Journal of Biomedical Practitioners

JBP

Periodico per le professioni biomediche a carattere tecnico - scientifico - professionale

Titolo articolo / Article title:

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Pagine / Pages: 34-45, N.2, Vol.5 - 2021

Submitted: 15 February 2021 – *Revised:* 21 March 2021– *Accepted*: 20 December 2021 – *Published*: 31 December 2021

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Open Access journal – www.ojs.unito.it/index.php/jbp – ISSN 2532-7925

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SOMMARIO / TABLE OF CONTENTS Numero 2, Volume 5 – 2021

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OPEN ACCESS JOURNAL
http://www.ojs.unito.it/index.php/jbp
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A Scientific, Technical and Professional Practice Journal for Biomedical Practitioners

Quantitative quality indicators and automated radiotherapy care paths

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N. 2, Vol. 5 (2021) – 34:45
Submitted: 15 February 2021
Revised: 21 March 2021
Accepted: 20 December 2021
Published: 31 December 2021

ABSTRACT

INTRODUCTION

High quality standards are often the key for success in modern radiotherapy. The goal of this study is to assess automated and targeted care paths to define new quantitative quality indicators in radiation oncology and optimize the efficiency and safety of the services provided.

MATERIALS AND METHODS

For this study, two international cancer centers part of the same network (UPMC San Pietro in Rome (CC#1) and UPMC Villa Maria in Mirabella Eclano (CC#2)) have been involved, both equipped with a linear accelerator and a CT scan. The data reviewed refers to a period between January 2019 and December 2019. Following the workflow of both centers during electronic medical record data input, we created automated models adaptable to the different types of treatment and customizable for each patient.

Using the ARIA v15 (Varian Medical System, CA, Palo Alto, USA) software, we converted the various steps of the care path in modules that can be connected to create the patient's care process. Care paths are therefore modules of an automated process consisting of tasks and appointments, with well-defined execution times within which they must be completed electronically.

To obtain quantitative information on both centers we focused on three factors: tasks completed in relation to their execution times, number of days, and staff compliance with the automated system.

RESULTS

Measuring the completed tasks allows to define the compliance of the automated process with the care paths, whereas the time required to complete the tasks helps identify areas for improvement. Within this study timeouts are always performed on time, but peer review and treatment approval outcomes are unsatisfactory.

A defined delay time allows to keep track of tasks in a precise manner and reviewing these values in both centers helps us understand if the task delivery time is appropriate or if there is room for improvement. All analyzed data show that the percentage of tasks completed in both centers and the completion times are different.

CONCLUSIONS

Automated care paths and their modules can be an effective and efficient tool to measure the tasks performed by a radiation oncology unit, especially if they are used as a tool of continuous quality improvement.

Keywords: Radiotherapy, quantitative quality indicators, automated care paths.

GOAL

This study aims at assessing automated and personalized care paths to define new quantitative quality indicators in radiation oncology, and therefore optimize the efficiency and safety of the provided services.

INTRODUCTION

High quality standards are often the key for success in modern radiotherapy [1].

It is known in fact that the complexity of modern radiation therapy techniques calls for equipment and software both sophisticated and fully integrated between them, managed by the multidisciplinary radiation oncology team to provide high quality care to patients, also in terms of efficacy and safety [2].

The care path of a patient admitted to a radiation therapy unit involves multiple phases involving various professionals. Sharing information, rapidly completing the tasks, and effective communication between members of radiation oncology team are therefore of fundamental importance. To guarantee seamless operations, a workflow must be developed based on the activity of the unit, on the tasks of the various staff members, and on the patient's needs (Image 1) [3].

This rationale is already present in most radiation therapy centers providing high-dose radiation therapies and specialty techniques, such as stereotactic body radiation therapy (SBRT) [4], stereotactic radiosurgery (SRS) [4], MRI-image guided radiation therapy (MR-IGRT), and respiratory gating (4D-RT): these techniques and treatments require a solid risk management process to prevent errors and identify possible incidents in good time. Effective risk prevention measures include peer review and chart rounds, which have a very important role in ensuring safe radiation therapy treatments and involve multiple professionals working in synergy to improve the quality of services [5]. Since both activities are extremely difficult to monitor in a continuous quality improvement approach, the use of dedicated indicators is beneficial [6].

