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RESEARCH ARTICLE

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Surgical Site Infections in patients undergoing major oncological surgery during the COVID-19 paNdemic (SCION): A propensity-matched analysis

Gouri Pantvaidya MS[1] | Shalaka Joshi MCh, MRes[1] | Prakash Nayak MS[1] | Sadhana Kannan MSc (Biostatistics)[2] | Ashwin DeSouza MCh[1] | Pabashi Poddar MCh[1] | Gagan Prakash MCh[1] | Preeti Vijaykumaran MCh[1] | Deepa Nair MS[1] | Richa Vaish MCh[1] | Shraddha Patkar MCh[1] | Devayani Niyogi MCh[1] | Poonam Joshi MS[1] | Vikram Chaudhari MS, DNB[1] | Vikas Singh MCh[1] | Saumya Mathews MCh[1] | C. S. Pramesh MS[1] | Rajendra A. Badwe MS[1] | Ajay Puri MS[1]

[1]Department of Surgery, Tata Memorial Hospital and Homi Bhabha National Institute, Mumbai, India

[2]Clinical Research Secreteriat, Advanced Centre for Treatment, Research and Education in Cancer, Mumbai, India

Correspondence
Shalaka Joshi, Department of Surgery, Tata Memorial Hospital and Homi Bhabha National Institute, Mumbai 400012, India.
Email: drjoshishalaka@gmail.com

Abstract

Background and Objectives: There are reports of outcomes of elective major cancer surgery during the COVID-19 pandemic. We evaluated if reinforcement of hand hygiene, universal masking, and distancing as a part of pandemic precautions led to a decrease in the incidence of surgical site infections (SSIs) in major oncologic resections.

Methods: Propensity score matching using the nearest neighbor algorithm was performed on 3123 patients over seven covariates (age, comorbidities, surgery duration, prior treatment, disease stage, reconstruction, and surgical wound type) yielding 2614 matched (pre-COVID 1612 and COVID 1002) patients. Conditional logistic regression was used to identify if SSI incidence was lower amongst patients operated during the pandemic.

Results: There was a 4.2% ($p = 0.006$) decrease in SSI in patients operated during the pandemic. On multivariate regression, surgery during the COVID-19 period (odds ratio [OR] = 0.77; 95% confidence interval [CI] = 0.61–0.98; $p = 0.03$), prior chemoradiation (OR = 2.46; CI = 1.45–4.17; $p < 0.001$), duration of surgery >4 h (OR = 2.17; 95%CI = 1.55–3.05; $p < 0.001$) and clean contaminated wounds (OR = 2.50; 95% CI = 1.09–2.18; $p = 0.012$) were significantly associated with SSI.

Conclusion: Increased compliance with hand hygiene, near-universal mask usage, and social distancing during the COVID-19 pandemic possibly led to a 23% decreased odds of SSI in major oncologic resections. Extending these low-cost interventions in the post-pandemic era can decrease morbidity associated with SSI in cancer surgery.

KEYWORDS
COVID-19 pandemic, oncologic surgery, propensity score matching, surgical site infection

1 | INTRODUCTION

Surgical site infections (SSIs) contribute to significant morbidity in patients undergoing surgery. They increase hospital stay and overall costs of treatment. The direct costs incurred by patients having SSI have been quoted to be approximately two times the costs of an inpatient without SSI.[1] Appropriate hand hygiene principles and reinforcement of sterility practices during in-hospital care have always been the bedrock that has helped surgical departments across various specialties reduce their incidence of SSI. The global pandemic caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) necessitated a rapid change of practice in hospitals to protect health care workers and patients to minimize the exposure and the transmission of the virus while continuing to offer "emergency" care and ensuring resources were available to treat the sudden influx of COVID-19 patients.

The first case of the COVID-19 pandemic was reported in India on January 27, 2020.[2] Being a tertiary oncology center, at our hospital, we continued to provide cancer care and perform oncologic surgeries throughout the pandemic. Even though logistic constraints did result in a relative reduction in numbers as part of the COVID-19 pandemic strategy, we recommended and reinforced extended compulsory hand hygiene for all patients, staff, and caregivers across the hospital.[3] We also instituted social distancing and minimized visitors to prevent the transmission of the virus within the hospital.

We hypothesized that strict implementation and repeated reinforcement of these principles during the pandemic, which included increased universal hand sanitization among surgeons, paramedical staff, patients and their caregivers, near-universal usage of masks, and restriction of crowds in the outpatient departments and inpatient wards may have resulted in an overall decrease in the rate of SSIs after cancer surgery.

