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**Impact of the pandemic on surgical oncology in Piedmont, Italy: a retrospective observational study**

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*Data availability*

Raw and anonymised data will be made available from the corresponding author on reasonable request.

**Abstract**

*Background and Methods*

This retrospective observational study analyzes how the COVID-19 pandemic affected surgical oncology healthcare in a large sample from Piedmont, Northern Italy. Patients admitted for regular hospitalization were included (n=99,651). Data from 2020 were compared to the averages from 2016-2019, stratified by tumor site, year, month, and admission method, using interrupted time series analysis post-March 2020.

*Results*

In 2020, oncological surgeries decreased by 12.3% (n=17,923) compared to the 2016-2019 average (n=20,432), notably dropping post-March (IRR=0.858; $p<0.001$).
The greatest reduction was observed for breast (-19.2%), colon (-18.2%), bladder (-17.5%), kidney (-14.2%), and prostate (-14%) surgeries.
There was a huge reduction in non-emergency admissions (-13.6%), especially for colon (-23.8%), breast (-19.4%), and bladder (-18.7%). The proportion of hospitalizations with emergency access increased ($p<0.001$).

*Conclusions*

The COVID-19 pandemic led to a significant decrease in cancer surgeries in Piedmont in 2020, with an increase in the proportion of admissions through emergency access.

*Discussion*

The research provides valuable insights for comparing data with other regions and evaluating the effectiveness of efforts to recover lost surgical procedures. These findings can be useful to

policymakers in developing coordinated measures and more efficient access strategies to healthcare services in any future emergency situations.

**Keywords:**

COVID-19, Impact assessment, Emergency admissions, Interrupted time series analysis, Healthcare access strategies, Management.

## Introduction

Since January 2020, the COVID-19 pandemic has caused more than 768 million confirmed cases and almost 7 million deaths.[1] Worldwide, governments implemented containment policies and restrictive measures to limit the spread of the virus, impacting the general population.[2] The indirect effects of the COVID-19 pandemic on cancer care and surgical services have been widely acknowledged, revealing a decrease in hospitalization volumes worldwide,[3–5] both for emergency and non-emergency access.[6] The surge in COVID-19 cases has created a critical demand for intensive care, straining hospital resources and staff. The shortage of resources in the normally functioning intensive care unit has particularly affected postoperative monitoring for surgical patients. In addition, because of the containment measures, such as lockdown, and the epidemiological situation, patients have been more reluctant to seek medical care than they used to be.[7]

Due to urgent measures to combat and contain COVID-19, the Italian government issued guidelines for reorganizing hospital activities. The aim was to harmonize potential initiatives for day care, regular admissions, and outpatient services. The goal was to handle potential increases in hospitalization needs and limit patient flows. Specific guidelines were provided for rescheduling clinically deferrable activities, including urgent, elective oncological, and high-priority non-oncological admissions.[8]

In Italy, almost 26 million confirmed cases and more than 190 thousand deaths have been reported.[9] Italy was the first European country to experience a significant impact from COVID-19, with the first wave hitting in mid-March, prompting strict measures like lockdown. Following the summer, a second wave emerged, marked by a sharp rise in cases and a new peak in November. To avoid another lockdown, the national government implemented a set of restrictions at the regional level, based on weekly assessments of the spread risk.[10] The pandemic posed significant challenges to the National Health Service in Italy, leading to the activation of urgent measures at individual hospitals to manage the growing needs while minimizing the risk of virus transmission and ensuring appropriate treatment for each patient. The diversion of resources to deal with the emergency and concerns about SARS-

CoV-2 infection resulted in a reduction in non-COVID-19 related healthcare services.[11,12] Overall, in Italy there were 1.3 million fewer admissions (-17%) in 2020 compared to 2019, with medical admissions accounting for 52.4% and surgical admissions for 47.6%. Oncological surgery, in particular, experienced a 13% reduction compared with the previous year.[13]