Quality assurance systems were first introduced in 1992 [7]. Current indicators in literature regarding radiation therapy were provided by the ISTISAN 2002 report [8]. These indicators aim at detecting the quality of the care provided [9][10][11]. Monitoring all patient and department activity with shared digital agendas [11][12] allows to have a large amount of data available and keep track of the patient's entire care path from the first radiation therapy visit to remote visits. This is also useful to highlight areas of improvement and consider new possible radiation therapy quality indicators [12][13][14]. Our goal is to define and test the new indicators to monitor the tasks performed during the patient's care path and have a consistent and shareable quality program.

MATERIALS AND METHODS

The study involved two cancer centers: UPMC San Pietro FBF (CC#1) and UPMC Villa Maria (CC#2). Both centers are equipped with a linear accelerator and a CT scan dedicated for radiation therapy, both are fully digitized and have undergone the Joint Commission International (JCI) accreditation process, complying with all quality standards required by the accreditation body.

At the time of the data analysis, CC#1 was already accredited and in the second accreditation phase, while CC#2 was preparing for the first accreditation. Staff and patient volumes are shown in Table 1. In both centers, more than half of the treatments are performed with special techniques (60% of the total treatments) and all patients undergo daily image-guided radiation therapy (IGRT).

The data reviewed refers to a period between January 2019 and December 2019. In both centers the same electronic medical record (EMR) system is used connected to a record and verify (R&V) system. The workflow (Figure 1) shows all tasks shared by the radiation therapy team, divided in different groups: each colored band represents the area of competence of each professional category, however some tasks are shared among several professionals (meetings, EMR control, etc.). Following the workflow, in the development of the EMR, customized automated care paths were created for the types of possible radiation treatments9. In fact, the ARIA v15 software (Varian Medical System, CA, Palo Alto, USA) allows to convert all steps of the patient's workflow into modules of an automated process (Figure 2).

DIGITAL CARE PATHS

Care paths are automated care processes that contain different modules. These are divided into tasks and appointments (see Table 2) and associated with the professional categories of reference. The term "appointment" refers to procedures directly related to the patient and digital agenda in the EMR: these are steps included in the care path workflow that team members complete in a predefined timeframe, such as "CT Simulation" (Figure 2). The term "task" refers to procedures linked to the team that are not dependent on the digital agendas. Some task examples are shown in Figure 2: all modules represent tasks related to the associated "CT Simulation" appointment on the EMR agenda (Figure 2).

	CC#1	CC#2
PATIENT/YEAR	720	450
ADMINISTRATIVE (ADMIN)	2	2
RADIATION THERAPIST (RTT)	4	3
RADIATION ONCOLOGIST (RO)	6	2
MEDICAL PHYSICIST (MP)	4	2
NURSE (RN)	3	2

