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The financial impact of COVID-19 on a surgical department: The effects of surgical shutdowns and the impact on a health system

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ABSTRACT

Background: The COVID-19 pandemic resulted in sweeping shutdowns of surgical operations to increase hospital capacity and conserve resources. Our institution, following national and state guidelines, suspended nonessential surgeries from March 16 to May 4, 2020. This study examines the financial impact of this decision on our institution's health system by comparing 2 waves of COVID-19 cases.

Methods: The total revenue was obtained for surgical cases occurring during the first wave of the pandemic between March 1, 2020 and July 31, 2020 and the second wave between October 1, 2020 and February 29, 2021 for all surgical departments. During the same time intervals, in the prepandemic year 2019, total revenue was also obtained for comparison. Net revenue and work relative value units per month were compared to each respective month for all surgical divisions within the department of surgery.

Results: Comparing the 5-month first wave period in 2020 to prepandemic 2019 for all surgical departments, there was a net revenue loss of \$99,674,376, which reflected 42% of the health system's revenue loss during this period. The department of surgery contributed to a net revenue loss of \$58,368,951, which was 24.9% of the health system's revenue loss. Within the department of surgery, there was a significant difference between the net revenue loss per month per division of the first and second wave: first wave median $-\$636,952$ [interquartile range: $-1,432,627$; $26,111$] and second wave median $-\$274,626$ [$-781,124$; $396,570$] ($P = .04$). A similar difference was detected when comparing percent change in work relative value units between the 2 waves (wave 1: median -13.2% [interquartile range: -41.3% , -1.8%], wave 2: median -7.8% [interquartile range: -13.0% , 1.8%], $P = .003$).

Conclusion: Stopping elective surgeries significantly decreased revenue for a health system. Losses for the health system totaled \$234,839,990 during the first wave, with lost surgical revenue comprising 42% of that amount. With elective surgeries continuing during the second wave of COVID-19 cases, the health system losses were substantially lower. The contribution surgery has to a hospital's cash flow is essential in maintaining financial solvency. It is important for hospital systems to develop innovative and alternative solutions to increase capacity, offer comprehensive care to medical and surgical patients, and prevent shutdowns of surgical activity through a pandemic to maintain financial security.

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Introduction

Cases of COVID-19 first emerged in December 2019¹ and rapidly spread across the world, severely impacting human health and hospital financial security. In the United States, the COVID-19 pandemic was declared a national emergency on March 12, 2020.² This resulted in sweeping shutdowns of surgical operations to increase hospital capacity and conserve resources. On March 13, 2020, the American College of Surgeons and Center for Medicare &

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Medicaid Services (CMS) recommended hospitals and surgeons limit elective procedures to decrease viral exposure.^{3,4} Subsequently, on March 17, 2020, CMS issued further guidance on triaging procedures by focusing on medical urgency of the operation, overall health of the patient, and logistical feasibility of performing the operation.⁵ Our institution, following national and state recommendations, suspended nonessential surgeries from March 16 to May 4, 2020. The CMS subsequently released guidelines on May 6, 2020 to allow gradual resumption of elective procedures.

Elective surgery is known to provide substantial margins to a hospital system, accounting for as much as two-thirds of hospital revenue.⁶ During the COVID-19 pandemic, projections and simulations were used to predict the financial impact that halting elective surgeries would have on a hospital system. There is universal agreement that the cancellation of elective surgeries resulted in significant financial losses across all surgical divisions and the entire health system.^{7–11} During the COVID-19 pandemic, surveys of physicians in various surgical departments revealed a decrease in surgical volume, loss of revenue, reduction in operating room capacity, increased use of telehealth, and loss of income.^{12–19} In accordance with the recommended guidelines to suspend elective surgeries, private and university-based surgical specialties detailed their experience. Procedural volume was significantly reduced in gastrointestinal surgery,²⁰ otolaryngology,²¹ hand and microsurgery,²² oral and maxillofacial surgery,²³ radiology,²⁴ and neurosurgery.²⁵

The COVID-19 cases within the state of Pennsylvania (Figure 1)²⁶ and the University of Pennsylvania Health System (UPHS) census (Figure 2) followed a similar pattern with waves of cases rising and declining. The first wave of COVID-19 lasted approximately 5 months, beginning in March 2020 and lasting through July 2020. A similar 5-month period existed for the second wave of local cases, beginning in October 2020 and lasting through February 2021.

The goal of this study was to examine the financial impact during the cessation of elective surgeries, the immediate period after resumption of elective surgeries, and the second wave of COVID without cessation of elective surgeries. We then aimed to look at a similar timeline during the second wave of COVID-19 cases to understand the financial impact of continuing surgeries during a pandemic and its relative effect on safety. To the authors' knowledge, this was the first study looking at the impact of the COVID-19 pandemic on a department of surgery at a large academic institution, with reporting of the real-world financial data.

Methods

This study was granted an exemption from our institutional review board. A review was conducted of financial data from the

Department of Surgery at UPHS during the COVID-19 pandemic. The following 11 divisions were included in our department of surgery: cardiovascular surgery, colon and rectal surgery, endocrine and oncologic surgery, general surgery, gastrointestinal (GI) surgery, plastic surgery, thoracic surgery, transplant surgery, trauma, urology, and vascular surgery. Four additional surgical departments were included in the revenue loss analysis: neurosurgery, orthopedic surgery, otorhinolaryngology, and oral maxillofacial surgery.

The “first wave” of local COVID-19 cases was defined as March 1, 2020 through July 31, 2020, and the “second wave” of cases was from October 1, 2020 to February 29, 2021. The UPHS Department of Surgery revenue and work relative value units (wRVUs) during the first and second wave were compared to the same period from the year before: March 1, 2019 through July 31, 2019 for the first wave and October 1, 2019 through February 29, 2020 for the second wave.

Hospital census/decay rates

A prospectively maintained hospital census was maintained throughout the pandemic for the 3 major hospitals of UPHS. Decay rates were calculated for each wave at each hospital using linear regression analysis to assess whether the rate of decline of cases differed during each wave.