Therefore, it is crucial to understand the extent of the problem for time-sensitive oncological conditions delving into specific regional contexts, as they might have undergone varied consequences owing to distinct epidemiological situations. The northern regions of Italy were the most affected by the COVID-19 pandemic probably due to their higher population and industrial density.[14] Assuming a reduction in cancer surgery services and a change in hospital admission ways in the Piedmont region (Northern Italy), in line with national and international reports, this study aims to contribute to a more comprehensive understanding of the impact of the pandemic on surgical oncology. The present study primarily aimed to provide an overview of the changes in hospitalization volumes of cancer surgery in Piedmont. In addition, it aimed to describe the overall activity of cancer surgery by exploring hospitalization days, waiting time, and emergency access to care.

## Materials and Methods

A retrospective observational study was conducted using the Hospital Discharge Records (HDR) of the Piedmont region (Northern Italy). The researchers obtained fully anonymized HDR and no Ethics Committee approval was required. The HDR data were extracted from 2016 to 2020 and included only records reporting a primary diagnosis of malignant tumor according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM),[15] i.e. codes from 140 to 208. Only surgical hospitalizations were included (according to the Diagnosis Related Group, DRG) and day care was excluded.

Data included the ICD-9-CM code of the primary diagnosis of the hospitalization, dates of reservation, beginning, and end of the hospitalization, and admission mode. Tumor sites were categorized according to the ICD-9-CM classification as shown in Supplementary Table S1. The dates

were used to describe year and month of hospitalization, waiting time (difference between beginning and reservation dates), and length of stay (hospitalization days). The admission mode was categorized as "emergency admission" if the origin of hospitalization was the emergency department (emergency room and related short-stay observation ward) and "non-emergency admission" for other origins (such as: scheduled admission, transfer from another facility/ward or from a primary care physician).

*Statistical analysis*

Descriptive analyses stratified by year of observation (from 2016 to 2020) were performed. Waiting time and hospitalization days had non-normal distributions (Shapiro-Wilk test) and were described using median and interquartile range (IQR). In addition, average volumes, hospitalization days, and waiting time were calculated for the 2016-2019 period.

To describe the change in hospitalization volumes (overall and stratified by months and tumor sites), percentage differences were calculated considering 2020 data and the 2016-2019 period data.

Differences in distribution of waiting time and hospitalization days between 2020 and the 2016-2019 period were tested using the Mann Whitney U test. In addition, Interrupted Time Series models (overall and stratified by tumor sites)[16] were performed to assess the change in the level of hospitalizations after March 2020, i.e. the beginning of drastic containment measures in Italy.

To develop the model, incidence rates of hospitalization were calculated using the Piedmont population at 31 December of the corresponding year of observation.[17] The impact of the pandemic and its related measures was expressed using incidence rate ratio (IRR) and 95% Confidence Interval (CI). To assess the robustness of the model, additional models were adjusted for seasonality and over-dispersion, and autocorrelation was tested.[16]

Last, to compare the mode of admission in 2020 and in the 2016-2019 period, percentage differences were calculated (overall and stratified by tumor site).

The analyses were performed with STATA v16 and SPSS v26. Significance was set at p-value<0.050.

**Results**

*Hospitalization volumes, length of stay, and waiting times.*

Hospitalization volumes, hospitalization days, and waiting times from 2016 to 2020 are shown in Table 1. In 2020, an overall reduction in cancer surgery hospitalizations was observed (-12.3%) compared with the average for the period 2016-2019 (n=20388). About inpatient days, a reduction in overall hospitalization days (-16.53%) and average length of stay (-1.5%) was observed. There was also a decrease in days on the waiting time for hospitalization (-14.1%) and average waiting time (-1.52%). The median waiting days were 22 days (IQR=12-39) in the period 2016-2019 and 20 days (IQR=10-36) in 2020 ($p<0.001$). The median hospitalization days were 6 days (IQR=3-10) in the period 2016-2019 and 5 days (IQR=3-10) in 2020 ($p<0.001$).