Table 1: staff and patient volumes for (CC#1) and CC#2 in 2019

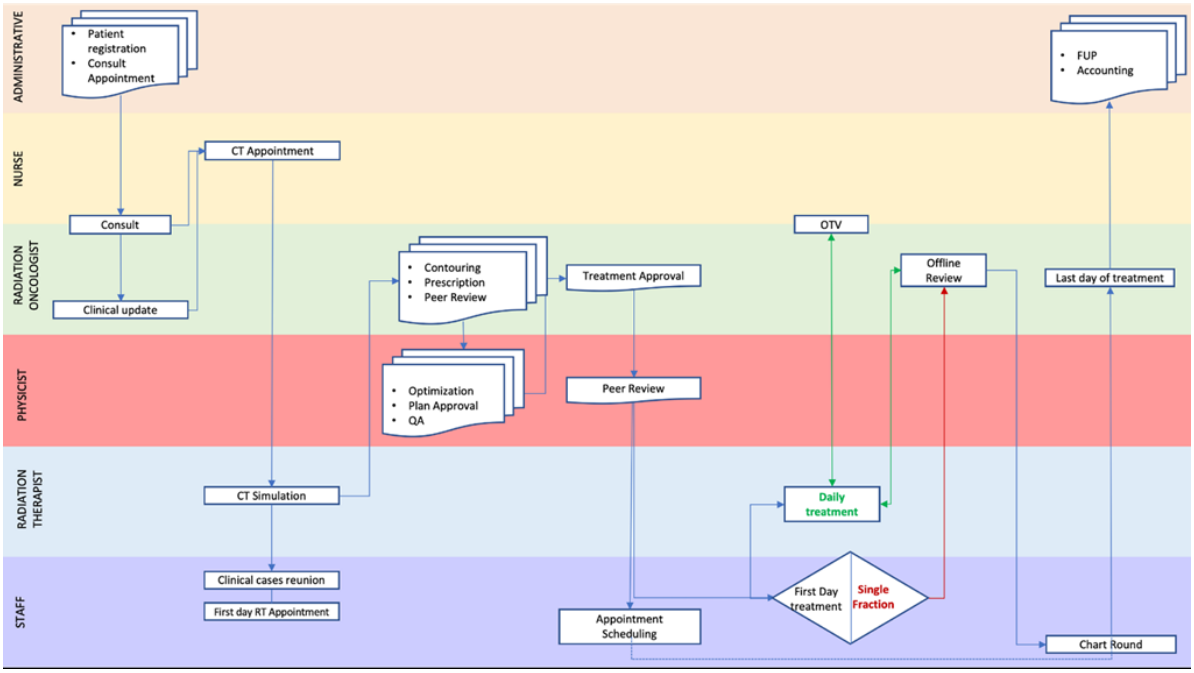


Figure 1: schema del flusso di lavoro (Workflow) e delle attività che lo compongono nel CC#1 e nelCC#2

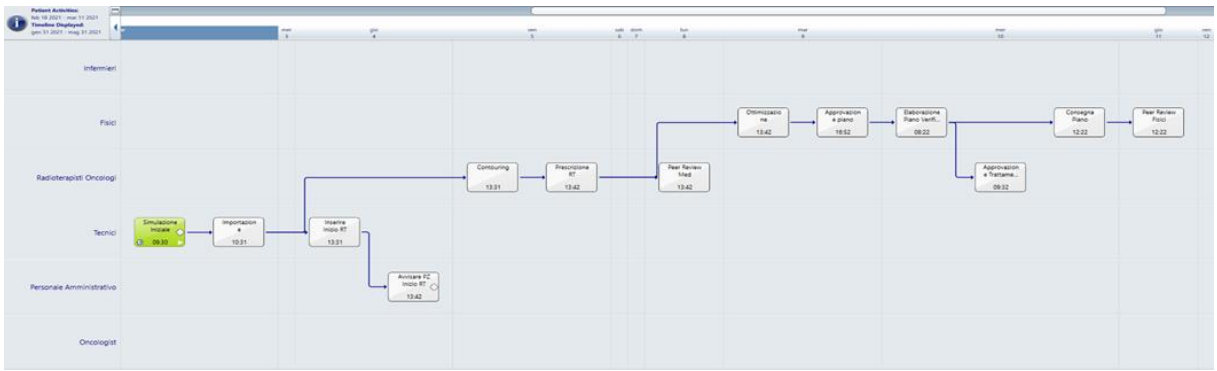


Figure 2: Example of a digital care path flow in CC#1 and CC#2

Care path modules are interconnected, the next task becomes "available" only when the previous task has been successfully completed. The various tasks can be completed by any staff member of the associated category: this allows a physician to complete a task left on hold by a colleague or a nurse to visualize all tasks related to the nursing team. Each module has a timeframe during which the task must be completed (expiration time) and default time slots are available between the modules (lag time). Tasks completed before the predefined time are considered completed ahead of time; tasks completed in due time are defined as on time, and tasks completed after the due time are considered overdue. When a module is closed, the care path directly enables the next step, and this is notified in the agenda of the category associated with that task. Modules can be added or removed to create a personalized digital path for each patient.