To validate this hypothesis, we decided to analyze our SSI incidence during the pandemic and perform a matched comparison to a surgical cohort in a non-COVID-19 era.

2 | METHODS

2.1 | Study design

This study was initiated after Institutional Review Board approval. The study was initiated after registration with the Clinical Trials Registry of India (CTRI/2020/08/027210). It was a retrospective analysis of prospectively maintained surgical data across various specialized surgical oncology units such as head neck, breast, gynecology, thoracic, GI, bone and soft tissue, neurosurgery, and urology. Data were retrieved for two time periods: Cohort A (pre-COVID cohort) comprised of patients operated in the pre-COVID period which was from October to December 2019 and Cohort B (COVID cohort) included patients undergoing surgery during the COVID-19 pandemic, from April to June 2020. All patients undergoing elective oncologic surgeries during these two time periods were included. Patients undergoing emergency procedures and surgeries for infected wounds like wound wash, lavage, and debridement were excluded from the study.

The primary objective of the study was to assess if there was a decreased incidence of SSI in patients undergoing surgery during the COVID-19 pandemic as compared to those who had surgery in the pre-COVID era. We also tried to identify other factors affecting SSI for patients undergoing oncologic surgery.

Demographic data were collected for site of cancer, risk factors for SSI, previous oncologic treatment, details of surgical procedures, COVID-19 testing, and 30-day SSI. Data were obtained from prospectively maintained databases and from hospital electronic medical records. Surgical wounds are routinely classified as clean, clean contaminated, contaminated, and dirty as per the CDC criteria for the classification of surgical wounds and the diagnosis of an SSI and its classification into superficial incisional, deep incisional, and organ space infection was as per the CDC procedure associated module SSI 2020.[4] When feasible, wound swabs were sent for culture and sensitivity testing in patients with suspected SSI. All SSIs were further graded as per the Clavien and Dindo classification.[5] Patients in both cohorts were followed up as per routine follow-up schedules and data were included till 30 days from the date of surgery. There were no changes made in the follow-up schedules for patients operated during the pandemic. The 30-day mortality was also documented.

Depending upon the type and duration of surgery, the antibiotic policy differed in each of the specialty surgical units. However, it was consistent during the two time periods and there was no change instituted in antibiotic policy during the COVID-19 pandemic. Any change in the antibiotic used or prolonged duration for an individual patient was done at the discretion of the treating unit and depended on the occurrence of SSI and/or other systemic infections. Data on change in antibiotic usage and/or prolonged duration were collected for the two data sets. There were no changes in departmental policy on skin/bowel preparation, glycaemic control, wound coverage, or wound handling during the two study periods.

2.2 | Statistical analysis

Baseline clinicopathologic characteristics of the two cohorts were reported as numbers and percentages. The propensity scores for each group were estimated using logistic regression. Factors for matching were jointly decided by the investigators before collation of data in the two cohorts based on available literature regarding factors affecting SSI and likely disparity in the two cohorts. Seven covariates were considered for matching: age, comorbidities (diabetes mellitus ± renal disorders vs. other comorbidities vs. none), duration of surgery (<4 h, 4–8 h, >8 h), previous oncologic treatment (yes vs. no), type of surgical wounds (clean, clean contaminated, contaminated), stage of disease (early vs. advanced vs. NA), use of reconstruction (yes vs. no). These were used in the logistic regression model for calculating the propensity score. Previous oncologic treatment was considered as positive if the patient had received any form or combination of surgery, chemotherapy, or radiation therapy within 1 year of the current date of surgery. Reconstruction was a combination of microvascular, pedicle, or local flaps where applicable. Factors for PSM were selected a priori by the team of co-investigators, to balance the possible bias of operating patients with early stage tumors, and lesser comorbidities during the COVID-19 pandemic, which would in turn affect the incidence of SSI.

A simple nearest neighbor matching algorithm was used to achieve the best covariate balance after matching, using a caliper of 0.2. Matched data were obtained in a ratio of at least 1 (Cohort B):2(Cohort A). The overall propensity score distribution between the groups was assessed by a Jitter plot (Figure 1A). The standardized mean difference (SMD) is the difference in the proportion or means of each covariate between the two cohorts standardized by a standardization factor so that it is on the same scale for all covariates. SMDs close to zero indicate good balance. Kernel density plots were used to represent standardized differences before and after matching (Figure 1B). SMDs before and after matching for each covariate were represented using a Love Plot (Figure 1C).

