

COVID-19 pandemic preparedness: A practical guide from an operational pharmacy perspective

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Purpose. To describe our medical center's pharmacy services preparedness process and offer guidance to assist other institutions in preparing for surges of critically ill patients such as those experienced during the coronavirus disease 2019 (COVID-19) pandemic.

Summary. The leadership of a department of pharmacy at an urban medical center in the US epicenter of the COVID-19 pandemic proactively created a pharmacy action plan in anticipation of a surge in admissions of critically ill patients with COVID-19. It was essential to create guidance documents outlining workflow, provide comprehensive staff education, and repurpose non-intensive care unit (ICU)-trained clinical pharmacotherapy specialists to work in ICUs. Teamwork was crucial to ensure staff safety, develop complete scheduling, maintain adequate drug inventory and sterile compounding, optimize the electronic health record and automated dispensing cabinets to help ensure appropriate prescribing and effective management of medication supplies, and streamline the pharmacy workflow to ensure that all patients received pharmacotherapeutic regimens in a timely fashion.

Conclusion. Each hospital should view the COVID-19 crisis as an opportunity to internally review and enhance workflow processes, initiatives that can continue even after the resolution of the COVID-19 pandemic.

Keywords: COVID-19, pharmacotherapy, pharmacy

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The early weeks of response to the pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) challenged health systems to adapt and expand patient care to manage a surge of critically ill patients with coronavirus disease 2019 (COVID-19).¹ NYU Langone Health (NYULH) is a tertiary academic medical center located in Manhattan with 6 inpatient facilities and several outpatient locations throughout the New York City and Long Island, NY, areas. There are 19 established pharmacies throughout the NYULH enterprise. The NYULH department of pharmacy services formed and commissioned a "COVID-Rx" team to implement an adaptive COVID-19 preparedness and response strategy. In preparation for the COVID-19 pandemic, the medical center's operational bed capacity was increased from 700 to 836

beds, including an increase of 160 intensive care unit (ICU) beds. All pharmacy operations were reevaluated to identify the urgency of contingency planning to ensure continuity of patient care. This article is the second of a 2-part series on pharmacist practice management preparedness during unprecedented circumstances. Herein we describe the operational strategies implemented by the NYULH COVID-Rx team to manage the exponential increase in admissions of patients with COVID-19.

Staffing model and scheduling

Strategic staffing models were implemented through online conferencing and, as necessary, in-person site evaluations by individual stakeholders.^{2,3} The NYULH department of pharmacy consists of 90 pharmacists

and 82 pharmacy technicians. Our first assessment toward building a dynamic staffing model required a full review of all pharmacy personnel across the health system and their current responsibilities. Managers, pharmacists from ambulatory and inpatient care sites, technicians, and pharmacy residents assisted with all duties related to the operations of the pharmacy department.

Routine pharmacy tasks such as verification, compounding, dispensing, hand delivery of medications, restocking of automated dispensing cabinets (ADCs) and returns processing were considered essential. Ten pharmacy managers from other sites rotated through the medical center and were repurposed to perform these essential tasks during the morning, evening, and overnight shifts. The selection of pharmacy personnel to perform each of these pharmacy tasks was undertaken in consideration of the specific level of expertise required to perform them. For instance, operational pharmacy managers assisted with medication hand deliveries to allow reallocation of experienced pharmacy technicians to perform tasks that required further technician training. Our pharmacy residents' training was redesigned to enable them to assist with both clinical and operational needs, including rounding in newly established units designated as "COVID-ICUs," participating in medical code responses, and assisting with operational needs such as sterile compounding, hand deliveries, and other tasks. Taking a team approach of having the entire department assist with all functions around the clock helped maximize efficiency and minimize potential interruptions in pharmacy productivity.

