Surviving the surge: Evaluation of early impact of COVID-19 on inpatient pharmacy services at a community teaching hospital

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Purpose. The coronavirus disease 2019 (COVID-19) pandemic has presented novel challenges to healthcare systems; however, an analysis of the impact of the pandemic on inpatient pharmacy services has not yet been conducted.

Methods. Results of an observational assessment of operational and clinical pharmacy services at a community teaching hospital during the first weeks of the COVID-19 pandemic are presented. Service outcomes of the inpatient pharmacy were evaluated from February 1 to April 8, 2020. Outcomes during the weeks preceding the first COVID-19 admission (February 1 to March 11, 2020) and during the pandemic period (March 12 to April 8, 2020) were compared. Evaluated outcomes included daily order verifications, clinical interventions, and usage of relevant medications. An exploratory statistical analysis was conducted using Student's *t* test.

Results. During the pandemic period, the number of new order verifications decreased from approximately 5,000 orders per day to 3,300 orders per day ($P < 0.01$), a reduction of 30% during the first 4 weeks of the pandemic compared to the weeks prior. Average daily pharmacokinetic dosing consults were reduced in the pandemic period (from 82 to 67; $P < 0.01$) compared to the prepandemic period; however, total daily pharmacist interventions did not

differ significantly (473 vs 456; *P* = 0.68). Dispensing of hydroxychloroquine, azithromycin, enoxaparin, and sedative medications increased substantially during the pandemic period (*P* < 0.01 for all comparisons).

Conclusion. The operational and clinical requirements of an inpatient pharmacy department shifted considerably during the first weeks of the COVID-19 pandemic. Pharmacy departments must be adaptable in order to continue to provide effective pharmaceutical care during the pandemic.

Keywords: clinical, coronavirus, health system, operational, pharmacy

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The global coronavirus disease 2019 (COVID-19) pandemic has led to serious complications for patients, healthcare providers, and healthcare systems in the United States and abroad.[1,2] As of May 4, 2020, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative pathogen in COVID-19, had caused over 247,000 patient deaths worldwide, including approximately 62,000 in the United States.[3] The influx of highly infectious patients into hospitals has led to significant restructuring of clinical care models, especially in cities that have been disproportionately impacted by COVID-19, including Detroit, MI. Additionally, as healthcare systems are flooded with SARS-CoV-2–infected patients, the vast majority of elective procedures have been temporarily suspended and public health messaging has been urging patients to avoid hospitals, and public places more generally, if possible.[4-6] This has led to dramatic shifts in hospital censuses, with attendant disruption to the economic homeostasis of the institutions.[7] Pharmacy practitioners and departments, from both operational and clinical perspectives, can expect to be impacted significantly. The area of clinical pharmacy, specifically, has long been disadvantaged by an inability to charge for the majority of inpatient services. This disadvantage has manifested itself in the chronic need to justify provided services—a need that is troublesome for a profession whose practitioners generally lack prescribing authority—as clinical outcomes are often difficult to disentangle from confounding variables. This has led to the reliance on key performance indicators to track interventions in many institutions.[8-10] It is currently unknown which pharmacist interventions are likely to be most impactful in the current pandemic; however, published recommendations have promoted interventions ranging

from medication stewardship to coordination of laboratory timing to telehealth visits, when feasible.[11,12]

Operational pharmacy services will also be impacted, and pharmacists and technicians will have to be adaptable to the shifts in medication needs that will accompany the influx of critically ill patients. For example, the anticipated influx of critically ill patients may require substantial workflow modifications to compound, batch, and deliver sedative medications for ventilated patients. Additionally, the development of overflow intensive care units (ICUs) may necessitate restructuring of delivery services.

Several editorials recommending suggested activities for pharmacy students, clinical pharmacist specialists, and community pharmacists have been published recently; however, none have commented on the operational impact the crisis has had on inpatient pharmacy departments.[11-16] As the COVID-19 pandemic continues in earnest, pharmacy departments will need to adapt to the crisis in order to continue to provide timely value-based care. Additionally, we contend that the crucial role of clinical pharmacists as leaders in the interpretation and dissemination of evidence-based medicine will need to be emphasized and recognized by institutional leaderships at higher administrative levels. Herein, we describe the early impact of the COVID-19 crisis on the operational and clinical components of an inpatient pharmacy department at a large community teaching hospital.