Univariate conditional logistic regression was used to identify factors predicting SSI after obtaining a matched data using propensity score matching (PSM). All factors significant at $p < 0.05$ were considered for multivariate conditional logistic regression. Effect estimated was represented using odds ratio (OR) along with 95% confidence interval (CI). All statistical analysis was done using SPSS R Plugins in SPSS ver21 for Windows (SPSS Inc) and STATA 14.0. All p-values (two-sided) less than 0.05 were regarded as statistically significant.

3 | RESULTS

A total of 3123 patients (Cohort A = 2121, Cohort B = 1002) satisfied the inclusion criteria and were analyzed in the study. After matching for the predetermined factors, the post-matching data set

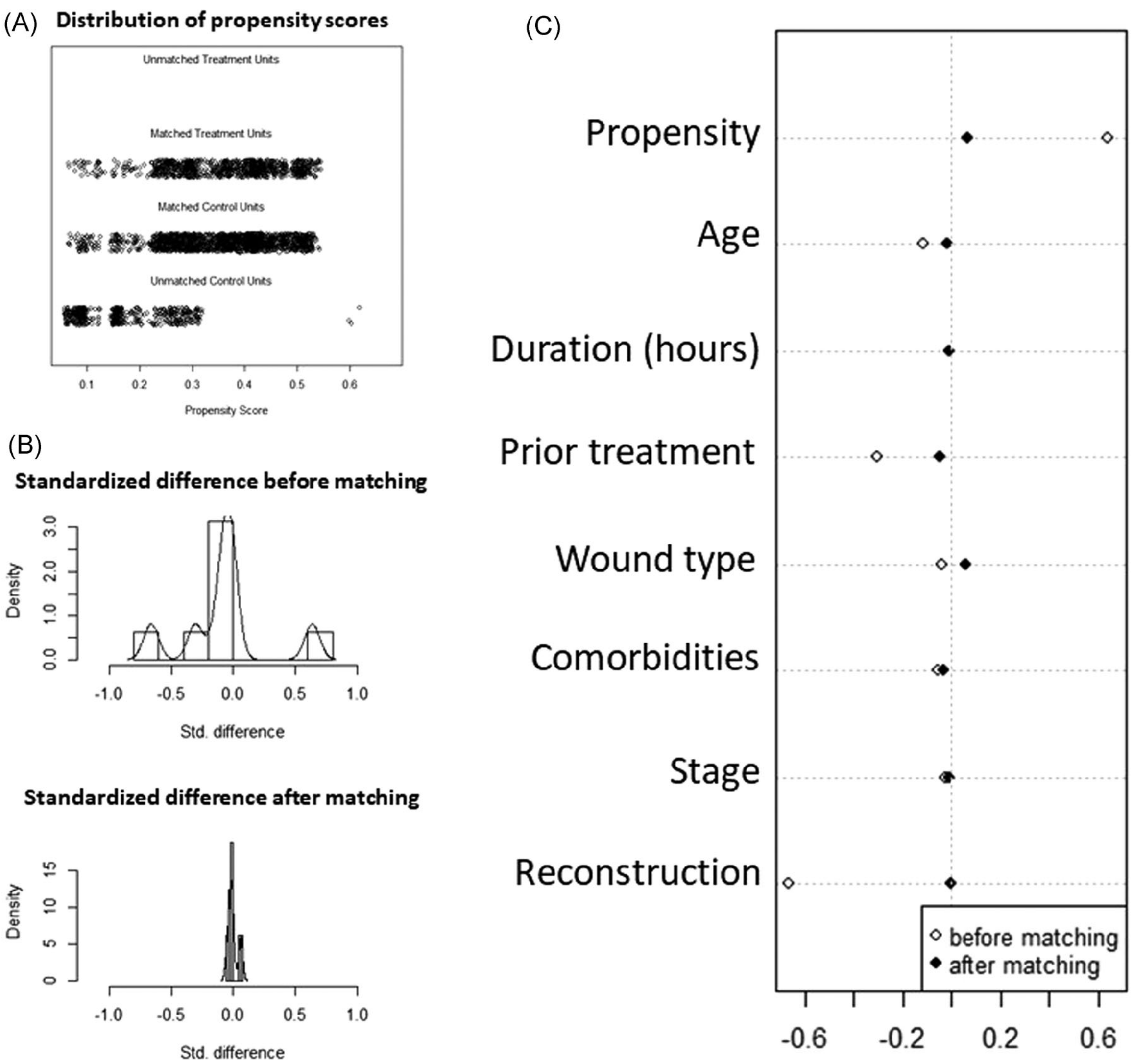

FIGURE 1 Methodology of propensity score matching (A) Jitter plot showing distribution of propensity scores, (B) Kernel Plot, and (C) Love plot for demonstrating absolute standardized differences before and after matching