In anticipation of the COVID-19 pandemic, we developed a contingency plan to anticipate potential staff absences due to illness or the need to serve as caregivers in the setting of home isolation for an extended period of time. Our plan included collapsing the pharmacy department's operational footprint and centralizing the

KEY POINTS

- A hospital at the US epicenter of the coronavirus disease 2019 (COVID-19) assembled an interdisciplinary team to forecast and allocate medication supply in order to ensure continuity of care.
- Optimization of automated dispensing cabinets (ADCs) to minimize staff virus exposure and ensure ready medication access, with regular review of par levels and ADC inventory, was essential in meeting increased medication demand on patient care units.
- Order templates within the computerized prescriber order entry and smart infusion pump systems were optimized to help ensure appropriate prescribing and effective medication supply management.

operational model to focus on the core functions of medication preparation, verification, and delivery. It was decided that this plan would be put into effect if more than 15% of our team was on extended leave; that threshold was determined by evaluating the number of staff members required to maintain consistent decentralized pharmacy operational services. Consistency was important, as we wanted patient care teams and nursing staff to have an appropriate understanding of where pharmacy support was available. (Each institution is unique, and specific threshold requirements and resources for decentralized pharmacist staffing will vary accordingly). Other staffing models, such as implementing a 3-day work week (ie, three 12-hour shifts) in order to keep staff healthy and limit SARS-CoV-2 transmission, were considered but not adopted at our institution.^{2,3} As a major medical center in the

US epicenter of the pandemic, NYULH experienced exponential increases in the rate of admissions and patient census, which did not allow us to reduce the number of pharmacy staff on-site for patient care activities. However, that is a strategy we would encourage other institutions to consider if it is deemed feasible. An additional approach to consider is a pharmacist work-from-home model (state law permitting); this would involve remote completion of tasks such as medication order verification through the electronic health record (EHR) or review and approval of intravenous (i.v.) medication compounding via electronic i.v. workflow management systems.

Staff safety

Our top priority was to ensure the safety of the entire pharmacy department. The infection prevention and control (IPC) department provided guidance for the use of personal protective equipment (PPE) and PPE conservation strategies. At the start of the pandemic we rapidly identified team members who would require N95 face masks and coordinated mask-fit testing promptly. We wanted to ensure that our team was protected with the appropriate PPE in areas where PPE use was required. This is vital to consider in order for a pharmacy team to execute the full array of operational and clinical tasks, such as delivering medications and restocking ADCs, working in decentralized pharmacy areas, and responding to medical internal emergencies in a safe manner. Moreover, we assessed our ability to implement social distancing measures in the central pharmacy. Unfortunately, full implementation of a robust social distancing protocol was not practical due to the increased volume of medication dispenses and the presence of large automated dispensing systems, medication storage carousels, and refrigerators. However, the pharmacy staff used appropriate PPE, maintained clean work areas, and performed hand washing. We encourage other institutions to

implement social distancing strategies if feasible.

Open communication was essential throughout this process to drive accountability, consistency, safety, and trust. A dedicated COVID-19 guidance document was created as a single source for all pharmacy-related information pertaining to COVID-19, including clinical and operational needs. This document facilitated real-time sharing of updates and served as a reference for our pharmacy staff on the following topics: medication handling, storage and disposal, PPE requirements, designated COVID-19 units, verification queue assignments, clinical pharmacotherapy assignments, and COVID-19 clinical protocols. The guidance document was updated daily due to the dynamic nature of the pandemic. It is imperative to educate the pharmacy team about internal guidelines and ensure that the most up-to-date information is relayed in a timely fashion. Placing all relevant information in a single Web-based location allowed us to efficiently relay information to our team. The guidance document served as our department's real-time strategy and was frequently updated as new evidence emerged.

Purchasing and maintaining inventory

The volume of critically ill patients admitted with SARS-CoV-2 infection led to increased utilization of healthcare resource and supplies such as hospital beds, PPE, ventilators, and dialysis machines and also had an immediate impact on the use and procurement of medications. Successful implementation of an adaptive COVID-Rx team included designating team members to anticipate the health system's needs and ensure the sustainability of medication supplies and resources.^{4,7} In preparation for the initial surge of critically ill patients infected with SARS-CoV-2, our COVID-Rx team reviewed all essential medications needed to treat the projected number of patients, created necessary storage space for these items, and anticipated supply chain

interruptions. This anticipatory stock was procured from drug wholesaler partners, manufacturers, nonprofit generics manufacturer CivicaRx, and 503B outsourcing vendors. Adequate communication was essential in coordinating with distributors and manufacturers in order to provide justification for large inventory purchases; this was especially important in placing orders for controlled substances that were on allocation and orders for quantities higher than the institution's previous average usage. Other essential medical supplies to be purchased and monitored included isopropyl alcohol, adapters for connecting medication vials to i.v. diluent containers, and diluents for compounding of i.v. bags.