Table 1 - Oncology surgery hospitalizations: volumes, length of stay, and waiting time. Piedmont (Italy) Years 2016-2020.

| | **Hospitalization Volumes** | **Hospitalization Days** | | | **Waiting time** | | |
|---|---|---|---|---|---|---|---|
| **Year** | **N** | **N (days)** | **Median** | **IQR** | **N (days)** | **Median** | **IQR** |
| **2016** | 20281 | 183900 | 6 | 3-10 | 607148 | 25 | 12-42 |
| **2017** | 20432 | 188602 | 6 | 3-11 | 550837 | 22 | 11-37 |
| **2018** | 20482 | 185959 | 6 | 3-10 | 547232 | 21 | 11-37 |
| **2019** | 20358 | 179357 | 5 | 3-10 | 558726 | 22 | 13-37 |
| **2020** | 17878 | 153963 | 5 | 3-10 | 486195 | 20 | 10-36 |

In 2020, comparing the volumes with the same months of the average of the period 2016-2019, only in January was a slight increase observed (+1.22%); the reduction started in February (-2.54%) and March (-11%), continued in April (-18%) and peaked in May (-26%). The number of hospitalizations

also remained lower in the following months: June (-15.36%), July (-11.74%), August (-13.16%), September (-4.09%), October (-12.29%), November (-22.84%) and December (-10.12%).

The hospitalization volumes and their percentage differences over the period under consideration stratified by the ten tumor sites the highest percentage difference between 2020 and the 2016-2019 period are shown in Table 2. Details on hospitalization volumes stratified by all tumor sites are reported in Supplementary Table S2.

Table 2 - Oncology surgery hospitalization volumes stratified by tumor sites: first ten sites with the highest percentage difference between 2020 and the 2016-2019 period. Piedmont (Italy). Years 2016-2020.

| **Tumor site** | **2016** | **2017** | **2018** | **2019** | **2020** | **Average 2016-2019** | **Delta 1** | **Delta 2** |
|---|---|---|---|---|---|---|---|---|
| **Urinary tract** | 278 | 280 | 266 | 295 | 213 | 279.75 | -23.86% | -27.80% |
| **Testicle** | 143 | 126 | 131 | 137 | 104 | 134.25 | -22.53% | -24.09% |
| **Breast** | 2782 | 2555 | 2365 | 2313 | 2023 | 2503.75 | -19.20% | -12.54% |
| **Colon** | 2166 | 2300 | 2301 | 2146 | 1820 | 2228.25 | -18.32% | -15.19% |
| **Bladder** | 3783 | 3838 | 3867 | 3818 | 3158 | 3826.5 | -17.47% | -17.29% |
| **Skin-melanomas** | 65 | 49 | 67 | 49 | 48 | 57.5 | -16.52% | -2.04% |
| **Cervix of the uterus** | 128 | 118 | 106 | 111 | 97 | 115.75 | -16.20% | -12.61% |
| **Oro-nasopharynx** | 474 | 421 | 439 | 412 | 372 | 436.5 | -14.78% | -9.71% |
| **Kidney** | 677 | 703 | 715 | 758 | 612 | 713.25 | -14.20% | -19.26% |
| **Prostate** | 1718 | 1731 | 1841 | 1894 | 1545 | 1796 | -13.98% | -18.43% |

Delta 1 = percentage difference between 2020 volumes and the average of the period 2016-2019.

Delta 2 = percentage difference between 2020 and 2019 volumes.

The interrupted time series analyses showed a significant change in volumes after March both for total hospitalizations (IRR=0.858; p<0.001; CI 95% [0.839-0.878]) and for admissions for some tumor sites: colon (IRR=0.801; p<0.001; CI 95% [0.726-0.883]), lung (IRR=0.779; p<0.001; CI 95% [0.692 -0.876]), pleura (IRR=0.777; p=0.048; CI 95% [0.605-0.998]), prostate (IRR=0.744; p=0.001; CI 95% [0.624-0.887]), bladder (IRR=0.794; p<0.001; CI 95% [0.703-0.898]), kidney (IRR=0.794; p=0.021; CI 95% [0.652-0.966]), urinary tract (IRR=0.68; p=0.001; CI 95% [0.540-0.855]), secondary locations (IRR=0.892; p=0.024; CI 95% [0.808-0.985]), and multiple myeloma (IRR=0.772; p=0.011; CI 95% [0.633-0.942]). The additional models adjusted for seasonality and over-dispersion did not show substantially different results and autocorrelation was not identified.