constituted of 2614 patients (Cohort A = 1612, Cohort B = 1002). All further results are reported in the post-matched cohort of 2614 patients. The median age in both groups was 48 years. The maximum number of patients belonged to breast (781/2614, 29.9%), head and neck (709/2614, 27.12%), and gastrointestinal (GI; 338/2614, 12.9%) surgical oncology units. Of the patients undergoing GI surgeries, colorectal surgeries, hepatobiliary surgery, and upper GI and pancreatic surgery constituted 44.7% (151/338), 36.7% (124/338), and 18.6% (63/338) of the resections 42.2% were males and 57.8% were females. Approximately 20% of patients had reconstructive surgery along with oncological surgery (23.4% in the pre-COVID and 19.4% in the COVID era). In the COVID cohort, out of 1002 patients, 521 (51.9%) had previous chemotherapy ± radiotherapy before surgery whereas 438/1002 patients (43.8%) had no prior treatment and 43 (4.3%) patients had previous surgery. In the pre-COVID cohort, out of 1612 patients, 650 (40.3%) had previous chemotherapy ± radiotherapy before surgery; 862 (53.5%) had no prior treatment and 100 (6.2%) had prior surgery. The incidence of diabetes mellitus was 13.1% (211/1612) and 11.2% (112/1002) whereas the incidence of other comorbidities mainly hypertension, bronchial asthma, and cardiac disorder was 23.8% (383/1612) and 22.9% (229/1002) respectively in Cohorts A and B, respectively. Patients underwent resections for advanced-stage cancers in 55% and 61.6% patients in Cohorts A and B, respectively. Further details of demographic details of the two cohorts, before and after matching are given in Table 1. Of the seven factors used for matching, comorbidities and duration of surgery were matched perfectly with a non-significant p-value in the postmatched Cohort B whereas factors such as stage of disease, reconstruction, prior treatment were matched to the best of ability. A non-intentional selection bias for surgery of patients with a higher stage due to lockdown related travel restrictions and less use of reconstruction as triaging in the times of reduced operating room availability during the pandemic could be responsible for this. (Table 1).

The average blood loss in the two cohorts was 375 and 400 ml, respectively. The average hospital stay was 8.2 days in both cohorts. Prophylactic COVID testing before surgery was done in 74% of patients in Cohort B. Only eight of the patients operated in the study period had suffered COVID-19 infection and these patients underwent surgery only after two subsequent negative swabs, as per institutional policy. The average length of stay was 8 days in both cohorts. The 30-day mortality in the entire data set was 0.9% (26/2614), being 1.1% and 0.7% in Cohorts A and B, respectively (p = 0.42). SSI was documented in 10 patients (6—Cohort A, 4—Cohort B) before death.

3.1 | Change in antibiotic policy

There was no significant change in antibiotic usage policy in the two study cohorts with 320 (19.8%) patients in Cohort A versus 181 (18%) in Cohort B patients having either a prolongation or change in antibiotic usage. This was not statistically significant (p = 0.28).

3.2 | SSI rates

The incidence of SSI in the combined cohorts was 18.4%. This included superficial, deep space, and organ space infections. The incidence was 20.1% for Cohort A and 15.9% for Cohort B. There was a 4.2% (p = 0.006) decrease in the rate of SSI in patients who underwent surgery during the pandemic. Of the SSI, 51% were superficial (251/483) and the rest were a combination of deep and organ space infections. There was a statistically significant decrease in the incidence of superficial SSI (p = 0.003) as compared to deep SSI (p = 0.294) or organ space SSI (p = 0.52). Clavien and Dindo grades I–IIIA constituted 78% of the SSI in the overall data set. A detailed description of the SSI subtypes and the Clavien and Dindo grading in the two study cohorts is shown in Table 2.