Revenue

The net revenue data were retrieved from the Epic Electronic Health Record Clarity data model, specifically the OpTime module for surgeries performed in a hospital operating room. These data were retrieved on September 10, 2021. This allowed for >6 months of collections for surgical revenue from the last surgical cases included. The following criteria were used:

1. Only the 3 major UPHS-associated city hospitals were included: Hospital of the University of Pennsylvania, Penn Presbyterian Medical Center, and Pennsylvania Hospital.
2. Excluded were all diagnostic procedures such as scopes, cardiac catheterizations, or diagnostic studies that may have been scheduled using the OpTime system and any nonsurgical procedures.
3. The hospital accounts from the resulting data set after applying the filters above were retrieved. These accounts were used to retrieve the financial information from each hospital encounter tied to the operating room trip.
4. Because there is often >1 operating room trip(s) tied to a single hospital encounter relationship, the first operating room event

New reported cases

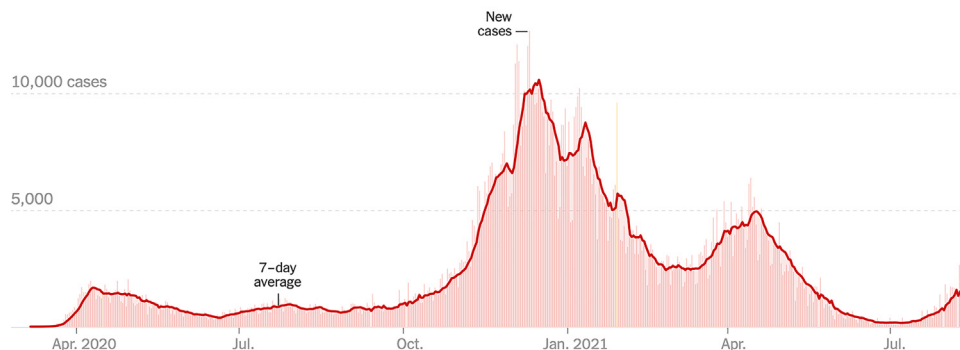


Figure 1. New reported COVID-19 cases in Pennsylvania.

UPHS COVID Confirmed Inpatient Census

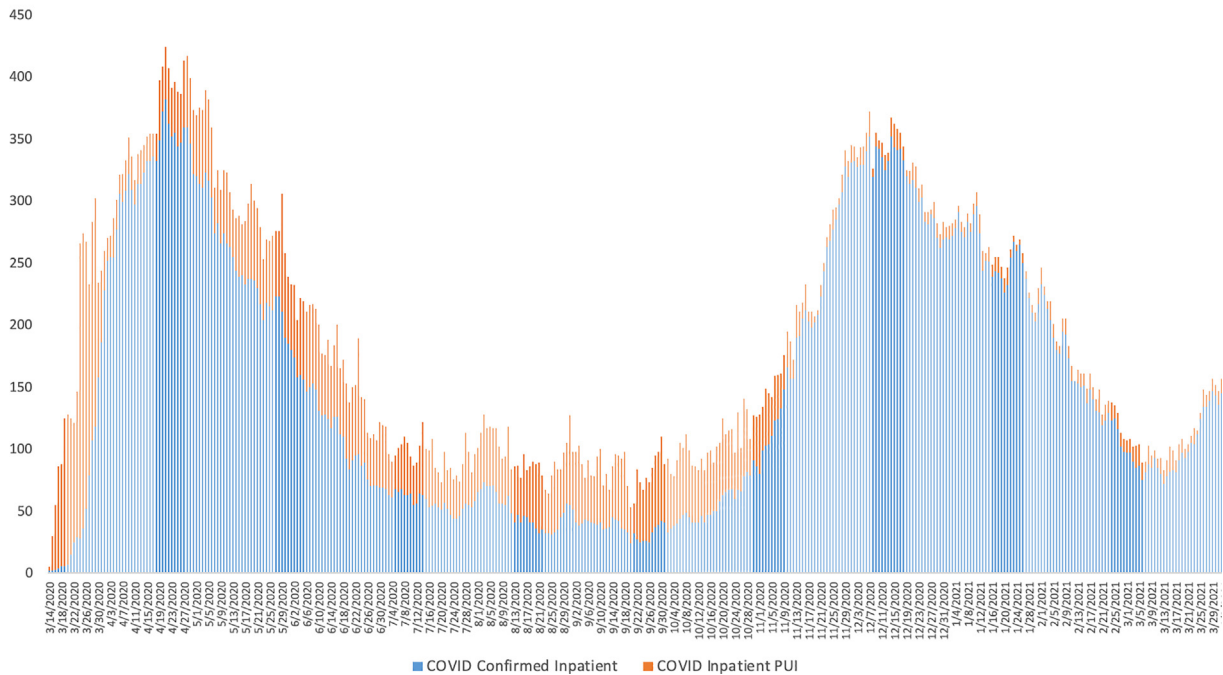


Figure 2. COVID-19 inpatient census at the University of Pennsylvania Health System. *PUI*, persons under investigation; *UPHS*, University of Pennsylvania Health System

within any hospital encounter was selected to attribute the hospital financials to only 1 surgeon and avoid duplication or attribution of monetary amounts.

5. The hospital encounters include both inpatient and outpatient (same-day surgery) types.
6. All financial information relates only to the hospital component (technical), and no professional components were included.
7. Revenue generated during each month of the first and second wave was calculated and compared to the prior year.

wRVUs

Similar to the criteria used for revenue data collection, using Vizient (Irving, TX), the wRVUs were calculated per surgeon per division within the department of surgery during the first and second wave and compared to the respective time intervals from the prior year.

