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### **The impact of the SARS-COV-2 pandemic on the workloads of UPMC Advanced Radiotherapy Centers in Italy.**

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## The impact of the SARS-CoV-2 pandemic on the workloads of UPMC advanced radiotherapy centers in Italy

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## ABSTRACT

### GOALS

The Advanced Radiotherapy Centers of UPMC San Pietro FBF of Rome (CC#1) and UPMC Villa Maria of Mirabella Eclano (CC#2) conducted a study to review variations in department workloads and workflows experienced during the pandemic. The potential relation between these variations and the new procedures introduced to prevent and contain the COVID-19 infection was also studied.

### MATERIALS AND METHODS

The data used were obtained from reports present in the ARIA<sup>®</sup> system (v. 15.1 Varian Medical Systems, Palo Alto, CA, U.S.A.). To examine the workloads was used the Downtime, an indicator that directly quantifies the inactivity of the department, derived from the ratio between the daily stand-by time of the LINACs (TrueBeam STx<sup>®</sup>, Varian Medical Systems, Palo Alto, CA, U.S.A.) and the mean number of treatments performed every day. In order to examine the workflows and possible delays, we measured the time between the treatments ("Therapy intervals").

### RESULTS

The Downtime average at CC#1 slightly increased from 3.1% in 2019 to 3.8% in 2020. However, the monthly analysis shows significant reduction (March-April-May) and increase (November-December) peaks. At CC#2, the 2020 Downtime trend was fairly consistent (average value: 3.3%), with an increase during the first wave of the pandemic.

The "5-10 min" Therapy intervals at CC#1, reviewed comparing the March-April-May 2020 quarter with 2019, were higher in the first months and lower in May; the "10-15 min" intervals were stable; the ">20 min" intervals slightly increased in March 2020. At CC#2, the trend in 2020 decreased during the months of higher health care emergency and increased during the summer months.

### CONCLUSIONS

The fact that the trends of the indicators show peaks only during the periods of major health care emergency indicates an impact of the pandemic, both on the workload and on the workflow. However, they also highlight the staff's ability to rapidly adapt to the new procedures, without affecting the overall performance of the both centers.

**Keywords:** Advanced Radiotherapy, workload, SARS-CoV-2.

## INTRODUCTION

In 2020, Italy was one of the most affected countries in the world by the SARS-CoV-2 pandemic, with two waves during that year: the first began in March, the second in October [1]. During the peak of the health care emergency, many clinical services suffered a major reduction of their activity, and thousands of medical and specialist centers were forced to close. Hospital services globally were also severely disrupted, with a high number of elective operations, treatments for chronic non-urgent diseases, and many other non-virus-related services that had to be postponed [2].

As in other countries around the world, this had a serious effect and impact on the field of radiation therapy. The American Society for Radiation Oncology (ASTRO) shared with the European Society for Therapeutic Radiology and Oncology (ESTRO) a survey that was sent to over 500 departments in the United States to understand the impact of the pandemic on their clinics and the process adaptations made to address it [3]. In Europe, the surveys were sent to 500 radiation oncology departments [4], and a total of 139 completed surveys were received (response rate: 28%) from 29 different countries. Most of these surveys came from: Italy (14%), Germany (12%), Spain (11%), The Netherlands (7%), Switzerland (6%), United Kingdom (6%), and Belgium (5%). The remaining ones arrived from the other 22 countries. The questionnaire highlighted that the departments treat an average of 1,300 new cancer cases every year, and that during the pandemic the average number of patients treated was 100 per day.

As shown in Table 1, treatment of some new cases was postponed (58%) and there was a decrease in the number of patients (60%).

Country	New cases postponed	New cases postponed %	Reduced number of RT	Reduced number of RT %
Italy	8/20	40%	12/20	60%
Germany	13/17	76%	9/17	53%
Spain	11/15	73%	8/15	53%
The Netherlands	4/10	40%	5/10	50%
Switzerland	8/9	89%	5/9	56%
United Kingdom	8/8	100%	7/8	88%
Belgium	3/7	43%	6/7	86%
Other	26/53	49%	32/53	60%
All	81/139	58%	84/139	60%

Table 1: Postponed new cases and shortfall in access to RT reported with the survey in Europe. [4].