QUALITY INDICATORS

The study focused on measured outcomes, selected to be used as independent quality indicators for cancer centers. To do so we reviewed all data on the completed tasks sorted by team and compared them between CC#1 and CC#2. To create a quantitative data reference for both centers we focused on three different parameters:

- **Percentage of completed tasks and related timing:** *Total number of tasks scheduled in the unit and completed, divided by expiration time.*
- **Passed days:** *Days passed from task planning and actual date and time of completion.*
- **Staff compliance:** *Number of tasks completed electronically by the individual team member, divided by the total tasks of their team.*

		GROUP	LAG TIME	EXPIRATION TIME
APPOINTMENT	Consult	RO	-	45 (min)
TASK	Consult	RO	1 (h)	45 (min)
	Consult	RN	10 (min)	30 (min)
	Patient Registration	ADMIN	-	15 (min)
APPOINTMENT	CT Simulation	RTT	-	30 (min)
TASK	Time Out (CT Sim)	RTT	10 (min)	15 (min)
	Target Delineation	RO	3 (h)	3 (h)
	Prescription	RO	1 (d)	15 (min)
	4D Gating	MP	1 (d)	2 (h)
	Planning Approval	MP	1 (h)	30 (min)
	Treatment Approval	RO	1 (h)	30 (min)
	Initial Chart Checks	MP	3 (h)	2 (h)
	Peer Review	MP	1 (d)	15 (min)
	Peer Review	RO	1 (d)	15 (min)
APPOINTMENT	Daily treatment	RTT	-	30 (min)
TASK	Time Out (First Day)	RTT	1 (min)	10 (min)
	Time Out (Daily)	RTT	10 (min)	15 (min)
	On Treatment Visit	RN	7 (d)	15 (min)
	Last Day of treatment	RO	10 (min)	15 (min)
	Last Day of treatment	RN	10 (min)	15 (min)
APPOINTMENT	Follow Up	RO	-	30 (min)
TASK	Follow Up (FUP)	RO	1 (h)	15 (min)
	Follow Up (FUP)	RN	10 (min)	15 (min)

Table 2- Task/Appointment in CC#1 and CC#2 divided by assigned team with related Lag Time and Expiration Time. MP (Medical Physicist); RO (Radiation Oncologist); RN (Radiation Nurse); ADMIN (Administrative Staff); RTT (Radiation Therapist).

RESULTS

A short list of tasks was selected to describe the trend in the use of automated care paths in the two centers. Table 3 shows their percentage of completion in CC#1 and CC#2, during the

defined period and the expiration date. "Time Out" tasks, prior to any care, therapeutic and/or diagnostic activity, in which all patient data is verified for correctness, were completed on average "on time" in both centers:

"Time Out First Day (RTT)" (99%) and "Time Out Daily (RTT)" (89% CC#1; 100% CC#2). The "Planning Approval" and "Treatment Approval" tasks are completed in "overdue" (53% and 88% in CC#1; 71% and 77% in CC#2), as well as "Peer Review (MP)" (46% CC#1; 86% CC#2) and "Peer Review (RO)" tasks (82% CC#1; 83% CC#2).

The major discrepancies between the two centers refer to the "Consult" (first radiation therapy visit) and the 4D Gating Task. In CC#1, the "Consult" tasks are completed late with an average of 52%, while in CC#2 the same tasks are completed on time with an average of 63%. In addition, "4D Gating" tasks are completed late in CC#1 (87%) and on time in CC#2 (52%).

Figure 3 shows the completion rates of tasks considered for review with the related average time frames for each month of 2019. The "Time out First Day" and "Time out Daily" tasks of the Radiation Therapists group have a linear trend oriented towards "on time" completion during all months, compared to other tasks, while there is an irregular trend with a significant percentage of overdue tasks of "Treatment Approval" and "Peer review" for the Radiation Oncologist group.