Statistical analysis

Standard descriptive statistics were used to represent differences in hospital revenue and wRVUs. To determine if there were significant differences in revenue due to the pandemic, Wilcoxon signed-rank tests were used to compare division revenue to the prior year for the first and second wave of the pandemic. Wilcoxon signed-rank tests were also used to assess differences in revenue on a month-to-month basis during the 2 waves of the pandemic compared to the year before. Wilcoxon rank-sum tests were used to compare if net differences in revenue and percentage change in revenue were significantly different between the 2 waves of the pandemic when compared to the prior year. Significance was set at a 2-tailed P value $< .05$, and all analyses were conducted using RStudio (Boston, MA).

Results

The hospital percent census curve followed a similar pattern to the state of Pennsylvania's new reported cases; however, the higher case numbers in Pennsylvania during the second wave did not cause a significantly higher peak in the hospital census (Figures 1 and 2). The decay rates calculated during the first wave (Figure 3) and second wave (Figure 4) revealed an overall similar rate of decay, with 1 hospital having a faster decay rate during the first wave and the other 2 hospitals having faster decay rates during the second wave.

All surgical departments had a significant impact on the health system revenue loss. Over the 5-month first wave period, comparing 2020 relative to 2019, there was a net revenue loss of \$99,674,376, which reflected 42% of the health system's revenue loss during the period. In descending order of net revenue loss during this period, the department of surgery had the greatest loss at \$58,368,951 (25% of the health system's total loss), followed by orthopedic surgery at \$17,545,464, neurosurgery at \$13,046,397, otorhinolaryngology at \$8,596,801, and oral maxillofacial surgery at \$2,116,763.

Within the department of surgery, there was a significant difference between the net revenue loss per month per division when comparing the first and second wave: first wave median $-\$636,952$ [IQR $-1,432,627$; 26,111] and second wave median $-\$274,626$ [$-781,124$; 396,570] ($P = .04$). Similarly, there was a significant difference in percent change in revenue between the first and second wave when compared to the corresponding months from the prior year (first wave: -20.1% [-36 , 0.6%], second wave -7.8% [-17 , 7.1%]; $P = .009$).

In paired comparison, there was a significant difference in revenue between the 2 years for the first wave ($P < .001$), but no significant difference when comparing net revenue between corresponding months during the second wave ($P = .10$). The first wave month-to-month pairwise signed-rank test demonstrated a

Decay from First Peak

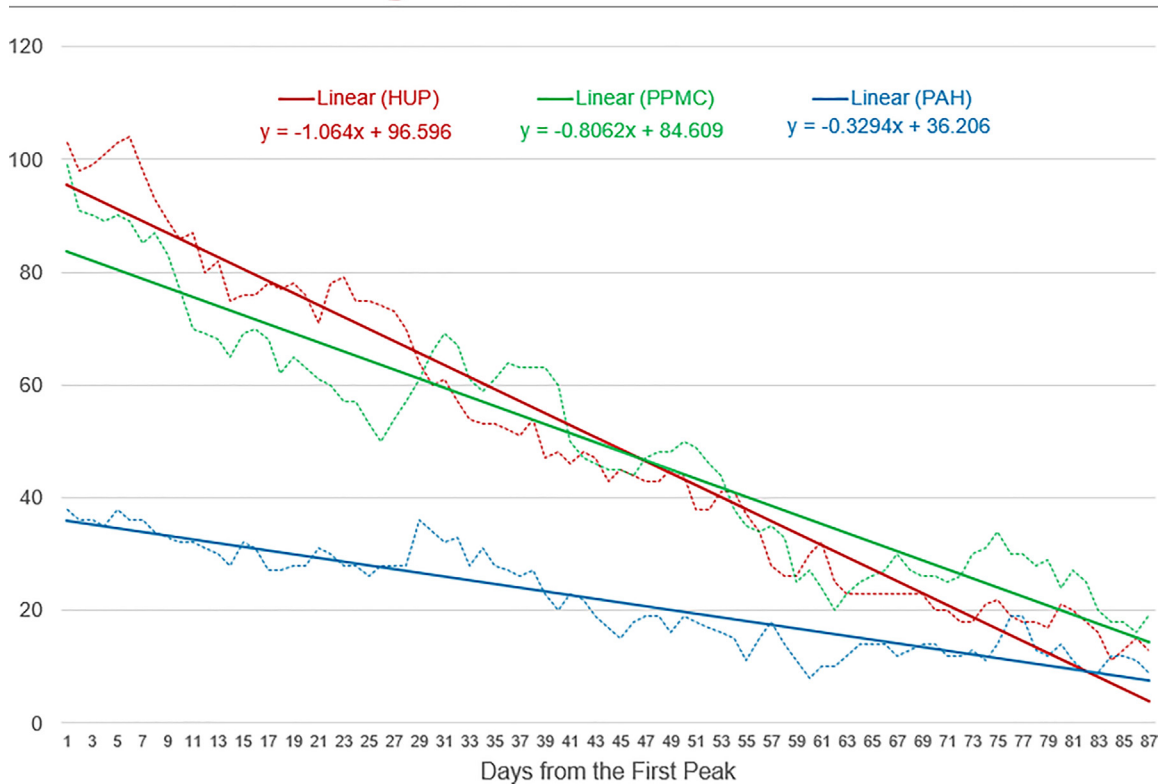


Figure 3. Rate of decay of COVID-19 cases after the first peak.

significant difference in net revenue during the months involved in the elective surgery shutdown: March ($-\$16,274,906$ $P = .009$), April ($-\$26,013,896$, $P = .03$), and May ($-\$20,889,403$, $P = .01$). There was no significant difference for the subsequent months of June ($\$6,108,420$, $P = .47$) and July ($-\$1,299,166$, $P = .65$). During the second wave, there was no significant difference between the respective months (all $P > .05$). Tables I and II reveal the overall trend of the change in revenue during the first and second wave relative to the respective months from the prior year.