Wound swabs were sent for culture and sensitivity testing in 75% of the patients with SSI. Cultures were sent in 91% (181/198) of patients with deep space infections and in 37 of the 38 patients with organ space infections.

3.3 | Univariate and multivariate analysis of factors affecting SSI

A conditional logistic regression analysis was done on the matched cohort to identify factors predicting SSIs. Univariate analysis showed that surgery during the COVID-19 period was associated with decreased incidence of SSI (OR = 0.79; 95% CI = 0.64–0.98; p = 0.034). Other factors like prior CT ± RT (OR = 2.86; 95% CI = 1.79–4.56; p < 0.001), duration of surgery >4 h (OR = 6.17; 95% CI = 3.76–10.14; p < 0.001) and clean contaminated surgical wounds (OR = 2.3; 95% CI = 1.7–3.02; p < 0.001) were significantly associated with higher incidence of SSI (Table 3). On multivariate analysis, surgery in COVID cohort (OR = 0.77; 95% CI = 0.61–0.98; p = 0.03), prior CT ± RT (OR = 2.46; 95% CI = 1.45–4.17; p < 0.001), longer duration of surgery (OR = 2.17; 95% CI = 1.55–3.05; p < 0.001], clean contaminated wound type (OR = 2.50; 95% CI = 1.09–2.18; p = 0.012) were significantly associated with SSI (Table 4).

4 | DISCUSSION

The COVID-19 pandemic made surgical departments across the globe evolve and implement new policies to enable social distancing, universal use of face masks, and stricter hand hygiene to tackle spread of the SARS COV-2 virus among health care personnel and patients. Similar policies were instituted at our center to reduce the spread of the virus. To validate our hypothesis that the stricter implementation and repeated reinforcement of these policies during the pandemic may have resulted in an overall decrease in the rate of SSI after cancer surgery, we compared two cohorts of patients. To mitigate selection bias in an observational study, that any difference in SSI between the two cohorts could be attributed to less intensive cases and patients with lesser comorbidity being operated during the COVID-19

TABLE 1 Demographic profile of patients before and after propensity score matching

Clinico-pathological Characteristics	Before propensity score matching: Cohort A (Pre-COVID), *N* = 2121 (%)	Cohort B (COVID), *N* = 1002 (%)	*p* (chi-square)	After propensity score matching: Cohort A (Pre-COVID), *N* = 1612 (%)	Cohort B (COVID), *N* = 1002 (%)	*p* (chi-square)
Primary site						
Breast	473 (22.3)	339 (33.7)	<0.001	442 (27.4)	339 (33.7)	<0.001
Head and neck	555 (26.2)	216 (21.6)		493 (30.6)	216 (21.6)	
GI	401 (18.9)	182 (18.2)		156 (9.7)	182 (18.2)	
Bone and soft tissue	148 (7)	73 (7.3)		131 (8.2)	73 (7.3)	
Thoracic	107 (5)	54 (5.4)		87 (5.4)	54 (5.4)	
Urology	146 (6.9)	51 (5.1)		82 (5)	51 (5.1)	
Gynaecology	192 (9.1)	70 (7)		179 (11.1)	70 (7)	
Central nervous system[a]	99 (4.6)	17 (1.7)		42 (2.6)	17 (1.7)	
Age						
Median	49	48	–	48	48	–
Gender						
Male	1005 (47.4)	402 (40.1)	<0.001	702 (43.6)	402 (40.1)	0.08
Female	1116 (52.6)	600 (59.9)		910 (56.4)	600 (59.9)	
Previous treatment						
Surgery alone	167 (7.8)	43 (4.3)	<0.001	100 (6.2)	43 (4.3)	<0.001
CT ± RT	755 (35.6)	521 (51.9)		650 (40.3)	521 (51.9)	
None	1199 (56.6)	438 (43.8)		862 (53.5)	438 (43.8)	
Albumin (g/dl)						
<3 g/dl	35 (1.7)	25 (2.5)	0.108	25 (1.6)	25 (2.5)	0.087
≥3 g/dl	2082 (98.2)	975 (97.3)		1583 (98.2)	975 (97.3)	
Not done	4 (0.1)	2 (0.2)		4 (0.2)	2 (0.2)	
Hemoglobin (g/dl)						
Median	12	12	–	12	12	–
Comorbidities						
DM ± renal disorders	370 (17.4)	112 (11.2)	<0.001	211 (13.1)	112 (11.2)	0.263
Others	518 (24.4)	229 (22.9)		383 (23.8)	229 (22.9)	
None	1233 (58.2)	661 (65.9)		1018 (63.1)	661 (65.9)	
ASA grading						
I–II	2034 (95.9)	973 (97.1)	0.096	1557 (96.9)	973 (97.1)	0.466
III–IV	87 (4.1)	29 (2.9)		55 (3.4)	29 (2.9)	
BMI						
<20	371 (17.5)	191 (19.1)	0.002	288 (17.9)	191 (19.1)	0.039
20–25	934 (44)	469 (46.8)		711 (44.1)	469 (46.8)	
25–30	589 (27.9)	278 (27.7)		456 (28.2)	278 (27.7)	
>30	213 (10)	58 (5.8)		146 (9.1)	58 (5.8)	
NK[b]	14 (0.6)	6 (0.6)		11 (0.7)	06 (0.6)	