*Comparison of admissions by mode of access*

The average volume of admissions during 2016-2019 was 1964 for patients with emergency access and 18424.25 for patients with non-emergency access, with an average length of stay of 20.4 days (median= 15 days, IQR = 9-24) in the former case and 7.84 (median = 5 days, IQR = 3-9) days in the latter. In 2020, admissions following emergency access were 1948, while those following non-emergency access were 15930, with an average length of stay of 18.9 days (median = 16 days, IQR=9.75-27) in the former case and 7.35 (median = 5 days, IQR = 2-8) days in the latter.
While there was a small reduction in hospitalizations following emergency admissions (-0.81%), a marked reduction was observed for non-emergency admissions (-13.54%). The average duration of hospitalization was also reduced, falling by -7.35% in the first case and -6.25% in the second. The proportion of admissions following emergency access increased ($p < 0.001$).
The reduction in admissions following non-emergency access was more marked for some cancer sites: colon (-23.84%), breast (-19.4%), bladder (-18.7%). Details on admission mode stratified by tumor sites are reported in Supplementary Table S3.

**Discussion**

In the present study, a substantial reduction in hospitalization volumes for oncological surgery in 2020 (-16.53%) compared with the average of the previous four years was evident, despite the implementation of policies aimed at avoiding delays in oncological surgeries, which remain one of the main treatments for patients with oncological pathology.[8,18] In addition, our findings highlighted a significant reduction in oncological surgical procedures for certain tumor sites, starting in March 2020 during the first wave of COVID-19 in Italy and the initial lockdown. Our results confirmed the impact of COVID-19 pandemic, especially during the early waves, similar to what has been documented in other countries.[3,4] In particular, the reduction we found was lower than the decrease of -33.9% (95% CI: -39.9; -27.9) in cancer surgical treatments administered during the pandemic globally, while it was more consistent with the reduction reported in Europe, i.e. -20.9% (95% CI: -30.1; -11.7).[19] This heterogeneity is not limited to cross-country comparisons but it has been reported also within Italy, especially when considering surgeries for different cancer sites. For instance, in 2020 in Lombardy, one of the Italian regions most affected by the pandemic, an overall drop of 60.1% was shown,[20] suggesting that the epidemiological situation had a great influence on the impact on oncological surgeries. Moreover, the site-specific significant reductions that we reported in Piedmont were different from results from other regions (e.g. in Southern and Central Italy significant reduction have been revealed for breast, thyroid, and skin cancer),[21,22] indicating discrepancies that cannot be explained solely by differences in the SARS-CoV-2 epidemiological context. It is possible that the observed differences are due to organizational disparities; therefore, it is crucial to further investigate organizational variations in service delivery and pathways for different types of cancer, to understand which reductions were avoidable and which organizational strategies were effective. Hence, these findings can serve as a starting point for policymakers to identify areas that require further exploration to ensure the provision of essential services during emergencies such as this pandemic.

The reduction in waiting times for hospital admission may be attributed to a decrease in overall oncological surgeries. Our study found a slight decrease in waiting list duration in 2020, contrary to

previous literature.[23–25] However, these previous studies focused on single tumor site or on smaller sample, thus making difficult a comparison.

By analyzing the average length of hospital stay, which has shown a decrease of 1.5%, we gain further insight into the changes occurring in healthcare delivery. The decrease in hospital stays can be attributed to multiple factors. Firstly, hospitals encountered immense pressure during the peak of the COVID-19 pandemic, prompting the implementation of strategies to expedite patient discharges after surgeries and increase bed availability. Moreover, there is a significant emphasis on minimizing the risk of SARS-CoV-2 transmission, which necessitates shorter hospital stays to reduce patient exposure.[26] By reducing the duration of hospitalization, the potential for viral transmission is mitigated, benefiting both patients and healthcare workers.[27] These changes exemplify the evolving landscape of healthcare delivery in response to the pandemic.