Based on the "Activities and expiration date" report generated by ARIA, the Elapsed Days were calculated subtracting the actual completion date of the task from the expiration date of that task. The result, expressed in days in decimals, is shown in the table (Figure 4).

Comparing the predefined expiration time for each task with the Elapsed Days calculated on average for each month in the two centers, only a few tasks were completed in line with the expected times, and therefore on time (Consult CC#2, TimeOut First Day, TimeOut Daily).

	CC#1			CC#2		
	ON TIME	OVERDUE	AHEAD	IN TIME	OVERDUE	AHEAD
Consult	48%	52%	0%	63%	37%	0%
TO First Day (RTT)	99%	1%	0%	99%	1%	0%
TO Daily (RTT)	89%	8%	3%	100%	0%	0%
Planning Approval (MP)	13%	53%	34%	14%	71%	15%
Treatment Approval (RO)	9%	88%	3%	14%	77%	9%
Peer Rev. (MP)	16%	46%	38%	6%	86%	8%
Peer Rev. (RO)	16%	82%	2%	11%	83%	6%
4D Gating	5%	87%	8%	52%	38%	10%

Table 3: Percentage of tasks conducted "On Time", "Overdue" and "Ahead" in CC#1 and CC#2 selected for review

The remaining tasks, on the other hand, show a completion trend toward an overdue delay (Treatment Approval (RO), Peer Review (MP), Peer Review (RO), 4D Gating, Planning Approval

(MP)), with some ahead percentages of completion (Peer Review (MP) CC#1, 4D Gating, Planning Approval (MP) CC#1).

Upon a second review we were able to assess the staff's compliance with the use of the EMR through these automated steps.

By reprocessing the data assessed for the Elapsed days, we were able to analyze the tasks by single operator. Figure 5 shows the staff's compliance with the completion of the considered task for each group, in both centers.

For each professional category, 100% of tasks were completed by each member in varying percentages: the RO4 of CC#1, for example, completed 45% of the total tasks of its group, while the other 3 members of the group completed a smaller amount of tasks and was therefore less compliant with this system.