Methods

We conducted an observational pre-post study that evaluated the early impact of the COVID-19 pandemic on inpatient pharmacy clinical and operational outcomes pertaining to medication supply, pharmacy personnel, and documented clinical interventions. A 9-week time period was selected for evaluation of the impact of SARS-CoV-2 on inpatient pharmacy department services at Beaumont Hospital, Dearborn, a 632-bed tertiary care hospital located in southeastern Michigan, outside of Detroit. The hospital is part of the broader Beaumont Health system.

A comparative evaluation of the pharmacy department's personnel structure, operational output, and clinical output was conducted for the time period of February 1 through April 8, 2020. This timeframe was selected to ensure that the assessment period included prepandemic data (collected from February 1 until the day before the first suspected case of SARS-CoV-2 infection at our hospital on March 12) and continued until daily SARS-CoV-2–related medication dispensing peaked and began to decline on April 5. Evaluated variables included operational structure (pharmacist and technician roles, responsibilities, and number and distribution of full-time equivalents [FTEs]), pharmacy output (order verifications and numbers and types of clinical pharmacist interventions), clinical pharmacist specialist roles, and shifts in supply and demand for key medication classes pertinent to the COVID-19 pandemic. The evaluated medications were chosen by consensus among study investigators as those that were related to management of patients with COVID-19 and underwent the most dramatic shifts during the first weeks of the COVID-19 pandemic. These medications included hydroxychloroquine, azithromycin, neuromuscular blockers, fentanyl, propofol, and

enoxaparin. Dispensing data for vasopressin and norepinephrine were also collected due to the increase in ICU patients in the study period. Pharmacy interventions were tracked using the electronic medical record (Epic Systems Corporation, Verona, WI). Intervention tracking is a standardized method of documenting specific clinical services provided to inpatients by pharmacists. For this study, data on the following interventions were collected: comprehensive medication reviews (CMRs), interventions made during multidisciplinary rounds, medical emergency responses, and patient education.

An exploratory statistical analysis was conducted to compare quantitative outcomes during the prepandemic period (February 1 through March 11) and the pandemic period (March 12 through April 8). Descriptive statistics were used to describe continuous and categorical data. Student's *t* test was used to compare continuous parametric variables (inpatient census, total dispenses for medications, and number of interventions), and the Mann-Whitney *U* test was used to compare nonparametric variables between cohorts. Statistical significance and power were not established a priori, and all results should be considered hypothesis-generating evidence. Qualitative discussions regarding the differences in operational personnel and management structure and clinical specialist's roles during the prepandemic and pandemic periods were also performed.

Results

Inpatient census and SARS-CoV-2 population. The first patient with suspected SARS-CoV-2 infection was admitted to the hospital on March 12, 2020. The number of patients admitted with confirmed or suspected SARS-CoV-2 infection continued to increase until April 5, after which point the number of daily admissions temporarily stabilized and began to decline. Data on the inpatient census of SARS-CoV-2–positive patients after March 12, 2020, are shown in Figure 1. In the prepandemic period, the mean inpatient daily census was 471 patients per day. During the pandemic period, the mean inpatient daily census declined significantly to an average of 379 patients per day ($P < 0.01$). However, there was a relative increase in the number of patients in ICUs. The increase in the number of high-acuity patients was accompanied by an increase in the mean number of new ventilations per day in the pandemic period relative to the prepandemic period (7.7 vs 5.5; $P < 0.01$).

Operational output. The shifts in average census and patient acuity impacted the operational output of the pharmacy. The reduced hospital census was followed by a reduction in new medication orders and a corresponding reduction in order verifications (Table 1). Specifically, during February and early March (the prepandemic period), the pharmacy department was responsible for verifying approximately 5,000 medication orders per day. This figure decreased significantly during the pandemic period to an average of approximately 3,300 orders per day ($P < 0.01$), a daily reduction of approximately 30%.

Although there was a reduction in the average total number of verifications, there was a large increase in the dispensing of compounded intravenous (i.v.) medications, which required the reallocation of pharmacy technicians and pharmacists. Additionally, steps were taken to

continue to ensure that controlled substances were still compounded, delivered, and tracked in a manner appropriate for compliance with applicable legal requirements despite the increased workload. This was important, as the surge of COVID-19 cases led to significantly increased use of fentanyl, midazolam, and neuromuscular blockers, all of which are compounded at our institution. The increased use of controlled sedatives, in turn, led to anticipatory batching of these medications to ensure there was adequate supply in automated dispensing cabinets on patient floors.