Data from Italy show a significant impact of the pandemic on departments that responded to the questionnaire, reporting a 60% reduction in the number of treatments, with 40% of new cases postponed to a later date.

The phenomenon also characterized the activity of Advanced Radiotherapy Centers of UPMC San Pietro FBF of Rome (CC#1) and UPMC Villa Maria of Mirabella Eclano, although in a different manner.

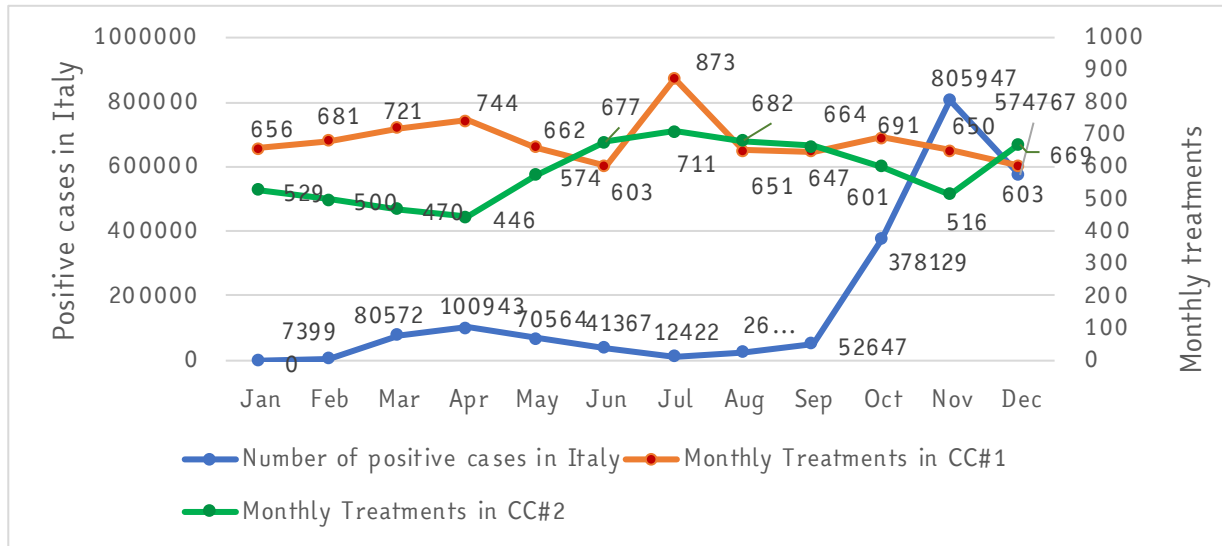


Figure 1: Trend comparison: SARS-CoV-2 positive cases in Italy1 and number of monthly treatments at CC#1 and CC#2.

Figure 1 shows how at CC#1 the reduction in radiotherapy treatments occurred not during the first wave of the pandemic, but in the first months after it, and therefore as a direct consequence. The subsequent decline of infections and the resumption of the clinical services caused a peak of the number of patients in Summer, and a plateau until November, when there was another deflection after the second wave.

At CC#2, on the other hand, the trend of treatments followed that of the COVID-19 positive cases in Italy: the decline was concomitant with the two waves of the pandemic during that year, while there was an increase in Summer when the country was less affected by the pandemic.

Being an essential service that requires continuity [5], the maximum priority was to make sure patients undergoing treatment could continue their therapy without interruption and guarantee the start of new plans of care. Moreover, since this patient population is among those more at risk in case of an infection due to their condition of immunodepression and oftentimes to their comorbidities [6], it was of primary importance to immediately activate all processes to prevent and contain the contagion [7].