Additional storage space was acquired within the hospital to accommodate the increased inventory, and proper security measures were arranged. A number of dedicated refrigerators were resourced to enable storage of essential medications and extension of the beyond-use dates (BUDs) of batched infusion bags of opioids and sedatives. The inventory application in the EHR was used by the pharmacy staff to keep track of pertinent information relating to each medication stored in overstock, such as quantity, lot numbers, and expiration dates.⁸ Electronic dashboards were developed to allow oversight of medication utilization and projection of estimated usage on a daily basis. These electronic dashboards were developed by retrieving data from ADCs, inventory carousels, and administration records from the EHR. For continuous infusions, supplemental infusion pump administration data was collected from third-party data analytics software. These dashboards were valuable resources for the COVID-Rx team to use in generating reports on average daily utilization of medications and predicting which medications might be subject to shortages. The dashboard also helped in prioritizing adaptive changes to medication utilization patterns by informing clinical pharmacotherapy specialists when to recommend

therapeutic alternatives to their healthcare teams. For example, the dashboard would display midazolam infusion characteristics (the number of patients receiving infusions, as well as the concentration and rate of each infusion and their location within the hospital); if a comparison of these variables to the current inventory on hand indicated an unsustainable usage pattern, the clinical pharmacotherapy specialists were informed to create an alternative sedation strategy. At the peak of the pandemic response, NYULH experienced a nearly 10-fold increase in the use of i.v. infusions of opioids (fentanyl and hydromorphone), sedatives (ketamine, propofol, dexmedetomidine, and midazolam), and vasopressors (norepinephrine and vasopressin). Daily virtual meetings were held with inventory personnel from each represented hospital pharmacy site within the health system. These meetings helped pharmacy personnel identify medications that were in short supply, redistribute overstocked medications between locations, and coordinate medication deliveries.

Sterile compounding

With the increased demand for compounded infusions, we looked to NYULH outpatient care sites for support with sterile compounding. As outpatient sites were closed and workloads decreased, outpatient pharmacy personnel, including pharmacists and technicians, assisted with batching of compounded sterile preparations (CSPs) that were used in high volume in ICUs. The health system's ambulatory care centers delivered CSPs to the medical center twice per day. The flexibility to use ambulatory infusion centers located more than 1 mile from the medical center was made possible by the Food and Drug Administration (FDA). On April 6, 2020, FDA waived the 1-mile radius requirement specified in the agency's "Hospital and Health System Compounding Draft Guidance" document.⁹ Additionally, on April 11, 2020, the United States Pharmacopeia Compounding Expert

Committee (USP CMP EC), in recognition of the increased demands on sterile compounding operations at compounding entities due to the COVID-19 pandemic, issued an operational strategies document authorizing BUD extensions.¹⁰ As described by the USP CMP EC, we assigned a 4-day BUD for compounded products stored at controlled room temperature and a 10-day BUD for refrigerated compounded products. The extension of BUDs allowed us to manage the drug supply and ensure consistent availability of compounded products to patients. Adjustments to compounding procedures were made in order to conserve PPE for sterile compounding activities. Compounding staff were instructed to use no more than 2 facemasks per shift and to store them in paper bags to prevent moisture buildup. Coverall suits were worn throughout the entire shift and stored in the anteroom. In addition, polyethylene-coated chemotherapy gowns were used for the entire shift and stored inside the hazardous sterile preparation room. Due to PPE conservation strategies for sterile compounding activities, the frequency of surface environmental sampling of primary engineering controls was increased to once monthly to ensure appropriate quality of compounded products.

Medication distribution: Cartfills and ADC management

Newly designated COVID-19 units, including both ICU-level and acute care units, were rapidly established to accommodate the projected surge of patient admissions. As these units were announced, the COVID-Rx team proactively maximized the use of ADCs by creating a standardized COVID-19 medication list based on reports of medications identified as investigational therapies for the treatment of SARS-CoV-2 infection and the medications necessary to manage mechanically ventilated patients with acute respiratory distress syndrome (ARDS), as listed in the [appendix](#). Both clinical

and operational pharmacists evaluated utilization of ADC-stocked medications on a daily basis.¹¹ Stock-out reports were assessed to develop par numbers for medications, determine how often to stock ADCs, and establish critical low levels for restocking purposes.