Medication supply shifts. At the time of writing there were no medications with a Food and Drug Administration (FDA)–labeled indication for the treatment of SARS-CoV-2 disease; however, there were a number of therapies whose use was supported by in vitro or limited in vivo evidence and that were being used in both the United States and abroad. These agents included hydroxychloroquine, azithromycin, remdesivir, corticosteroids, statins, tocilizumab, and others.[17-21] At the time of the first admissions of patients with COVID-19, guidance from professional organizations was limited. At the study institution, daily hydroxychloroquine and azithromycin dispensing increased substantially, likely due to the publication of results of a small, nonrandomized study.[22] For these medications, the average daily number of doses dispensed in the pandemic period was substantially increased from the prepandemic period (93 vs 28 [$P < 0.01$] for azithromycin 250 mg equivalents; 179 vs 9.3 [$P < 0.01$] for hydroxychloroquine 200-mg tablets) (Figure 2). Average daily enoxaparin syringe dispensing also increased significantly in the pandemic period vs the prepandemic period (106.4 vs. 49.1; $p<0.01$), due to the inclusion of an option for therapeutic anticoagulation in hospitalized SARS-CoV-2–infected patients with elevated D-dimer levels in the hospital's therapeutic guidelines.

Additionally, there were increases in dispensing of both sedatives and neuromuscular blockers during the pandemic period. Specifically, the average daily dispenses of propofol 1,000 mg/100 mL vials increased from the prepandemic period (from 57.1 to 184.8; $P < 0.01$), as did the average daily dispenses of fentanyl 1,000 µg/100 mL bags (from 19.6 vs. 95.1; $p < 0.01$) and midazolam 100 mg/100 mL bags (from 1.6 to 7.3; $P < 0.01$) (Figure 3). Daily neuromuscular blocker dispensing in the assessed time period increased from 46.8 to 62.3 ($P < 0.01$). However, despite the increased number of ventilated and sedated patients, the mean number of vasopressors dispensed per day did not differ significantly in the pandemic period vs the prepandemic period for either vasopressin 20 unit/100 mL infusions (4.9 vs 7.4; $P = 0.45$) or norepinephrine 16 mg/250 mL infusions (14.0 vs 10.7; $P = 0.27$).

The increased national demand for select medications being explored for COVID-19 treatment led to frequent supply chain issues. These issues, in turn, necessitated the procurement of different dosage forms from various manufacturers based on the available supply. The instability in the supply chain required that additional steps be taken to ensure that these diverse medication forms could be appropriately ordered, stored, and scanned via barcode for accessibility in automated dispensing cabinets and at the point of patient administration.

Pharmacy personnel. Prior to the COVID-19 pandemic, the pharmacy department at the study institution was comprised of centralized, decentralized, and specialist services. The centralized pharmacist services consisted of order verification, medication checking, and chemotherapeutic medication processing. These services were staffed by 7 FTEs during daytime hours, 7 FTEs in afternoon hours, and 2 FTEs on the overnight shift. Decentralized (unit-based)

services provided by 12 clinical pharmacists, including those staffing emergency room and operating room (OR) satellite pharmacies, consisted of pharmacokinetic dosing, patient education, antimicrobial stewardship, renal dose adjustment, i.v.-to-oral conversion, emergency medical responses, multidisciplinary rounding on certain units, and anticoagulation monitoring services on a daily basis. Decentralized pharmacist services staffing was consolidated in afternoon hours to 3 FTEs. The department also deployed a small cohort (*n* = 4) of inpatient clinical pharmacy specialists in the areas of intensive care (cardiac and medical), internal medicine, and antimicrobial stewardship. Models for deployment of departmental pharmacist FTEs during the prepandemic and pandemic periods are shown in Figure 4.

During the COVID-19 pandemic, in order to compensate for the shifts in census, acuity, and medication orders within the hospital, the pharmacy personnel plan was modified and reassessed on a daily basis due to the rapidity of changes ushered in by the surge period. Operationally, an additional pharmacist FTE was reallocated to medication checking during both morning and afternoon shifts to keep up with the increased compounded i.v. medication output. Decentralized pharmacy services staffing was reduced to 10 FTEs, and floor responsibilities were redistributed so that 2 dedicated FTEs could focus solely on COVID-19 patient reviews. COVID-19 reviews consisted of CMRs to optimize therapy and reduce the chances of infectious spread, as described in the next section. The rest of the prepandemic responsibilities were conducted by the remaining 8 pharmacists, with the exception of patient education, which was offered telephonically to preserve personal protective equipment. Specialist services were also modified. The internal medicine specialist was reassigned to one of the patient floors, which was modified into a dedicated overflow ICU. Additional services were

modified to assist operations as well. For example, the pharmacist and pharmacy technician FTEs staffing the OR satellite pharmacy were able to batch and compound i.v. medications due to the reduced number of surgeries in the pandemic period.

