a clinical pharmacotherapy specialist thought a patient met criteria for an investigational therapy, that possibility was discussed with the primary treatment team, which often consisted of clinicians from various subspecialties. Such discussions directly led to clinical specialists contacting investigators from open clinical trials to request screening...
of patients for inclusion and secondary review by a clinical pharmacy manager for approval of use of restricted investigational agents. All investigational therapies for COVID-19 were discussed with subject matter experts to assist with development of criteria for patient selection.

Although hospitalized patients with acute medical illness are already at increased risk for venous thromboembolism (VTE) and all such patients receive VTE prophylaxis at our institution, given recent findings from China there was concern that patients admitted with SARS-CoV-2 infection and critical illness may be at even higher risk for VTE due to systemic inflammatory response, mechanical ventilation, and immobility. Therefore, greater attention to review of VTE prophylaxis for all patients admitted to our institution with COVID-19 was prioritized in daily clinical reviews with the goal of ensuring use of enoxaparin as the preferred agent for VTE prophylaxis, as well as enoxaparin dosing in accordance with an individual patient’s body mass index and renal function. The antithrombotic stewardship pharmacotherapy specialists worked with subject matter experts to quickly develop an adaptive strategy for anticoagulation based on severity of illness, D-dimer level, and index of suspicion for VTE. Specific attention was paid toward optimizing dosing in obese patients, as this population was more severely affected by COVID-19 in the New York City area. To limit nurse-patient contact, the intravenous heparin algorithm was adjusted to decrease frequency of anti–factor Xa monitoring, with dose titration instructions built into the medication administration record. Further, a clinical trial to evaluate a strategy of prophylactic vs full-dose anticoagulation was initiated at our institution (ClinicalTrials.gov identifier, NCT04359277).

Management of critical drug shortages

The COVID-19 pandemic led to a significant increase in demand for medications essential for the care of critically ill patients. Due to a growing population of mechanically ventilated patients with ARDS, sedatives, analgesics, and paralytics to maintain ventilator synchrony appeared to be the most-requested drug classes. With impending stock-outs of these vital medications, the COVID-Rx team was responsible for providing recommendations for safe clinical alternatives. Recommendations included use of alternative dosage forms of medications in critical short supply, to minimize depletion. For example, use of enteral and transdermal opioids and sedative agents was suggested to allow for down-titrations of intravenous infusion doses. Intermittent rather than continuous infusions was strongly encouraged when appropriate. However, implementation of these measures had to be balanced with an understanding that great effort should be taken to minimize frequent nursing staff contact with COVID-19 patients. Therefore, long-acting intermittent-infusion therapies were recommended. None of these alternative strategies were regularly employed at our institution prior to the COVID pandemic; therefore, careful implementation was delicately balanced with the need for efficient rollout.
A clinical pharmacy presence in ICUs enabled clear communication of drug shortage action plans. Education was provided to ensure team comfort in using nontraditional pharmacotherapy agents and administration methods. It is important to note that no single approach to sedation or therapeutic paralysis could be widely adopted in all NYULH ICUs without depleting existing supplies of the requisite medications. Therefore, our rounding clinical pharmacotherapy specialists ensured variation in strategies to avoid overreliance on any single agent(s). For example, to prevent depletion of fentanyl infusion bags, balanced use of fentanyl and hydromorphone infusions was necessary, along with use of adjunctive enteral and transdermal opioids to decrease intravenous drug usage. A weekly summary of drug shortages and inventory levels was routinely communicated to the hospital leadership to minimize miscommunications regarding drug availability. We were successful in preventing drug stock-outs by having our clinical pharmacotherapy specialists serve as “gatekeepers” of use of medications in critically low supply.

**EHR-based clinical decision support**

The COVID-Rx team implemented clinical decision support (CDS) within the computerized prescriber order entry system, Epic CPOE (Epic Systems, Verona, WI), for all medications involved in the management of COVID-19. Our approach was targeted on antivirals such as remdesivir, unconventional treatments such as hydroxychloroquine and nitzoxanide, continuous-infusion medications, anticoagulants such as heparin and enoxaparin, and pharmacy monitoring flowsheets. The goal was to take an active role in safeguarding medications by ensuring proper use and preventing potential misuse. The COVID-Rx team quickly collaborated with other healthcare professions and the institution’s information technology (IT) team in making adjustments to CDS tools such as drug-drug interaction severity flags, default dosing and frequency parameters, and recommended therapy durations for each antiviral used in COVID-19 management. In addition, pertinent laboratory results, as well as heart rate–corrected QT interval values, were made visible upon order entry and verification. These enhancements standardized our approach to CDS support for use of COVID-19–targeted medications and added an extra layer of safety.

Other EHR changes focused on medications used in providing supportive care to patients with COVID-19. Management of sedation in critically ill patients with COVID-19 presented a new challenge to our team. Clinical considerations included the location of smart infusion pumps (ie, inside vs outside the patient room), limiting the number of times a nurse had to enter a patient’s room, and the need for multiple high-dose infusions to achieve sedation and ventilator synchrony. With these factors in mind, we created a “bolus from smart pump” EHR ordering functionality for all continuous-infusion medications including analgesics, sedatives, and neuromuscular blockers. With the CPOE interface, the bolus-from-pump option was displayed for each continuous-infusion medication order as an “as-needed” option, along with default dosing, frequency, and duration values. Concentrated medication infusions were also made available to decrease the overall contribution of infusion volume to a patient’s fluid balance and to decrease the number of bag exchanges required. These changes were accompanied by a system-wide emergent update of the smart pump drug library.

Within the EHR we enhanced existing pharmacy monitoring flowsheets for sedation, anticoagulation, antilinfective therapy, and ICU care. Each monitoring flowsheet provides a concise summary of all pertinent information associated with the intent of the report. For instance, the sedation monitoring flowsheet imports all formulations of medications into specific medication class categories, outlines every administration that can be viewed in relation to any selected time variable, and includes sedation scales and pertinent laboratory values for drug-specific monitoring (ie, creatine kinase and triglyceride concentrations). The rapid turnaround time for these EHR adjustments promoted adherence amongst the numerous clinical guidance documents developed by the pharmacy team, minimized calls to providers from staff pharmacists, and allowed us the opportunity to adjust and adapt in response to rapidly changing evidence regarding COVID-19.

**Conclusion**

As New York City became the US epicenter of the pandemic, our institution faced a number of challenges, such as tremendous demand on the healthcare system and personnel and emotional distress among all healthcare workers, including pharmacists. Clinical pharmacotherapy specialists at NYULH, who routinely work at the bedside along with physicians and nurses, had to balance being present beside clinicians of all disciplines to assist in patient care and the need to minimize personal exposure to SARS-CoV-2. We had to expand pharmacy services coverage to a growing number of critical care units and adapt to challenges through innovative mechanisms. At the time of writing this, some patients admitted to the hospital with COVID-19 have been transitioned to rehabilitation/chronic ventilator units, and clinical pharmacotherapy specialists are now assisting with supportive therapy for these patients. The pharmacy department was able to strategize and deploy its clinical pharmacotherapy specialists to meet the dynamic acute care needs of patients hospitalized for COVID-19.

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**Disclosures**

The authors have declared no potential conflicts of interest.
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