The UPMC San Pietro FBF Center (CC#1), accredited by Joint Commission International, has always followed specific protocols that guarantee top quality standards for all its services [8]. The UPMC Villa Maria Center, which opened only two years ago, has adopted the same policies



and procedures from the beginning of its activity. Some of these policies, such as "*Hand Hygiene*", "*Cleaning Clinical Equipment*", "*Use of Personal Protective Equipment*" and "*Infection Prevention and Control*", were implemented with appropriate modifications in line with the directives issued by international and national bodies, such as WHO (World Health Organization) [9] and ISS (Italian Higher Institute of Health) [10], as well as decrees issued by the Italian Government during the pandemic..

On 9 March 2020 both departments introduced the "Containment of COVID-19 infection" policy that provides for:

- Mandatory body temperature ( $< 37.5$  °C), hand sanitization, and use of face mask.
- Extreme punctuality with respect to scheduled appointments.
- Access allowed only to patients, except in specific cases when one accompanying person is allowed access, and paramedics transporting patients with disabilities or on a stretcher.
- Disinfection performed by staff of all surfaces and accessories with which patients come into contact, using anti-septic chlorhexidine gluconate solutions.
- If a patient undergoing treatment presents symptoms of a COVID-19 infection, in compliance with the ASTRO [11] and AIRO (Italian Association of Radiation Oncology) [12] guidelines, the radiation oncologist discontinues the therapy until the results of the nose swab PCR test for COVID-19 are available. In case of a negative result, it is possible to proceed with the radiotherapy treatment, otherwise alternative options are assessed: discontinue the treatment if palliative or in the event of an admission, or proceed in case of emergency, converting into hypofractionated therapy consistently with the patient's clinical picture. In these cases, the patient's appointments are postponed at the end of the shift, so that they can be managed separately from the other patients, ensuring the necessary care is provided under conditions of total safety.

Moreover, according to the protocols issued by the regional reference programs [13,14], the obligation to undergo the antigenic test once a week for all staff and, as a preventive measure, also for patients, has been introduced at both centers.

Introducing these measures was an interesting opportunity to assess if they had an impact on the daily activities of the departments. The study was conducted in the two centers reviewing changes in staff workloads during 2020 and comparing them to those recorded in periods not affected by the pandemic.

## MATERIALS AND METHODS

The workload variation at the UPMC San Pietro FBF Center (CC#1) was reviewed collecting data for 2020 and comparing them with those of 2019, which served as non-pandemic baseline. For the UPMC Villa Maria Center, on the other hand, due to its recent opening in December 2018,

it was considered appropriate to only assess the workload trend of 2020, comparing the periods of maximum emergency with the less critical periods.

Both centers are equipped with a VARIAN TrueBeam STx<sup>®</sup> linear accelerator (Varian Medical Systems, Palo Alto, CA, U.S.A.), and reports from ARIA<sup>®</sup> (v. 15.1 Varian Medical Systems, Palo Alto, CA, U.S.A.) were used for data collection from which it was possible to extrapolate:

- LINAC operational times.
- Number of treatments performed.
- Duration of individual treatments.

A specific indicator was developed to immediately calculate, quantitatively and objectively, potential reductions of activity, if any, in the centers in the various months of the year.

From the daily operational times of the LINAC, the number of hours in each shift when the LINAC was in stand-by was calculated. This figure, measured against the mean number of daily therapies performed every month, provides the Downtime of the department in relation to the treatments performed.

$$\text{Downtime} = \# \text{ hours if LINAC stand-by} / \# \text{ daily RT treatments performed}$$

In addition, the time between each irradiation and the next one, or Therapy interval, was calculated analyzing data on the duration of every single treatment.

Therapy intervals were quantified and grouped into separate categories based on their duration in "5-10 min", "10-15 min", and ">20 min". This allowed to study potential variations during critical periods of the pandemic and compared them to the baseline provided from 2019 for CC#1.

## RESULTS

By reviewing Downtime data at CC#1 in 2019, there was a median of 3%, a minimum of 2.0%, and a maximum of 4.9%, with an average of 33.3 treatments per day. In 2020, there was an increase of the median (3.65%), a minimum of 1.4%, and a maximum of 7.2% (Figure 2), with an average of 33.2 treatments per day.