Cumulatively, these changes resulted in stable workflow despite a smaller workforce (the department operated with 2 fewer FTEs per day, on average, during the pandemic period due to numerous quarantines among employees). These operational workflow changes were feasible as pharmacists were cross-trained to cover different services prior to the pandemic period. Pharmacy technician responsibilities also were shifted significantly during the pandemic period. There was an increased need for medication deliveries to critical care areas throughout the day. To compensate for the increased technician services needed for medication delivery and compounding, pharmacists and a labor pool of licensed nurses were utilized to assist in i.v. compounding and medication delivery, respectively.

Clinical output. The average number of daily clinical interventions was similar in the pandemic period relative to the prepandemic period (473 vs 456, $P = 0.68$) despite the lower overall census. The pharmacist intervention that increased most in the pandemic period was mean daily CMRs (84.7 vs 142.3, $P < 0.01$). During the pandemic period CMRs consisted of ensuring appropriate adherence to the health system's COVID-19 treatment guidelines, ensuring appropriate monitoring for medication adverse effects, performing i.v.-to-oral conversions and electrolyte replacement, de-escalating unnecessary antibiotics, and appropriately timing medication administrations and laboratory samples to avoid unnecessary intrusions into patient rooms under isolation. Other forms of pharmacy interventions, including responding to medical emergencies, educating patients, and giving recommendations on

multidisciplinary rounds, tended to remain unchanged in the pandemic period. Of note, mean daily pharmacokinetic dosing consultations were reduced significantly (from 82 to 67, $P < 0.01$). This reduction might have been related to shifts in the underlying population or a relative decrease in use of the medications typically targeted for pharmacokinetic monitoring (warfarin, vancomycin, and aminoglycosides). Details of changes to pharmacist interventions during the study period are provided in Table 1.

Clinical specialists: communication and coordination. The utilization of pharmacist clinical intervention documentation provides one method to justify the clinical (and associated economic) worth of clinical pharmacy services. However, overreliance on this method neglects consideration of vital services that pharmacists provide to improve patient care on a policy level. For example, pharmacist specialists and managers were involved in garnering consensus for hospital guidelines and protocols within a system-level multidisciplinary committee, after which site-level pharmacy managers and specialists presented updated guidelines to the clinical pharmacists, nurses, and physician cohorts. Multidisciplinary communication regarding medication supply was particularly important. Critical care specialists were in daily communication with intensivists regarding the appropriate ordering of medications or discussing the need to switch to alternative medications based on hospital availability. Meetings were also held among pharmacy managers, pharmacists, and pharmacy technicians on a daily basis to disseminate hospital and departmental COVID-19–related updates, discuss medication inventory status, and address staff questions. This communicative practice required intensive effort and large time commitment to standardize patient care and infection control practices across specialties, services, and patient floors.

Discussion

To our knowledge, the study described here was the first quantitative analysis of the early impact of COVID-19 on an inpatient pharmacy department in the United States. Although several papers suggesting services that pharmacists can provide to improve patient care in the current pandemic have been published,[11-15] most of these editorials lack discussions of the complicated inpatient context in which pharmacists in impacted areas are currently working. For example, at our institution the sudden influx of critically ill patients necessitated the restructuring of much of the inpatient pharmacy model. The increased need for the compounding, handling, and delivery of i.v. medications for high-acuity patients required reallocation of pharmacy technicians and pharmacists and occasional utilization of labor-pool resources to compensate for the modified workload. As clinical pharmacists and specialists were shifted to help in overflow ICUs or pharmacy operations, other clinical pharmacists were required to perform interventions in a larger cohort of patients in unique ways. These personnel shifts were accompanied by a corresponding change in the types, but not the overall number, of documented clinical interventions during the pandemic period despite the reduced inpatient census. Additionally, managers, pharmacists, and technicians were all required to communicate openly and often to nurses, physicians, and other providers on patient care units to ensure both the timely delivery of medications and the appropriate dissemination of institutional guidelines regarding medication handling, medical treatment, and infection prevention procedures.