(Continues)

TABLE 1 (Continued)

Clinico-pathological Characteristics	Before propensity score matching			After propensity score matching		
	Cohort A (Pre-COVID), *N* = 2121 (%)	Cohort B (COVID), *N* = 1002 (%)	*p* (chi-square)	Cohort A (Pre-COVID), *N* = 1612 (%)	Cohort B (COVID), *N* = 1002 (%)	*p* (chi-square)
Stage						
Early	800 (37.7)	346 (34.5)	<0.001	650 (40.3)	346 (34.5)	0.004
Advanced	1140 (53.7)	617 (61.6)		887 (55)	617 (61.6)	
NK/NA[b,c]	181 (8.4)	39 (3.9)		75 (4.7)	39 (3.9)	
Surgery access						
Open	1925 (90.8)	906 (90.4)	0.760	1524 (94.5)	906 (90.4)	<0.001
Minimally invasive	196 (88.7)	96 (9.6)		88 (5.5)	96 (9.6)	
Duration (h)						
<4	1249 (58.9)	641 (63.9)	0.019	1007 (62.5)	641 (63.9)	0.175
4–8	731 (34.5)	309 (30.9)		492 (30.5)	309 (30.9)	
>8	141 (6.6)	52 (5.2)		113 (7)	52 (5.2)	
Reconstruction						
Yes	431 (20.3)	194 (19.4)	<0.001	378 (23.4)	194 (19.4)	<0.01
No	1283 (60.5)	765 (76.3)		1144 (70.9)	765 (76.3)	
NA[c]	407 (19.2)	43 (4.3)		90 (5.7)	43 (4.3)	
Surgical implants						
Yes	98 (4.6)	56 (5.6)	0.243	93 (5.8)	56 (5.6)	0.847
No	2023 (95.4)	946 (94.4)		1519 (94.2)	946 (94.4)	
Wound type						
Clean	1122 (52.9)	545 (54.4)	0.15	910 (56.5)	545 (54.4)	0.081
Clean contaminated	992 (46.8)	457 (45.6)		696 (43.2)	457 (45.6)	
Contaminated	7 (0.3)	0 (0)		6 (0.3)	0 (0)	

Abbreviations: CT, chemotherapy; DM, diabetes mellitus; RT, radiotherapy.

[a]CNS tumors were not staged.

[b]NK – not known.

[c]NA – not available.

pandemic, we used PSM for the cohorts. A propensity-matched analysis can decrease the effects of confounding factors because of differences in baseline characteristics when comparing two cohorts in observational studies.[6] In our study, propensity scores were defined as the conditional probability of a patient receiving reinforced extended hygiene practices during the pandemic, given a set of observed covariates/factors that were matched between the two cohorts.

Using PSM, our study demonstrates a 23% odds of reduction in SSI and a 4.2% absolute reduction in the incidence of SSI in patients who underwent surgery during the COVID-19 pandemic as compared to those who had surgery in the pre-COVID times. There was a significant reduction of superficial incisional SSI as compared to deep or organ space SSI. Although data derived from observational studies cannot confirm direct causation, it would be reasonable to assume that a stricter implementation of extended hand hygiene, social distancing, and near-universal use of face masks in all personnel involved in patient care helped in decreasing the incidence of SSIs during the pandemic. Similar reductions noted in other studies for hospital-acquired respiratory infections and influenza spread during the COVID-19 pandemic have also been attributed to pandemic mitigation measures like increased hand hygiene, physical distancing, and use of personal protective equipment implemented by governments and hospitals.[7–10] There is limited literature available on the decrease in incidence of SSI during the COVID-19 pandemic and aside from our present study, we found only one other study by Losurdo et al.[11] that documented SSI during the COVID-19 lockdown in a general surgical unit in Italy and compared it to a pre lockdown cohort. Like the findings of our study, they found a significant decrease in superficial and deep SSIs in patients undergoing general surgical procedures during the lockdown as compared to a pre-lockdown cohort.[11]