Changes in wRVUs were also compared between the first and second wave of the pandemic. There was a significant difference in change in wRVUs between the first and second waves of the pandemic when compared to the corresponding month from the previous year (wave 1: median -834 [IQR: $-2,237$, -128], wave 2: median -47 [IQR: -969 , 126], $P = .004$) (Tables III and IV). A similar difference was detected when comparing percent change in wRVUs between the 2 waves, compared to the corresponding month from the previous year (wave 1: median -13.2% [IQR: -41.3% , -1.8%], wave 2: median -7.8% [IQR: -13.0% , 1.8%], $P = .003$). Figures 5 and 6 depict the overall trends of this percent change during each wave. The changes in wRVU were also compared between the various divisions in the department of surgery. Cardiac surgery had the greatest median drop in overall wRVUs ($-1,902$ [IQR: $-5,030$, $-1,136$]), whereas vascular surgery had the greatest median percentage decrease in wRVUs (-28.8% [IQR: -48.3% , -15.4%]); however, the differences for change in wRVUs and percentage difference between divisions were not significant ($P = .44$, $P = .92$, respectively). Similarly, there was no difference in net change in wRVUs and percentage change in wRVUs between the divisions in the second wave ($P = .21$, $P = .24$, respectively).

Discussion

In this study, we took the most comprehensive look at the financial impact that COVID-19 had on a surgical department, in addition to an in-depth look into how the pandemic affected various surgical subspecialties. As a result of the pandemic, hospital systems across the country were forced to completely halt or significantly curtail elective surgery. This decision had significant financial implications for surgery departments and hospital systems at large. However, no prior studies have quantified the financial effects that this policy and the pandemic had on surgery departments and health systems at large.

Suspending surgeries during the COVID-19 pandemic has resulted in significant financial strain for hospital systems. Despite the $\$178$ billion provided to hospitals and health care providers through the Coronavirus Aid, Relief, and Security Act (CARES Act), hospitals have been forced to reduce employee compensation, furlough staff, delay patient care, and even shut down entirely in some cases.²⁷ At our system, total losses were found to total $\$234,839,990$, with lost surgical revenue comprising 42% of that amount. Although our hospital system received funding from the CARES Act to help offset the significant loss in revenue, it did not replace an equal amount of the lost funds from surgical revenue. It is clear from this that the department of surgery has a critical role in providing cash flow and maintaining hospital solvency. Therefore, developing innovative and alternative solutions to increase capacity and to maintain comprehensive care to medical and surgical patients should be a priority for health systems going forward.

With continued community spread of COVID-19 cases with new COVID variants emerging, it is critical for health systems to recognize the financial ramifications that suspending elective surgery

Decay from Second Peak

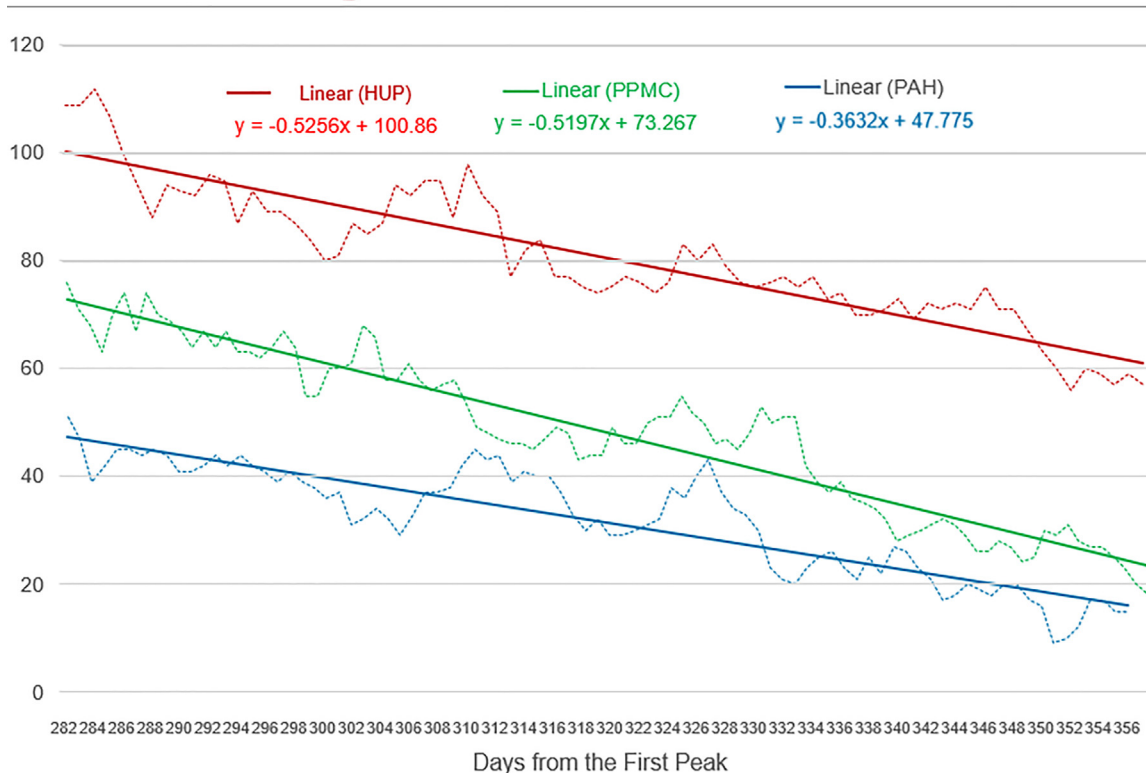


Figure 4. Rate of decay of COVID-19 cases after the second peak.