We believe the COVID-19 pandemic will require rethinking of the traditional role and expected outcomes of inpatient pharmacy services. Traditional pharmacy efficiency benchmarks such as order verification and pharmacokinetic monitoring were reduced in our population due to changes in census and the underlying population. The clinical changes were offset by a corresponding increase in the number of CMRs performed for inpatients, while other clinical services did not change substantially from baseline. At our institution, CMRs often consist of pharmacist interventions that have been cost-justified in the past, such as renal dose adjustment, i.v.- to-oral conversion, and antibiotic de-escalation.[23-25] However, CMRs in this period also included activities unique to the COVID-19 pandemic. These interventions included retiming of blood sampling for laboratory testing and retiming of medication administrations to limit nurse visits into patient rooms, which may have served to preserve personal protective equipment and reduced the risk of viral transmission to nurses.[26] Additionally, CMRs included ensuring providers were following health-system COVID-19 guidelines with respect to monitoring for adverse effects, such as QT interval prolongation with hydroxychloroquine use (with or without azithromycin therapy). The lack of previously published literature suggesting clinical and/or economic benefit of these interventions does not mean that these interventions are not providing significant benefit to patients and health systems. Unfortunately, financial justification of services during the COVID-19 pandemic is extremely relevant. The complicated decision of how best to use pharmacists in SARS-CoV-2–related patient care in the inpatient setting is occurring against the backdrop of numerous public reports regarding layoffs of nonessential healthcare personnel nationwide.[27] Thus, documentation of services will remain

important for the pharmacy profession going forward to justify these services as more data come forth.

However, demonstration of an improvement in clinical or economic outcomes related to these clinical pharmacy services will likely be difficult. For example, pharmacist involvement in multidisciplinary discussion and consensus may deter off-label use of potentially dangerous medications. There are a number of compounds that have demonstrated in vitro activity against SARS-CoV-1 and/or SARS-CoV-2.[28-31] However, clinical evidence of in vivo activity is often lacking or derived from underpowered studies conducted without randomization or controls. If these therapies are prevented up-front, it is difficult to estimate downstream impact in the form of clinical outcomes or healthcare cost avoidance unless comparisons between differing health systems are conducted. Documentation of interventions such as institutional guideline adherence may be a useful surrogate marker to demonstrate the ability of the profession to garner consensus for treatment recommendations and therefore reduce the number of potentially harmful experimental regimens administered to patients. We believe pharmacists can do well to continue to support physician and nurse education, medication safety, and the continuation of traditional clinical services, such as medication optimization and patient education via telehealth, until medication outcomes and/or clinical service studies are published and provide further guidance to the profession.

As others have suggested, we believe that pharmacy departments will continue to have a vital role to play in terms of ensuring medication availability at the health-system and patient care unit levels.[11-15] In our early experiences with SARS-CoV-2, the pharmacy department dispensed vastly increased amounts of COVID-19–related medications in addition to more

common medications such as sedatives for an increased number of critically ill and ventilated patients. It is also important to recognize that the suggested treatment regimens for COVID-19 are evolving daily and that health systems may utilize different therapies based on availability of drug supply and ability to enroll patients into clinical trials. For example, both the Infectious Diseases Society of America and National Institutes of Health have now released guidelines that do not recommend use of hydroxychloroquine, azithromycin, lopinavir/ritonavir, or corticosteroids outside of the setting of a clinical trial or local registry.[32,33] It will be important for pharmacists to keep a close eye on published literature and organizational recommendations in addition to hospital usage data so that medications are available to infected inpatients.

Our study had a number of limitations. First, it was an observational assessment of a single center's experience. The data provided do not suggest that the changes to the inpatient pharmacy model would be appropriate for other institutions. Additionally, COVID-19 has been spreading in discrete epicenters of the country, and many institutions may not have the patient burden and consequential changes in census and dispensing that our center experienced. It is hard to predict how the pandemic will impact other institutions; thus, the study may suffer from a lack of external validity. Finally, the data provided only characterize the surge period of the pandemic. At the time of writing, our institution still had over 100 infected inpatients, though the number of new daily admissions for SARS-CoV-2 infection had slowed. Additional adaptations may be required going forward as the hospital continues to strive to provide safe and effective patient care in a manner that is justifiable from an economic perspective. Despite

these limitations, this article provides a point of reference for other inpatient pharmacy departments not yet impacted by the COVID-19 pandemic.