TABLE 2 Incidence and grading of SSI

SSI	Cohort A (%)	Cohort B (%)
Incidence	324/1612 (20.1)	159/1002 (15.9)
SSI type		
Superficial	176 (10.9)	75 (7.5)
Deep	129 (8)	69 (6.9)
Organ space	18 (1.1)	14 (1.4)
NK[a]	1 (0.1)	1 (0.1)
Clavien–Dindo grade		
I	38 (2.4)	17 (1.7)
II	135 (8.3)	63 (6.3)
IIIA	72 (4.5)	53 (5.3)
IIIB	62 (3.8)	20 (2)
IVA	5 (0.3)	2 (0.2)
IVB	0 (0)	1 (0.1)
V	2 (0.2)	3 (0.3)
NK[a]	10 (0.6)	0 (0)

Abbreviation: SSI, surgical site infection.
[a]NK – not known.

SSI rates for patients undergoing oncologic surgeries have a wide range reported between 1.4% and 38%, depending upon the type of surgical wounds, prior treatment received, various comorbidities, and the site involved.[12–20] Our cohort constituted a population of patients undergoing major elective surgery for various primary cancers with the largest sites being breast, head and neck, and GI malignancies. Covariates that could be considered as risk factors for SSI were well matched between the two cohorts and present in a majority of our patients. About 50% of our patients had received either chemotherapy ± radiation or had undergone a previous surgical procedure before the current surgical procedure. Locally advanced tumors accounted for 57% of patients in the entire cohort (55% in Cohort A and 62% in Cohort B). Most resections were open surgeries (92%) as the largest sites were breast and head and neck cancers. Only 56% of our patients had clean wounds (56% in Cohort A and 54% in Cohort B). About 37% of our patients had surgery that extended >4 h (38% in Cohort A and 36% in Cohort B). Our overall incidence of SSI of 20% and 15.9% in Cohorts A and B, respectively, is within the accepted norms for patients undergoing major cancer surgery.[12–20]

This analysis which included a large cohort of patients also provided an opportunity to identify additional factors impacting SSI in patients undergoing major oncologic procedures. Prior treatment with chemotherapy, radiotherapy, or surgery was an independent predictive factor for developing SSI. Previous studies have documented discordant data, with some studies demonstrating a positive correlation[13,16,19,21,22] and some demonstrating a negative correlation.[18,23,24] Longer duration of surgery and clean-contaminated wounds are well-documented predictors of increased SSIs and were significantly associated with increased SSI in our study as well.[19,22,25] Only 0.2% (6 out of 2614) patients in our entire cohort had contaminated wounds, precluding any meaningful conclusion regarding the effect of contaminated wounds on SSI. Similar to some other studies, we could not demonstrate any significant correlation of SSI with increasing age, decreasing values of albumin or hemoglobin, presence of comorbidities like diabetes or renal disorders or use of orthopedic surgical implants.[18,22,24,26]

TABLE 3 Univariate conditional logistic regression analysis of factors affecting SSI

Characteristic	OR (95% CI)	*p*
Age	1.01 (0.99–1.01)	0.085
Surgery cohort		
Cohort B		
Cohort A	0.79 (0.64–0.98)	0.034
Prior treatment		
None		
Only surgery	0.43 (0.2–0.9)	0.02
CT ± RT	2.86 (1.79–4.56)	0.000
Albumin	0.62 (0.96–1.03)	0.969
Hemoglobin	0.99 (0.26–1.46)	0.281
Comorbidities		
Diabetes ± renal		
Other comorbidities	1.33 (0.89–1.97)	0.15
No comorbidities	0.99 (0.73–1.34)	0.96
ASA grading	1.14 (0.63–2.04)	0.65
Surgery access	1.76 (0.91–3.42)	0.09
Duration		
<4 h		
4–8 h	2.73 (2.03–3.67)	0.000
>8 h	6.17 (3.76–10.14)	0.000
Surgical implants	0.61 (0.36–1.03)	0.066
Wound type		
Clean		
Clean contaminated	2.3 (1.7–3.02)	0.000
Contaminated	0.65 (0.05–8.2)	0.7