Optimization of and increased reliance on ADCs were critical to a structured response to managing the rapid development of new COVID-19 units.^{12,13} Our approach relied on several strategies, including ADC reorganization, expansion of the ADC-only medication list, stocking of batched i.v. opioid and sedative infusions, increasing the number of ADC restocks for COVID-19 units, and medication formulation interchangeability at the point of dispensing. Optimizing the ADC content and removing medications with expected low utilization allowed for greater capacity for frequently utilized medications. The development of an ADC-only medication list was done in collaboration with nursing staff. This list consisted of supportive care medications such as bronchodilators, mucolytics, medications with a frequency of daily or as needed, anticoagulants, sedatives, and some antivirals suggested for off-label use as anti-COVID-19 therapies. Use of the ADC-only medication list was successful in decreasing medication delays and cartfill volumes. Additionally, certain units were converted to a “cartless” distribution model wherein an ADC was used as the primary source of medications, with only non-ADC-stocked medications delivered to patients by other means.

Due to the increased demand for i.v. opioids and sedative infusions, these medications were batched daily and restocked up to 3 times a day on all COVID-19 ICUs. Medication utilization reports on these batched medications prevented waste, allowed medications to be readily available on ICU floors, and provided insights to inform purchasing of stock. Redeployment of staff resources to support additional ADC restocks was also critical. ADC restocks for COVID-19 units were increased

from once per day to 3 times per day by redeploying pharmacy technicians from closed units (operating rooms and postanesthesia care units) and units with a lower census and/or capacity (pediatrics units). The additional restocks were critical to maintain sufficient supply in ADCs, particularly with regard to controlled substances and continuous infusions. Lastly, an “ADC dose equivalent” process was implemented due to the sporadic availability of parenteral medications. A medication dose equivalent option exists if an item is available in the same drug concentration in containers of multiple sizes and interchanging these items is both clinically and operationally acceptable. Therefore, if the default product is out of stock, the ADC interface automatically redirects the user to an equivalent that is in stock at that ADC location. This ADC functionality allowed for greater product flexibility within an individual ADC and decreased the number of unavailable products.

Medication handling

Specific strategies were implemented for the handling of formulary medications, patients’ own home medications, and cardiopulmonary arrest “code carts.” Medication deliveries and ADC restocking were performed primarily by pharmacy technicians, and the amount of PPE required depended on the location of entry (eg, a hallway outside of a negative pressure room vs a “respiratory isolation zone” in the emergency department). In high-risk isolation areas with pharmacy staff already present, the pneumatic tube system was used whenever possible to reduce overall virus exposure, preserve PPE, and expedite delivery. In order to minimize staff exposure to medication items possibly contaminated with SARS-CoV-2, we updated the hospital’s policy on the use of home medications.¹⁴ The frontline pharmacists used their clinical judgment to determine whether a home medication could be converted to a formulary alternative or withheld or whether it was

absolutely essential for inpatient use. If continuation of a home medication was deemed necessary, a nurse wiped down the medication package with a cleaning agent and placed it in a bag for handoff to the pharmacy, where it was again decontaminated, identified, and verified. For formulary medications that entered the rooms of patients with COVID-19 but were not ultimately used, similar precautions were taken, and medication packages were cleaned and reused when possible.

As the number of COVID-19 units increased, there was a corresponding increase in the demand for code carts. Our hospital's interdisciplinary resuscitation committee determined that during the COVID-19 pandemic, carts were to be positioned directly outside of patient rooms during emergencies to ensure that any unused content did not need to be discarded or decontaminated. This measure was especially important in light of critical shortages impacting nearly all essential emergency medications. At the time of a cardiopulmonary arrest, required medications were prepared by pharmacists outside the patient's room and passed to the resuscitation nurse through the door for immediate use. The code response pharmacist's PPE requirement was in accordance with the guidance provided by the NYULH IPC department. Upon completion of a code response, the cart was extensively decontaminated by the response team using sterile wipes prior to the return of the cart to the pharmacy for cart exchange. While this workflow was effective for our team, another strategy could be to make bags of a small supply of commonly used emergency medications readily available on all hospital floors; this could potentially prevent the opening and potential contamination of code carts during every emergency. We ultimately did not implement that strategy due to uncertainty as to whether it would decrease the number of carts actually accessed and due to the additional pharmacy technician labor required.