Conclusion

The COVID-19 pandemic resulted in significant changes in inpatient pharmacy personnel deployment and operational and clinical outputs. Pharmacy departments must be adaptable in order to continue to provide effective patient care during the public health crisis.

Disclosures

The authors have no declared no potential conflicts of interest.

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Figure 1. Inpatient census trends, including total confirmed or suspected coronavirus disease 2019 (COVID-19) cases, at the study site.

Figure 2. Trends in use of medications used for treatment of coronavirus disease 2019 at the study site during the 10-week study period.

Figure 3. Trends in sedative medication use at the study site during the 10-week study period.

Figure 4. Models for weekday deployment of 35 pharmacist full-time equivalents (FTEs) during the predemic period (A) and the pandemic period (B) at the study institution.

Key Points

- The coronavirus pandemic has been associated with reduced inpatient censuses, shuttering of elective services, and attendant disruption of the economic homeostasis of health systems.
- Our institution experienced a reduction in new medication orders, order verifications, and pharmacokinetic dosing consults during the study period.
- Pharmacists can continue to play a major role in the review of evidence, dissemination of consensus guidelines, and monitoring for and prevention of adverse drug reactions.

Table 1. Hospital and Pharmacy Variables Impacted by COVID-19 Pandemic

Variable	Prepandemic 2020 (Feb 1-Mar 11)	Pandemic 2020 (Mar 12-Apr 8)	*P* Value
Daily inpatient census, mean (SD)	471 (12)	379 (37)	<0.01
Total daily order verifications, mean (SD)	4,790 (1,074)	3,362 (679)	<0.01
Documented interventions per day, mean (SD)			
Pharmacokinetic dosing	82.1 (10)	66.6 (18)	<0.01
Comprehensive medication review	84.7 (45)	142.3 (86)	<0.01
Medical emergency response	1.8 (1.3)	2.5 (1.4)	0.19
Patient education	14.6 (8)	16.1 (16)	0.70
Multidisciplinary rounds	42.3 (30)	33.1 (18)	0.12
Total	472.6 (171)	455.9 (154)	0.68
Medication daily dispensed, mean (SD) doses			
Propofol (1,000 mg/100 mL)	57.2 (18.8)	184.8 (114.0)	<0.01[a]
Fentanyl (1,000 µg/100 mL)	19.6 (8.1)	95.1 (67.4)	<0.01
Midazolam (100 mg/100 mL)	1.55 (1.6)	7.25 (4.8)	<0.01

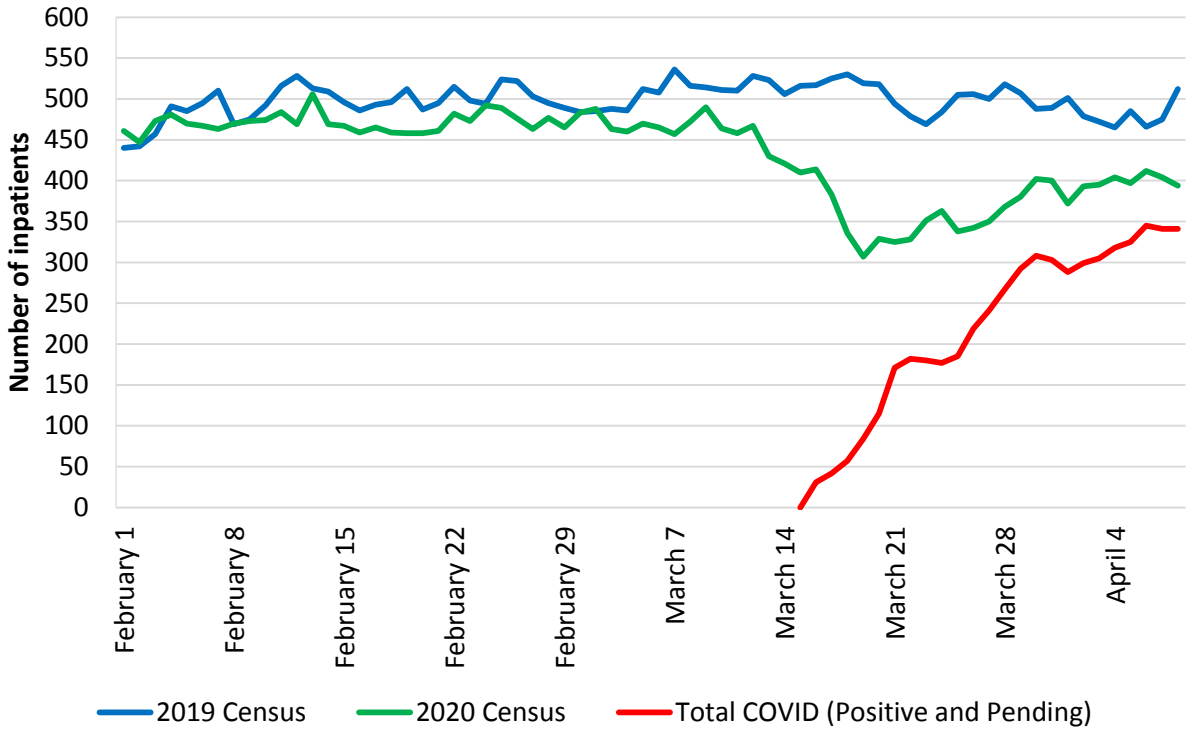
Neuromuscular blockers[b]	46.8 (34.3)	62.3 (45.7)	<0.01
Vasopressin (20 units/100 mL)	7.4 (13.6)	4.9 (13.9)	0.45
Norepinephrine (16 mg/250 mL)	10.7 (11.8)	14.0 (12.2)	0.27
COVID-19 medications[c]	27.7 (8.5)	277.4 (178.6)	<0.01[a]
Enoxaparin (all doses)	49.1 (5.6)	106.4 (66.4)	<0.01[a]