Note: Age: continuous variable; Surgery Cohort: Cohort A (pre-COVID-19) versus Cohort B (COVID-19); Previous treatment: Chemotherapy ± radiotherapy versus Only Surgery versus No treatment; Albumin: preoperative albumin < 3 mg/dl versus ≥3 mg/dl; Hemoglobin: continuous variable in g/dl; Comorbidities: Diabetes mellitus± Renal disorders versus Other comorbidities versus none; ASA Grading: I–II versus III–IV; Surgery Access: Minimally invasive versus open access; Duration of surgery: <4 h versus 4–8 h versus >8 h; Surgical implants: yes versus No; Wound Type: clean versus clean contaminated versus contaminated.
Abbreviations: CI, confidence interval; CT, chemotherapy; OR, odds ratio; RT, radiotherapy; SSI, surgical site infection.

TABLE 4 Multivariate conditional logistic regression analysis of factors affecting SSI

Characteristic	OR (95% CI)	p
Surgery cohort		
Cohort B		
Cohort A	0.77 (0.61–0.98)	0.03
Prior treatment		
None		
Only surgery	0.42 (0.19–0.91)	0.03
CT ± RT	2.46 (1.45–4.17)	0.001
Duration		
<4 h		
4–8 h	2.17 (1.55–3.05)	0.000
>8 h	3.94 (2.26–6.84)	0.000
Wound type		
Clean		
Clean contaminated	2.50 (1.09–2.18)	0.012
Contaminated	0.51 (0.04–6.57)	0.61

Note: Surgery Cohort: Cohort A (preCOVID-19) versus Cohort B (COVID-19); Prior treatment: Chemotherapy ± radiotherapy versus Only surgery versus No treatment; Duration of surgery: <4 h versus 4–8 h versus >8 h; Wound Type: clean versus clean contaminated versus contaminated.

Abbreviations: CI, confidence interval; CT, chemotherapy; OR, odds ratio; RT, radiotherapy; SSI, surgical site infection.

One of the main limitations of our study is its retrospective nature. However, a propensity-matched analysis helped reduce bias in our retrospective study, especially when randomization was not feasible. Another potential limitation is a heterogeneous population of different organ sites of cancers. However, matching for factors like type of surgical wounds (clean, clean contaminated, contaminated), duration of surgery, and need for reconstruction reduces this heterogeneity of varying cancer sites.

The strength of this study is that it is a single institution cohort with large numbers. Positive wound cultures documented SSI in three-fourths of our patients. All the patients were operated by the same group of surgeons and were operated on during a relatively short time period of nine months thus reducing bias due to differences in surgical skill, technique, protocols followed, and changes in infrastructure or health policy other than those for the COVID-19 pandemic.

5 | CONCLUSION

We documented a 23% reduction in the odds of developing SSI in major elective oncologic surgeries during the COVID-19 pandemic. This is most likely due to better implementation of hand hygiene, near-universal use of masks, and physical distancing by doctors, paramedical staff, patients, and caregivers. Although a direct causal link cannot be confirmed by our observational study, reinforcement of hand hygiene and other practices which are implementable interventions without major additional costs or increase in infrastructure, merit attention by surgical departments globally as they may help decrease morbidity after major oncologic procedures.

AUTHOR CONTRIBUTIONS

The study was conceptualized by Gouri Pantvaidya, Ajay Puri, and designed by all authors together. Each author contributed to data collection. Statistical designing and analysis were carried out by Gouri Pantvaidya, Shalaka Joshi, Prakash Nayak, and Sadhana Kannan with consensus from all other authors. Gouri Pantvaidya, Shalaka Joshi, Prakash Nayak, Sadhana Kannan, and Ajay Puri contributed to manuscript writing. The manuscript was read, suggestions were provided, and approved by all authors.

DATA AVAILABILITY STATEMENT

Data can be made available at request.

ORCID

Shalaka Joshi http://orcid.org/0000-0003-3813-4680
Prakash Nayak http://orcid.org/0000-0002-8385-2836
Gagan Prakash http://orcid.org/0000-0003-1722-4337
Shraddha Patkar http://orcid.org/0000-0001-8489-6825
Devayani Niyogi http://orcid.org/0000-0002-9767-3046
Ajay Puri http://orcid.org/0000-0002-4323-753X

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