Table 1

Net change in revenue per month comparing 2020 relative to 2019 (first wave)

Division	March	April	May	June	July	5-mo total
Cardiovascular surgery	-\$7,274,791.00	-\$11,429,163.00	-\$11,892,665.00	\$3,425,953.00	-\$508,708.00	-\$27,679,374.00
Colorectal	-\$168,929.00	-\$1,301,235.00	-\$1,175,486.00	-\$5,968.00	-\$784,081.00	-\$3,435,699.00
Surgical oncology	-\$422,448.00	-\$2,168,337.00	-\$1,698,540.00	\$485,852.00	-\$316,060.00	-\$4,119,533.00
Plastic surgery	-\$304,423.00	-\$1,959,591.00	-\$873,069.00	\$7,554.00	\$728,592.00	-\$2,400,937.00
General surgery	-\$1,432,627.00	-\$609,895.00	\$316,675.00	-\$759,506.00	-\$406,461.00	-\$2,891,814.00
GI surgery	-\$1,309,378.00	-\$1,286,308.00	\$141,567.00	\$2,483,930.00	\$760,482.00	\$790,293.00
Thoracic	\$757,539.00	-\$924,318.00	\$650,630.00	-\$589,560.00	\$340,426.00	\$234,717.00
Transplant	-\$1,250,319.00	-\$5,633,557.00	-\$1,715,591.00	\$1,406,930.00	-\$636,952.00	-\$7,829,489.00
Trauma	-\$2,109,950.00	\$3,253,503.00	-\$1,601,741.00	-\$256,400.00	\$933,985.00	\$219,397.00
Urology	-\$1,519,333.00	-\$2,573,884.00	-\$1,338,136.00	-\$116,476.00	-\$23,952.00	-\$5,571,781.00
Vascular	-\$1,240,247.00	-\$1,381,111.00	-\$1,703,047.00	\$26,111.00	-\$1,386,437.00	-\$5,684,731.00
Total	-\$16,274,906.00	-\$26,013,896.00	-\$20,889,403.00	\$6,108,420.00	-\$1,299,166.00	-\$58,368,951.00

GI, gastrointestinal.

has on hospital operations, especially without federal assistance. Continuing with surgeries is paramount to future hospital survival but should only be performed while providing optimal patient care. Therefore, it is important for hospital systems to develop protocols to safely allow surgeries to proceed during a pandemic. The American College of Surgeons provided an elective surgery acuity scale to assess the urgency of surgery.⁵ Many hospital systems created similar scales modified to their patient population to resume surgeries safely and efficiently. National and international collaborations have provided recommendations on the best practice to manage surgical patients during the COVID-19 pandemic.²⁸ Al-Shamsi et al described the growing evidence that cancer patients were at a higher risk of COVID-19 infection than noncancer patients, suggesting an important role for telemedicine to limit

clinic visits and proper timing for workup and treatment of patients.²⁹ Similar evidence described guidelines for safely managing patients requiring emergency surgery.^{30,31} A health care system generates revenue through several domains with elective surgeries as one of the most significant contributors.⁶ This financial transparency in the study undermines the impact of canceling elective surgery during the first wave, but also provides a justification for multidisciplinary efforts to continue elective surgery, as it led to significantly reduced losses during the second wave.

The continuation of elective surgeries is paramount to hospital survival and ultimate patient care during a pandemic; therefore, it is important for hospital systems to develop innovative solutions to increase capacity to account for treating patients with COVID-19 and patients undergoing urgent and elective surgery. Various

Table II
Net change in revenue per month comparing 2020/2021 relative to 2019/2020 (second wave)

Division	October	November	December	January	February	5-mo total
Cardiovascular surgery	\$568,274.00	\$5,344,253.00	−\$5,596,730.00	−\$4,686,219.00	\$1,313,166.00	−\$3,057,256.00
Colorectal	−\$198,754.00	−\$682,230.00	−\$575,876.00	−\$230,358.00	−\$125,376.00	−\$1,812,594.00
Surgical oncology	\$156,199.00	−\$526,369.00	−\$556,120.00	−\$812,909.00	−\$149,629.00	−\$1,888,828.00
Plastic surgery	−\$607,490.00	−\$274,626.00	−\$972,549.00	−\$191,364.00	−\$63,419.00	−\$2,109,448.00
General surgery	\$3,427,462.00	\$1,299,650.00	\$1,102,154.00	\$1,062,078.00	\$2,675,690.00	\$9,567,034.00
GI surgery	−\$523,042.00	\$102,722.00	−\$497,742.00	−\$1,394,149.00	−\$840,233.00	−\$3,152,444.00
Thoracic	−\$419,854.00	−\$289,909.00	\$225,549.00	\$1,089,419.00	−\$305,271.00	\$299,934.00
Transplant	−\$1,191,899.00	−\$1,804,011.00	−\$827,464.00	−\$2,900,088.00	\$12,618.00	−\$6,710,844.00
Trauma	−\$552,234.00	\$585,004.00	\$2,393,267.00	−\$2,535,271.00	−\$2,892,087.00	−\$3,001,321.00
Urology	\$105,617.00	−\$8,433.00	\$396,570.00	−\$371,383.00	−\$272,121.00	−\$149,750.00
Vascular	\$660,958.00	−\$444,840.00	−\$781,124.00	−\$1,483,627.00	\$1,497,147.00	−\$551,486.00
Total	\$1,425,237.00	\$3,301,211.00	−\$5,690,065.00	−\$12,453,871.00	\$850,485.00	−\$12,567,003.00

GI, gastrointestinal.

Table III
Change in work relative value units comparing 2020 relative to 2019 (first wave)

Division	March	April	May	June	July	5-mo average
Cardiac surgery	−1,854.48	−9,322.08	−5,030.15	−1,950.45	427.15	−3,546.00
Colon and rectal Surgery	−119.32	−2,600.35	−2,157.71	−68.85	−134.64	−1,016.17
Endocrine and oncologic surgery	−137.12	−4,116.97	−4,055.84	55.27	214.67	−1,608.00
GI surgery	−2,211.28	−7,550.06	−3,924.06	−62.11	−121.75	−2,773.85
Plastic surgery	−959.12	−7,767.53	−4,500.19	−522.86	−199.74	−2,789.89
Thoracic surgery	200.83	−847.32	−1,445.07	−673.97	81.31	−536.84
Transplant	87.90	−1,860.96	−1,725.84	−284.09	−429.62	−842.52
Trauma	−820.70	−2,023.95	−2,883.81	579.73	−764.50	−1,182.65
Urology	−3,856.39	−9,760.10	−3,696.02	−643.77	−457.57	−3,682.77
Vascular surgery	−1,163.57	−2,728.05	−2,262.90	−1,469.82	−669.33	−1,658.73
Total	−10,833.25	−48,577.37	−31,681.59	−5,040.92	−2,054.02	−19,637.43

GI, gastrointestinal.