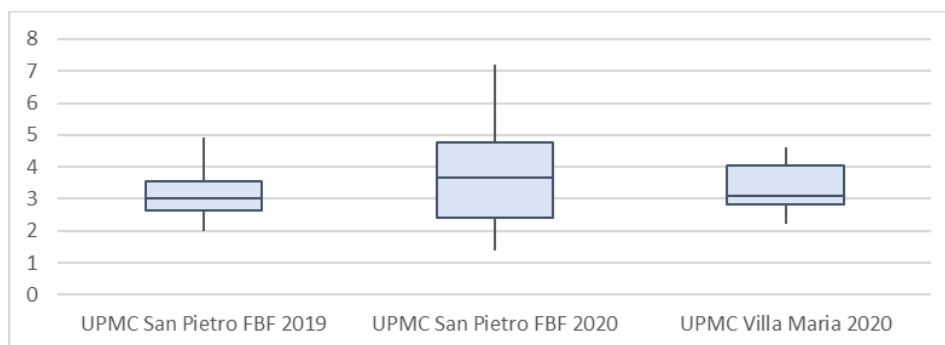


Figure 2/a: Boxplot of datasets on Downtime in 2019 and 2020 for CC#1, and in 2020 for CC#2

	UPMC San Pietro FBF 2019 (CC#1)	UPMC San Pietro FBF 2020 (CC#1)	UPMC Villa Maria 2020 (CC#2)
MIN	2	1.4	2.2
MAX	4.9	7.2	4.6
MEDIAN	3	3.65	3.2
DS	0.75	1.83	0.76

Figure 2/b: Boxplot of datasets on Downtime in 2019 and 2020 for CC#1, and in 2020 for CC#2

The increase peaks were observed in November and December 2020, with a downtime of 7.2% and 7%, respectively, with a concomitant reduction in the number of treated patients compared to the same period the previous year. The downtime reduction peaks occurred in March-April-May 2020: from 2.2% in March to 1.4% in May (Figure 3).