Lastly, the reduction in non-emergency hospital admissions amounted to -13.54% and the proportion of non-emergency admissions significantly decreased compared with the pre-pandemic period. In particular, substantial declines were observed for colon, breast, and bladder tumor sites. On the one hand, restricting surgeries to emergency has been reported among the most frequent modifications to cancer surgical care,[28] also considering data that specifically refer to the above-mentioned cancer sites.[29–32] On the other hand, the epidemiological situation related to the pandemic, coupled with concerns about potential contagion, likely contributed to a greater reluctance among individuals to seek hospital care, leading to the deterioration of conditions requiring emergency admissions.[7] Additionally, the impact of the pandemic on the provision and access to oncological screening and diagnostic services is another probable contributing factor. For instance, it was found that the reduction in colorectal cancer screening activity in Italy exceeded 50% in 2020.[33] Diagnostic delays can lead to more advanced stages of the disease, characterized by a poorer prognosis, and emergency presentations. These findings underscore the intricate interplay between the pandemic and healthcare-seeking behavior. Fear surrounding the virus may have deterred timely medical attention, resulting in more advanced disease presentations that necessitated urgent hospitalisation.[29,30,33,34] It is important to

recognize that COVID-19 is not the sole threat to stable elective surgical systems for cancer patients: other viral pandemics, seasonal pressures, and natural disasters all affect surgical patients on an annual and recurring basis.[35] The reflections derived from this study might be used to inform surgical system strengthening both during the COVID-19 pandemic and beyond.

Additionally, special attention should be given to the increased infectious risk faced by immunocompromised cancer patients, which implies a higher risk of critical bacterial/viral complications during the hospitalization and after the surgery, including a higher mortality rate by COVID-19.[36] The overall survival of cancer patients during the pandemic is not solely linked to the timing of surgical interventions. Therefore, a comprehensive approach that addresses the infectious risk and considers the broader impact of the pandemic on oncological care is crucial for improving patient outcomes in these challenging times.

*Limitations*

Although the available data and the analyses carried out allow for an in-depth description of the provision of surgical cancer care in Piedmont, it should be highlighted that there was a lack of data on other fundamental areas of cancer care, such as primary and secondary prevention interventions, as well as outpatient care, home care, hospice, and palliative care. Additionally, due to the nature of the databases used, which primarily capture retrospective data, their ability to accurately detect patients who did not undergo planned surgery is limited. These databases rely on information provided by healthcare institutions and may not capture the intricacies of prospective decision-making processes. Last, it was not possible to adjust the analyses for the severity of the disease.

**Conclusions**

This study revealed a substantial reduction in oncological surgery hospitalizations during the pandemic and suggested organizational disparities that cannot be exclusively attributed to the epidemiological context. Additionally, the decrease in non-emergency admissions highlighted the

modifications made to cancer care during the pandemic, while individuals' reluctance to seek hospital care may have contributed.

Our study provides an overview of the impact of COVID-19 on oncological surgical activities in Piedmont, laying the groundwork for comparison with data from other Italian regions, as well as the national and international landscape. Furthermore, it can serve as a starting point for evaluating the effectiveness of actions taken to recover lost oncological surgical procedures: future investigations will provide a more comprehensive and long-term understanding of the effectiveness of the efforts made to contain the surge of SARS-CoV-2 and to assess the prognostic impact of the delays and changes in treatment approaches. Finally, it is crucial that the lessons learned during the pandemic are translated into the daily management of oncology patients, emphasizing the importance of protecting these patients through dedicated spaces and prioritized pathways. The findings of our study can be useful to policymakers in developing coordinated measures and more efficient access strategies to healthcare services in any future emergency situations.

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