Table IV
Change in work relative value units comparing 2020/2021 relative to 2019/2020 (second wave)

Division	October	November	December	January	February	5-mo average
Cardiac surgery	1,107.86	1,411.16	−965.53	−135.17	−1,017.09	80.25
Colon and rectal Surgery	−356.84	−4,195.41	69.04	−706.25	206.54	−996.58
Endocrine and oncologic surgery	−446.47	−382.76	126.48	−1,514.97	−117.21	−466.99
GI surgery	−1,198.19	−468.15	−403.46	−1,472.30	−1,099.45	−928.31
Plastic surgery	884.78	−1,287.12	−1,101.59	−2,242.91	120.79	−725.21
Thoracic surgery	−476.35	−380.68	126.16	672.11	−536.94	−119.14
Transplant	−636.28	443.34	−529.90	−2,083.87	1,506.59	−260.02
Trauma	2,361.74	1,746.03	1,627.25	−795.98	778.12	1,143.43
Urology	−980.87	−968.64	104.81	−1,139.09	−689.56	−734.67
Vascular surgery	−364.44	−616.76	−567.40	−423.04	−588.33	−511.99
Total	−105.06	−4,698.99	−1,514.14	−9,841.47	−1,436.54	−3,519.24

GI, gastrointestinal.

steps can be taken to facilitate the continuation of elective surgeries safely. Health care employees can be used in transferrable roles to assist with similar clinical responsibilities. Independent contractors should be considered to plan for employee staffing shortages secondary to illness. Infrastructure capacity should be broadened to increase the use of overflow areas or other space not previously used for clinical purposes. At our institution, we used preoperative and postoperative bays for elective surgery patients because our surgical floors were used for COVID patient care. In the United Kingdom, the National Health Service advised on the creation of surgical hubs to increase surgical capacity.³² Hospital rooms that could be transitioned to negative pressure rooms underwent the

appropriate renovations. Patient and staff safety should be prioritized while continuing surgery through preoperative COVID-19 testing, employee symptom screening, and mandatory masking. Although no measure can wholly prevent transmission of COVID-19, these strategies can significantly reduce risk to patients and staff while enabling surgeries to proceed as scheduled.

In our local community, the number of new COVID-19 cases at the peak of the second wave in the state of Pennsylvania was nearly 4 times the number of new cases during the first wave peak. Despite the higher number of cases within our state and performing all types of surgeries (elective and nonelective) during the second wave, the hospital census and decay rates were relatively

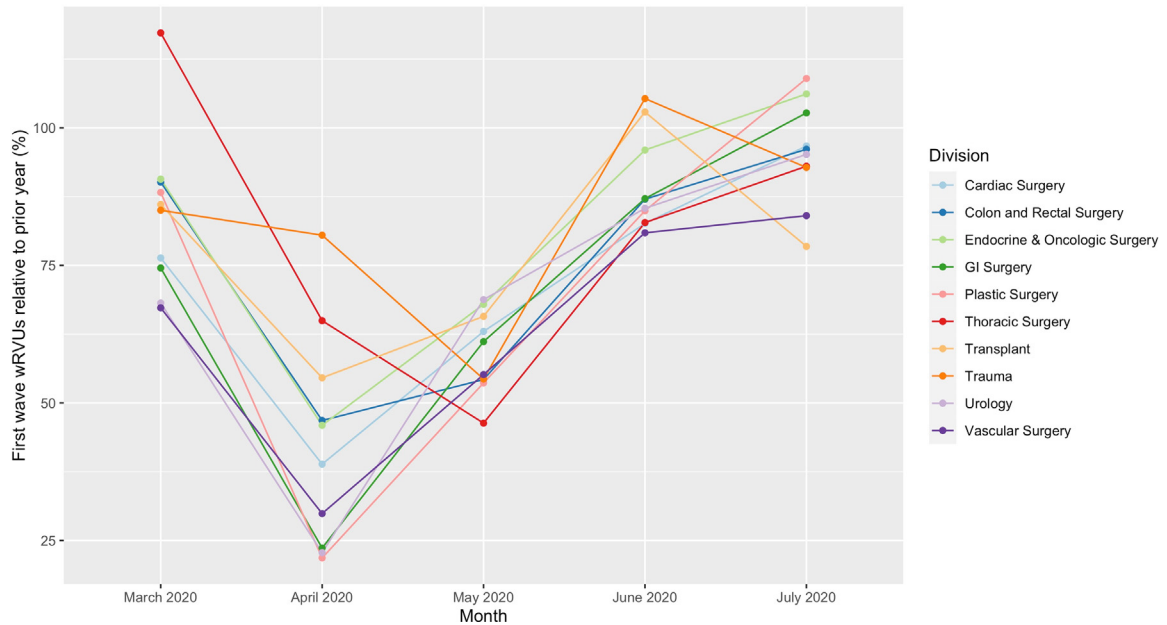


Figure 5. 2020 wRVUs relative to 2019 showing the financial impact of COVID-19 first wave. GI, gastrointestinal.