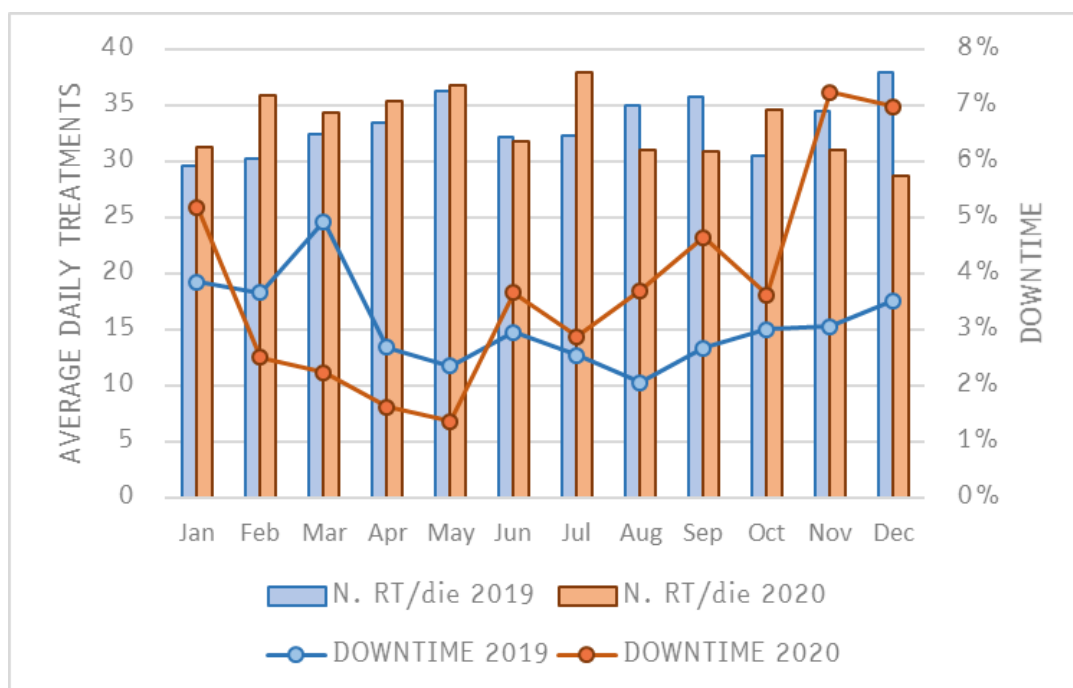


Figure 3: Downtime e media RT/die in CC#1, 2019 and 2020

For CC#2, the median downtime in 2020 was 3.2%, with a minimum of 2.2%, and a maximum of 4.6% (Figure 4). An increase peak was observed in March (4.4%) and in April (4.6%) when there was also a lower patient flow.

In May, the number of patients on treatment increased again with a progressive increase in the following months, up to a maximum of 711 therapies in July. There was also a downtime reduction until September.

In October and November, the downtime increased again (4.3%) with a new drop in treatment delivery: a total of 601 treatments were registered in October and 516 in November, compared with the mean 683 treatments delivered in the previous four months (Figure 7).

In December, there was a downtime of 3.3% and 669 treatments, close to the mean value reported during the less critical months of the year.

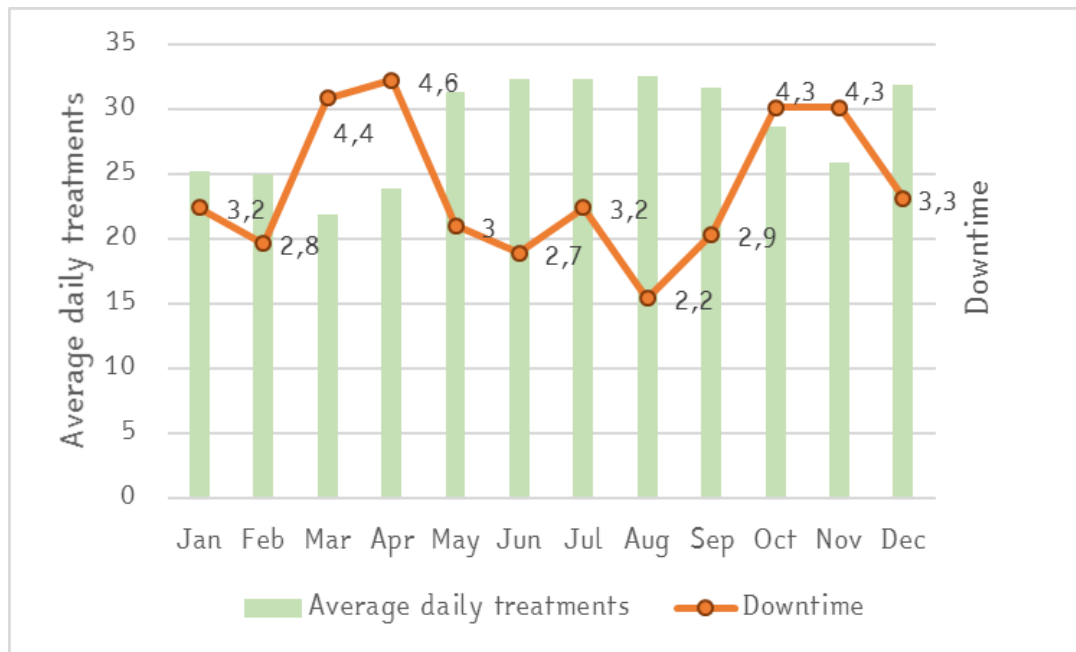


Figure 4: Downtime and average RT/die in CC#2, 2020

The *therapy intervals*, i.e., the time elapsing between one therapy and the next, show that, by their own definition, they are strictly dependent on the number of treatments performed.

In fact, from data obtained for CC#1 (Figure 5) shows that the two factors have a directly proportional trend between each other, except for the month of March characterized by a higher number of therapy intervals compared to April, despite a lower number of RTs per month.