Medication administration considerations

A complete evaluation of medication administrations was performed to characterize smart pump infusions and timing of medication administrations. We assessed the number of smart infusion pumps on hand and obtained additional pumps in order to maintain the best practice of using smart infusion pumps for all i.v. infusion administrations.¹⁴ Smart pumps were positioned outside of single-bed ICU patient rooms through the use of magnetic resonance imaging (MRI) extension tubing. This strategy was adjusted based on the availability of MRI tubing, the number of ICU patients, and the number of required i.v. continuous infusions per patient. Therefore, we had to reevaluate this process for patients receiving multiple continuous infusions requiring frequent dose titrations. The clinical pharmacotherapy specialists rounding in COVID ICUs were instrumental in guiding nurses on whether a smart pump could feasibly be kept outside of a patient room. For instance, a decision to keep a smart pump inside a patient's room included consideration of the following: a need for frequent dose titration (ie, intervals of <6 hours), a need for frequent line exchanges (as with infusions of propofol or clevidipine), and use of continuous-infusion medications not requiring dose titration by a nurse (eg, amiodarone, neuromuscular blockers).

Another component of our smart pump strategy was to revise our system-wide policy requiring independent double checks of continuous infusions for adult patients. The revision to the independent double check policy decreased the number of interruptions to nurses' workflow, and each continuous infusion was discussed during ICU rounds with the clinical pharmacotherapy specialists. Alternative strategies that organizations may consider for smart pumps include redistributing pumps throughout the healthcare system by relocating off-site ambulatory pumps to inpatient

facilities, expanding the list of medications approved for i.v. push administration, preferentially administering medications as intermittent vs continuous infusions, considering gravity administration for selected low-risk infusions, and encouraging the use of alternative medication administration routes.¹⁴ Another strategy proposed to decrease the frequency of nurse entry into patient rooms include adjusting medication administration times to enable bundling of patient care tasks. This strategy may not be feasible for critically ill patients with ARDS requiring frequent lifesaving interventions and medications. Communication between nursing personnel and rounding clinical pharmacotherapy specialists was essential to help coordinate timing of medication administrations within the ICU environment. The coordination of medication timing was balanced with consideration of the severity of illness of the patient, planned or potential procedures, the need for clinical imaging, and the nurse-to-patient ratio.

Discharge medication management

For patients admitted to acute care floors with COVID-19, specific attention was focused on minimizing the potential for postdischarge public virus exposure by allowing these patients to be discharged home for self-isolation. We were able to leverage the patient discharge process by using an onsite ambulatory care pharmacy to provide these patients with discharge medications. Prescriptions were sent electronically to the pharmacy and delivered to each patient's room prior to hospital discharge. Pharmacy staff coordinated with nursing personnel to ensure that patients received their medications, as well as necessary education, prior to discharge from the emergency department or an acute care unit.

Medication safety considerations

The COVID-19 pandemic created a need to strategize alternative medication management processes. Careful

consideration and planning is required for evaluation of new formulary additions, addition to the formulary of standard drug concentrations appropriate for short-term infusions and/or larger-volume or more concentrated continuous infusions, institutional i.v. push policy, and expansion of clinical indications for use of a particular agent. Developing dosing guidelines, order sets, and alternative-option alerts within a computerized prescriber order entry (CPOE) system can help to ensure compliance with clinical updates and drive alternative medication selection when needed.^{15,16} When building these new medication order records, it is important to validate drug-drug interaction data, dosing limits, and pregnancy warnings provided by the drug database vendor to ensure that displayed clinical alerting and drug interaction severities are appropriate. The COVID-Rx team quickly identified an increase in alerts associated with pharmacist-recommended COVID-19 therapies and quickly implemented a number of changes to limit nuisance alerts and ensure clinically meaningful alerting of ordering clinicians. Despite the large number of organizational changes and strain that occurred throughout the pandemic response, NYULH experienced a significant decrease in the number of reported medication errors. In times of turbulence and influx of newly hired or travel staff, the importance of reporting observed and experienced medication safety risks throughout an institution should continue to be emphasized.