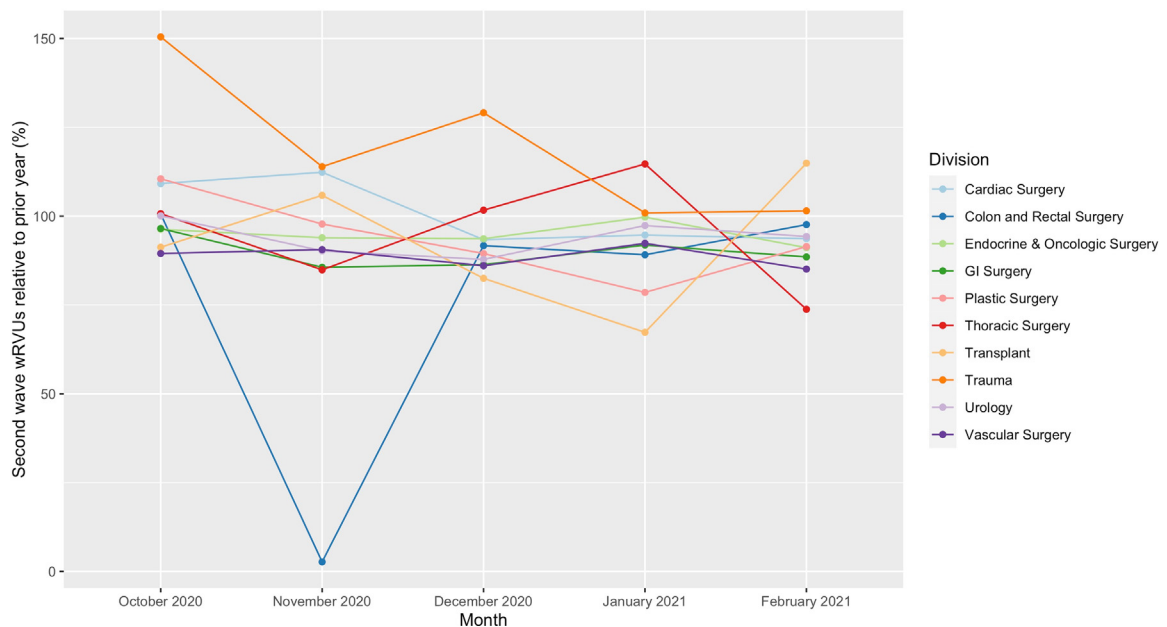


Figure 6. 2020 wRVUs relative to 2019 showing the financial impact of COVID-19 second wave. GI, gastrointestinal.

similar between the 2 waves. There is no single causative reason that increased community cases did not have a proportional increase in hospital COVID-19 census. The unpredictable outbreak during the first wave made it difficult for hospitals to plan with no precedent in the modern era. After weeks of planning and instituting mask mandates, social distancing, preprocedural COVID-19 testing, exposure and temperature screening at hospital entrances, increased hospital capacity, and sufficient personal protective equipment were used in the second wave. Outpatient and “drive-up” COVID-19 testing centers were available during the second wave. Additional testing on medically stable patients likely

contributed to the increase in state cases during the second wave but a disproportional change in hospital COVID-19 patients. Our institution also began telemedicine appointments to evaluate patients with newly diagnosed COVID-19 to triage their medical stability and determine the acuity of care required. However, these reasons alone do not independently explain the large difference between the significantly higher number of cases in the second wave of state cases compared to the hospital census.

There were several limitations within this study. Because this was a retrospective study analyzing the financial impact of a single health system within a single city, these findings may not be

generalizable to other hospital systems in the United States, and especially not in health systems outside of the United States. Each hospital system's cash flow varies by patient population and payer mix. Two separate 5-month windows were used to represent the first and second waves of COVID-19 cases. These months were compared to the respective months from the prior year to control for case volume over a given year; however, several limitations remained with using this method. By using the months from the previous year as a baseline reference, various changes remained between years, including surgeons leaving, new hires, vacation, time away during a pandemic, and new family responsibilities—especially with childcare because children were not allowed to attend school. Although these 2 waves were selected because they followed a similar trend, the 2 waves had several differences that potentially confounded our results: the number of COVID-19 cases within our state varied highly between the 2 waves (Figure 1), our hospital census reached a similar peak, but the rate of case rise and decline differed (Figure 2), and the 2 rates of decay within our hospital system also differed. In addition, there were cancellations of surgical cases due to preprocedural positive COVID-19 testing results. Because this testing was performed with 2 days before surgery, it was unlikely to fill that surgical time with another case and ultimately resulted in lower surgical productivity than the respective months from the previous year. Our financial reporting system, Vizient, is unable to search for canceled cases; therefore, we were unable to identify lost productivity due to preprocedural testing. Situations such as this present an opportunity where physicians can consider a patient waitlist that can be filled pending case cancellations. The wRVUs for colorectal surgery in November 2021 were not appropriately represented due to an abnormally low operative volume because of other academic engagements for surgeons or staff. Also, when comparing each divisions' percent change of wRVUs for every month, a similar pattern of financial loss was found for each specialty, but no significance was found likely due to insufficient power. Finally, it often takes months for a hospital system to obtain surgical collections and, ultimately, surgical revenue data. For this reason, we waited for 6 months (Sep 10, 2021) after our last surgical case (Feb 28, 2021) during the second wave to pull our revenue data. It is possible that all our surgical case collections were not obtained within that timeframe and therefore may suggest our second wave revenue is lower than actual.

In conclusion, stopping elective surgeries significantly decreased revenue for a health system. Losses for the health system totaled \$234,839,990 during the first wave, with lost surgical revenue comprising 42% of that amount. With elective surgeries continuing during the second wave of COVID-19 cases, the health system losses were significantly lower. The contribution surgery has to a hospital's cash flow is essential in maintaining financial security. It is important for hospital systems to think of innovative and alternative solutions to increase capacity, offer comprehensive care to medical and surgical patients, and prevent shutdowns of surgical activity through a pandemic to maintain financial security.