Moreover, using the 2019 data as baseline, therefore not influenced by the pandemic, it was interesting to compare the numbers, focusing on the most critical period of the year, identified as the first wave: March-April-May.

In 2020, compared to the previous year, there was a significant increase of the "5-10 min" intervals in March and April, followed by a decrease in May. The "10-15 min" intervals are fairly regular in all three months under consideration.

The trend of the ">20 min" intervals is also linear in the two quarters reviewed, except in March when it increased slightly in 2020 compared to 2019 (Figure 6).

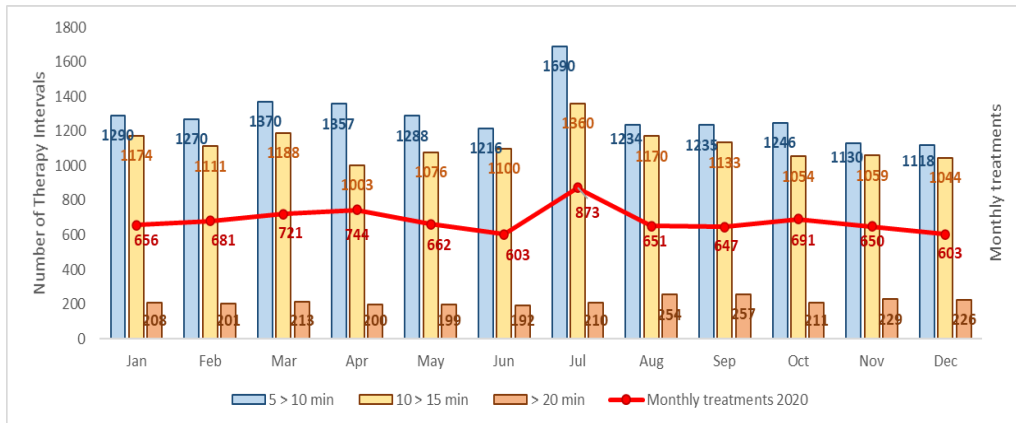


Figure 5: Distribution of therapy intervals in CC#1, 2020.

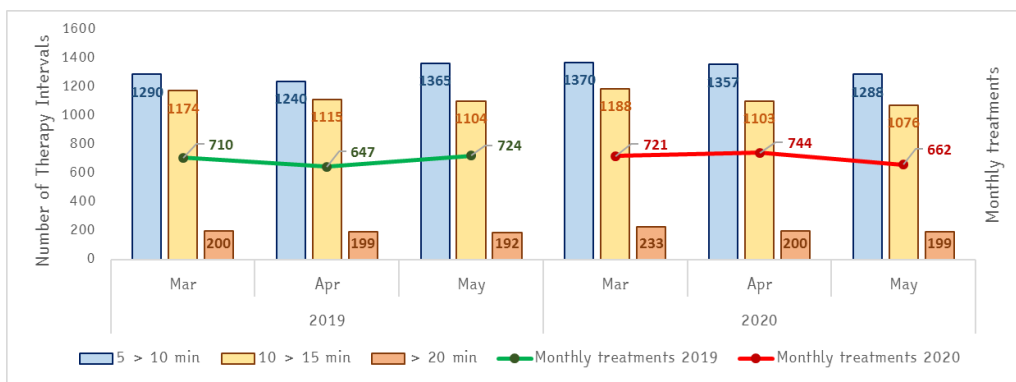


Figure 6: Distribution of therapy intervals in March-May for CC#1. Comparison between 2019 and 2020

The dataset for CC#2 also showed that the total value of therapy intervals follows the trend of the downtime and of the number of treatments. In particular, this was lower in March and April compared to the summer months, and reduced again in October and November, finally rising again in December (Figure 7).