Conclusion

Each health system is unique and has or may face different obstacles in combating the COVID-19 pandemic; the strategies outlined here can be implemented to varying degrees in other institutions. A dynamic and flexible staffing model is essential in order to anticipate and manage new obstacles. Cross-training in routine pharmacy tasks among pharmacists, managers, and technicians is recommended in

preparation for any future similar event. The participation of the pharmacy leadership in daily frontline clinical and operational activities provided us with a unique exposure and allowed for added opportunities for communication with staff. Each hospital must view the current crisis as an opportunity to internally review and enhance workflow processes, which can continue even after the resolution of the COVID-19 pandemic.

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Disclosures

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Appendix—Example of automated dispensing cabinet stocking list for COVID-19 intensive care unit at NYU Langone Health^a

Acetaminophen 325 mg tablet, 325 mg liquid, 500 mg tablet
Acetylcysteine 10% and 20% 4 mL vial
Albuterol sulfate MDI and 2.5 mg/3 mL nebulizer
Amiodarone 150 mg/100 mL and 360 mg/200 mL bag
Aspirin 81 mg chewable tablet
Azithromycin 500 mg tablet and vial
Cefepime 1,000 mg vial
Ceftriaxone 1,000 mg vial
Chlordiazepoxide 25 mg capsule
Dexmedetomidine 4 µg/mL vial, 50 mL and 100 mL
Enoxaparin 30 and 40 mg syringe, additional sizes if space available
Famotidine 20 mg tablet and vial
Fentanyl 2,500 mg/250 mL bag
Fentanyl 100 µg/2 mL vial
Fentanyl 50 µg/h, 75 µg/h, 100 µg/h patch
Furosemide 10 mg/mL vial, 2 mL and 10 mL
Gabapentin 300 mg/6 mL
Guaifenesin 100 mg/5 mL oral liquid
Heparin 5,000 units/mL vial
Heparin 25,000 units/250 mL bag
Hydromorphone 1 mg/mL and 2 mg/mL vial, 2 mg and 4 mg tablet
Insulin lispro 300 units/3 mL vial
Ipratropium bromide MDI and 0.5 mg/2.5 mL nebulizer
Ketamine 500 mg/250 mL bag
Lorazepam 1 mg and 2 mg tablet
Lorazepam 2 mg/1 mL vial
Magnesium 2,000 mg bag
Meropenem 500 mg and 1,000 mg vial
Methylprednisolone 40 mg and 125 mg vial
Metoprolol tartrate 5 mg/5 mL vial
Midazolam 100 mg/100 mL bag
Midodrine 5 mg tablet
Norepinephrine 4 mg/250 mL and 16 mg/250 mL bag
Ondansetron 4 mg/2 mL vial
Oxycodone 5 mg and 30 mg tablet
Oxycodone 5 mg/5 mL oral liquid
Pantoprazole 40 mg/10 mL vial
Phenobarbital 65 mg/1 mL vial
Phenylephrine 100 µg/5 mL syringe

Phenylephrine 100 mg/250 mL bag

Piperacillin/tazobactam 3,375 mg and 4,500 mg vial

Polyethylene glycol 3350 17,000 mg packet

Potassium chloride 10 mEq/100 mL and 10 mEq/50 mL bag

Potassium chloride 20 mEq tablet and 20 mEq/15 mL oral liquid

Propofol 10 mg/1 mL vial, 50 and 100 mL

Quetiapine 50 mg tablet

Rocuronium 50 mg/5 mL vial

Rapid sequence intubation kit (etomidate, rocuronium, succinylcholine)

Senna 8.6 mg tablet and 8.8 mg/5 mL oral liquid

Sodium bicarbonate 8.4% 50 mEq/50 mL vial

Sodium chloride 0.9% and 3% nebulizer

Valproate 500 mg vial

Vancomycin i.v. formulations (premixed or nurse-assembled products)

Vasopressin 20 units/1 mL vial

Vecuronium 10 mg/10 mL vial

^aStocking of antivirals dependent on available evidence.