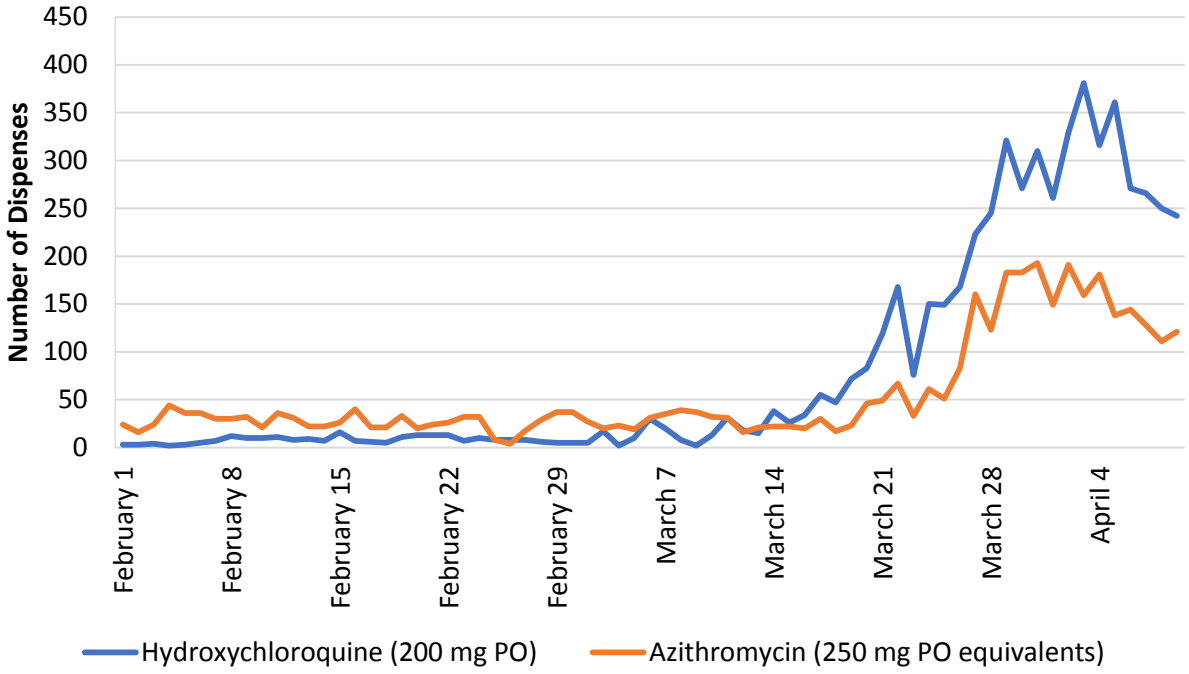
Abbreviation: COVID-19, coronavirus disease 2019.