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References

- Wang C, Horby PW, Hayden FG, et al. A novel coronavirus outbreak of global health concern. *Lancet (London, England)*. 2020;395:470–473.
- Federal Emergency Management Agency. COVID-19 emergency declaration; 2020. <https://www.fema.gov/news-release/20200726/covid-19-emergency-declaration>. Accessed April 14, 2020.
- American College of Surgeons. COVID-19: recommendations for management of elective surgical procedures; 2020. <https://www.facs.org/covid-19/clinical-guidance/elective-surgery>. Accessed April 25, 2020.
- Centers for Medicare and Medicaid Services. Non-emergent, elective medical services, and treatment recommendations; 2020. <https://www.cms.gov/files/document/cms-non-emergent-elective-medical-recommendations.pdf>. Accessed April 7, 2020.
- American College of Surgeons. COVID-19: guidance for triage of non-emergent surgical procedures; 2020. <https://www.facs.org/covid-19/clinical-guidance/triage>. Accessed May 5, 2020.
- Jackson RL. The business of surgery: managing the OR as a profit center requires more than just IT—it requires a profit-making mindset, too. *Health Manag Technol*. 2002;23:20–22.
- Tonna JE, Hanson HA, Cohan JN, et al. Balancing revenue generation with capacity generation: case distribution, financial impact and hospital capacity changes from cancelling or resuming elective surgeries in the US during COVID-19. *BMC Health Serv Res*. 2020;20:1119.
- COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br J Surg*. 2020;107:1440–1449.
- Bedard NA, Elkins JM, Brown TS. Effect of COVID-19 on hip and knee arthroplasty surgical volume in the United States. *J Arthroplasty*. 2020;35:S45–S48.
- Bose SK, Dasani S, Roberts SE, et al. The cost of quarantine: projecting the financial impact of canceled elective surgery on the nation's hospitals. *Ann Surg*. 2021;273:844–849.
- Martin BI, Brodke DS, Wilson FA, et al. The impact of halting elective admissions in anticipation of a demand surge due to the coronavirus pandemic (COVID-19). *Med Care*. 2021;59:213–219.
- Stöß C, Steffani M, Kohlhaw K, et al. The COVID-19 pandemic: impact on surgical departments of non-university hospitals. *BMC Surg*. 2020;20:313.
- Haffer H, Schömig F, Rickert M, et al. Impact of the COVID-19 pandemic on orthopaedic and trauma surgery in university hospitals in Germany: results of a nationwide survey. *J Bone Joint Surg Am*. 2020;102:e78.
- Paul KD, Levitt E, McGwin G, et al. COVID-19 impact on orthopedic surgeons: elective procedures, telehealth, and income. *South Med J*. 2021;114:311–316.
- Sarac BA, Schoenbrunner AR, Wilson SC, et al. The impact of COVID-19-based suspension of surgeries on plastic surgery practices: a survey of ACAPS members. *Plast Reconstr Surg Glob Open*. 2020;8:e3119.
- Crowley JS, Reghunathan M, Kadakia N, et al. Financial decisions and reopening a practice during the COVID-19 pandemic: a survey of California plastic surgeons. *Ann Plast Surg*. 2021;86:S354–S359.
- Teoh JY-C, Ong WLK, Gonzalez-Padilla D, et al. A global survey on the impact of COVID-19 on urological services. *Eur Urol*. 2020;78:265–275.
- Malgor RD, Sobreira ML, Mouawad NJ, et al. Brazilian vascular surgeons experience during the coronavirus (COVID-19) pandemic. *Vascular*. 2021;29:451–460.
- Mouawad NJ, Woo K, Malgor RD, et al. The impact of the COVID-19 pandemic on vascular surgery practice in the United States. *J Vasc Surg*. 2021;73:772.e4–779.e4.
- Purdy AC, Smith BR, Hohmann SF, Nguyen NT. The impact of the novel coronavirus pandemic on gastrointestinal operative volume in the United States. *Surg Endosc*. 2022;36:1943–1949.
- Fan T, Workman AD, Miller LE, et al. The impact of COVID-19 on otolaryngology community practice in Massachusetts. *Otolaryngol Neck Surg*. 2021;165:424–430.
- Leti Acciaro A, Montanari S, Venturilli M, Starnoni M, Adani R. Retrospective study in clinical governance and financing system impacts of the COVID-19 pandemic in the hand surgery and microsurgery HUB center. *Musculoskelet Surg*. 2022;106:291–296.
- Pu JJ, McGrath CP, Leung YY, et al. The impact of coronavirus disease 2019 on the disease pattern of oral and maxillofacial surgery inpatients: a comparative study. *Front Med*. 2021;8:613663.
- Parikh KD, Ramaiya NH, Kikano EG, et al. COVID-19 pandemic impact on decreased imaging utilization: a single institutional experience. *Acad Radiol*. 2020;27:1204–1213.

25. Sivakanthan S, Pan J, Kim L, et al. Economic impact of COVID-19 on a high-volume academic neurosurgical practice. *World Neurosurg.* 2020;143: e561–e566.
26. New York Times. New reported cases; 2021. <https://www.nytimes.com/interactive/2021/us/pennsylvania-covid-cases.html>. Accessed August 14, 2021.
27. US Department of Health and Human Services. CARES Act Provider Relief Fund. <https://www.hrsa.gov/provider-relief>. Accessed April 14, 2020.
28. Spolverato G, Capelli G, Restivo A, et al. The management of surgical patients during the coronavirus disease 2019 (COVID-19) pandemic. *Surgery.* 2020;168: 4–10.
29. Al-Shamsi HO, Alhazzani W, Alhurajji A, et al. A Practical approach to the management of cancer patients during the novel coronavirus disease 2019 (COVID-19) pandemic: an international collaborative group. *Oncologist.* 2020;25:e936–e945.
30. De Simone B, Chouillard E, Sartelli M, et al. The management of surgical patients in the emergency setting during COVID-19 pandemic: the WSES position paper. *World J Emerg Surg.* 2021;16:14.
31. American College of Surgeons. COVID-19 guidelines for triage of emergency general surgery patients; 2020. <https://www.facs.org/covid-19/clinical-guidance/elective-case/emergency-surgery>. Accessed July 15, 2021.
32. National Health Service. Delivery plan for tackling the COVID-19 backlog of elective care; 2020. <https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2022/02/C1466-delivery-plan-for-tackling-the-covid-19-backlog-of-elective-care.pdf>. Accessed July 10, 2022.