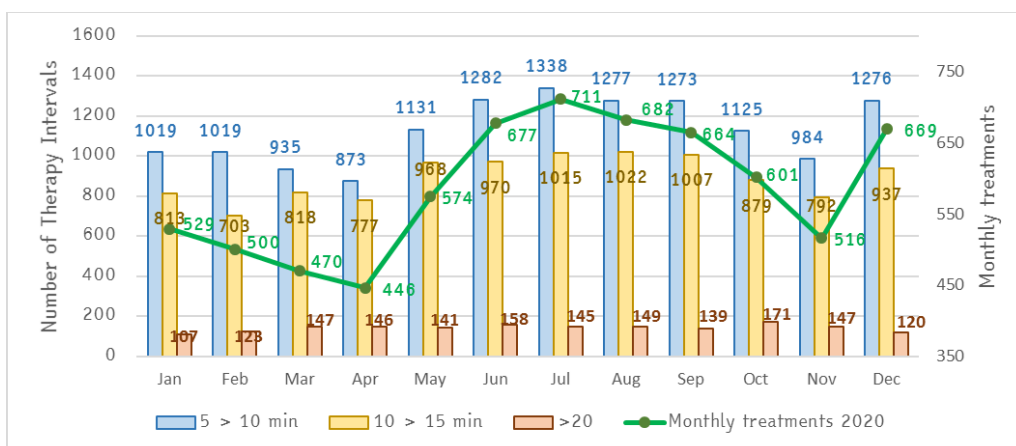


Figure 7: Distribution of therapy intervals in CC#2, 2020

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## CONCLUSIONS

Assessing the overall impact of the SARS-CoV-2 pandemic in the two radiation therapy centers allows to determine its relevance in terms of impact on the department workloads. However, during the time interval taken into consideration, there were different variations depending on the context.

Assessing the overall impact of the SARS-CoV-2 pandemic in the two radiation therapy centers allows to determine its relevance in terms of impact on the department workloads. However, during the time interval taken into consideration, there were different variations depending on the context.

From the dataset of the UPMC San Pietro FBF (CC#1), it was interesting to review the peaks of downtime reduction: it is not by chance that these occurred between March and May, when Italy was facing the first wave of the pandemic.

It appears, in fact, that the data from this period can easily be attributed to the onset of the pandemic, and to the fact that these were the first months when the new policies and safety measures for the containment of the infection were introduced.

In March, in particular, there was a larger number of "5-10 min" therapy intervals than in April, despite the lower number of monthly treatments. In practical terms, this indicates the need for more time to dedicate to each patient to sanitize the bunker. In May and in the following months, this indicator decreased as staff become more accustomed with the policies.

The trend of "10-15 min" therapy intervals, which can be traced to the treatment delivery times, is stable, together with the mean daily treatments. The slight increase of the "> 20 min" therapy intervals may be associated with the occasional delay of patients due to the need to scrupulously comply with the schedule and to possible Police checks on the way to the centers.

We also observed that despite these workflow and workload variations (such as the increase in median downtime and peak variations, both decreasing and increasing) obtained comparing data from 2019 and 2020, the average number of daily treatments remained practically constant: 33.3 RT/day in 2019 and 33.2 RT/day in 2020.

From the data collected at the UPMC Villa Maria (CC#2), it appears even more evident that the periods characterized by a high downtime correspond to the two periods of maximum health emergency in Italy. In this regard, it is worth noting that during the first period, some cities close to Mirabella Eclano, where the Center is located, were classified as "red zones" because of the high number of positive cases to SARS-CoV-2 and that, in general, the Region of Campania was classified several times as "red zone" for extended periods of time during the second period. This was a crucial factor for the Center's activities and translated into a dramatic reduction of number of patients during these periods.

However, apart from the most critical months of the pandemic, we witnessed an increase in the number of monthly treatments during 2020, an increased staff levels among radiotherapy

technicians, radiation oncologists, nurses and administrators, and extended work shifts, thus showing an increase in the activity.

In conclusion, it is safe to say that despite the changes that occurred during the year linked to periods of maximum health emergency, the staff managed to cope with the emergency, guaranteeing compliance with the infection prevention and containment policies, without significantly affecting the workload and the overall workflow of the department.

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