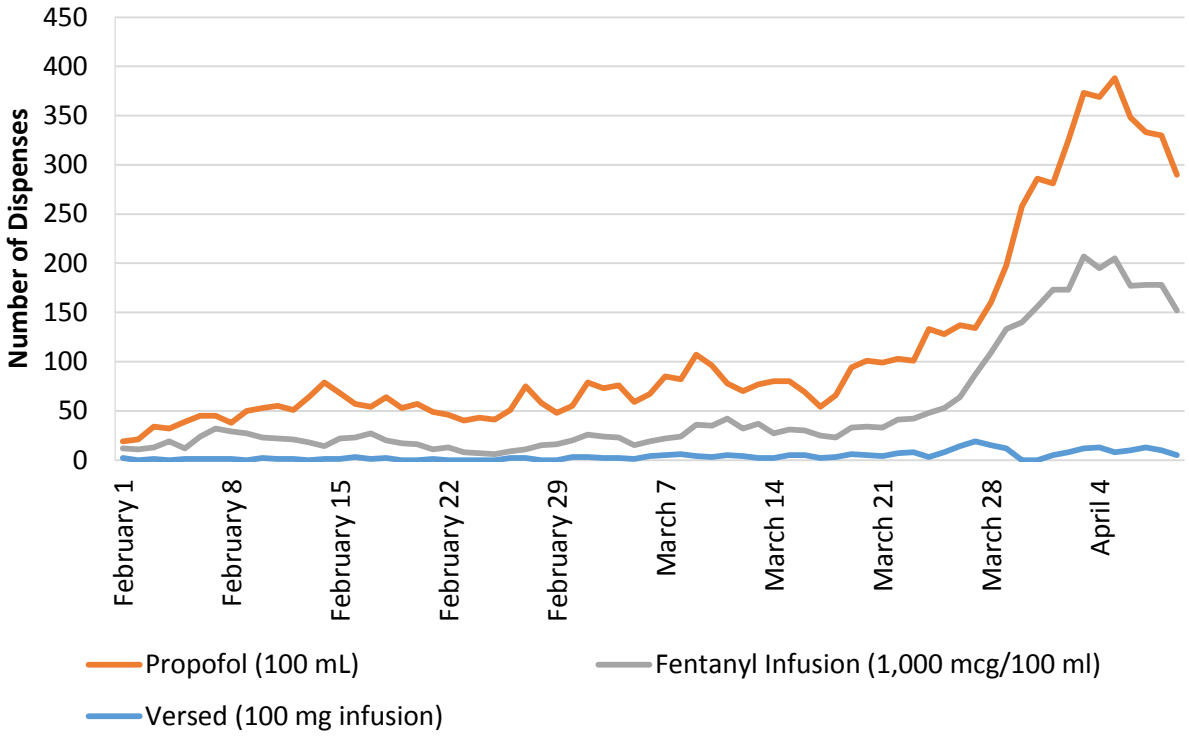
[a]Results verified using Mann-Whitney *U* test for nonparametric distributions.

[b]Neuromuscular blockers consisted of cisatracurium (20-mg vial), rocuronium (50-mg vial), and vecuronium (10-mg vial).

[c]Combined average dispensing of azithromycin (250-mg tablet equivalents) and hydroxychloroquine (200-mg tablets).







[Fig 4A]

Unit	Role	Pharmacist FTEs by Shift		
		Day	Afternoon	Midnight
Centralized	Lead pharmacist	1	0	0
	Order verification	2	3	1
	Medication checking	3	3	1
	Chemotherapy processing	1	1	0
Decentralized	Infusion center	1	1	0
	Emergency department	1	1	
	Operating room	1	1	0
	Generalist services: ICU	2		
	Generalist services: non-ICU	7		
	Specialist services	4	0	
Total		23	9	3

[Fig 4B]

Unit	Role	Pharmacist FTEs by Shift		
		Day	Afternoon	Midnight
Centralized	Lead pharmacist	1	0	0
	Order verification	2	2	1
	Medication checking	4	4	1
	Chemotherapy processing	1	1	0
Decentralized	Infusion center	0	0	0
	Emergency department	1	1	
	Operating room	1	1	0
	Generalist services: ICU	3		
	Generalist services: non-ICU	3		
	Specialist services	2	0	
Total		22	8	3