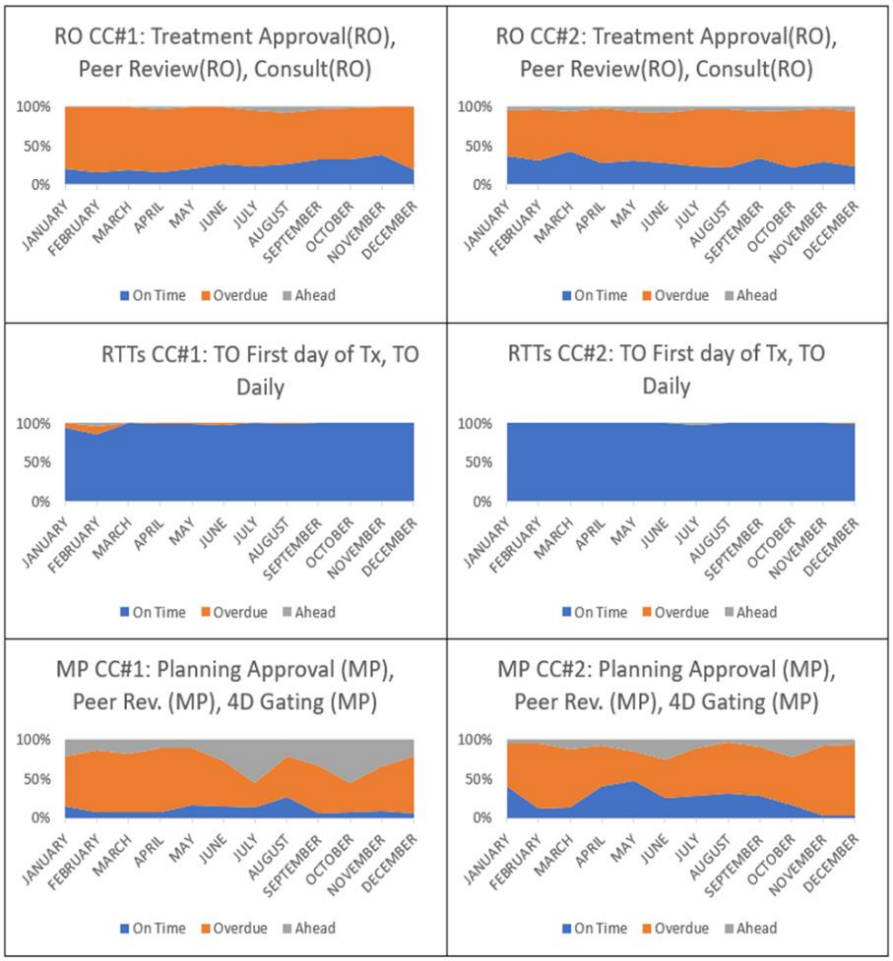
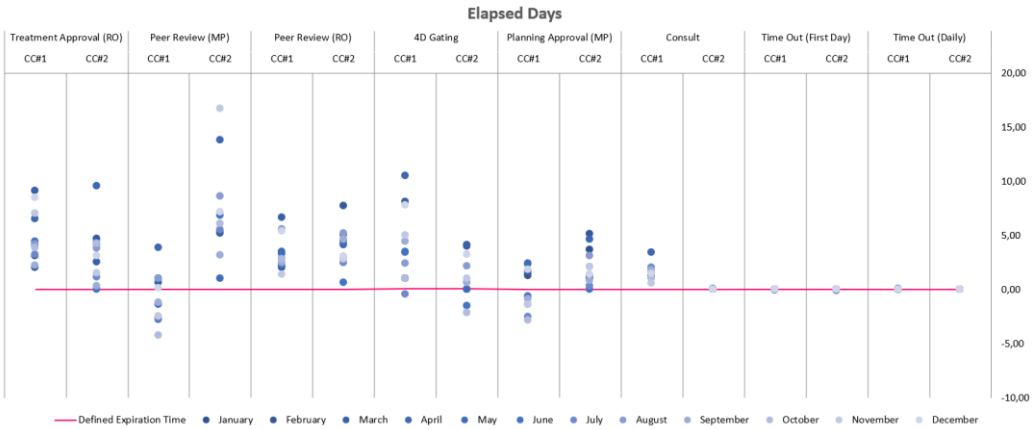


Figure 3: Distribution of task closing times of the various groups, by months.



	Treatment Approval (RO)		Peer Review (MP)		Peer Review (RO)		4D Gating	
	CC#1	CC#2	CC#1	CC#2	CC#1	CC#2	CC#1	CC#2
Defined Expiration Time	0,02	0,02	0,01	0,01	0,01	0,01	0,08	0,08
January	2,00	4,15	1,00	5,20	2,00	5,05	1,00	0,00
February	3,10	4,70	1,00	5,25	2,20	7,73	1,00	4,00
March	9,13	2,54	0,63	5,34	6,63	4,09	8,10	4,10
April	6,52	9,58	3,85	13,80	3,50	4,51	10,50	0,00
May	4,13	4,31	-2,80	1,00	3,28	4,25	3,50	0,00
June	4,45	0,00	-1,36	6,85	2,24	0,61	3,40	-1,50
July	3,21	1,13	-2,67	5,48	2,87	2,48	-0,42	0,66
August	4,16	3,82	1,00	8,61	5,60	5,20	2,40	2,16
September	2,20	0,33	-1,20	3,16	2,48	4,60	4,42	0,66
October	3,86	4,24	-4,24	6,06	2,76	3,02	1,00	-2,16
November	7,04	1,55	-2,49	16,70	1,40	2,80	5,00	1,00
December	8,50	3,09	0,12	7,17	5,41	3,00	7,80	3,25

	Planning Approval (MP)		Consult		Time Out (First Day)		Time Out (Daily)	
	CC#1	CC#2	CC#1	CC#2	CC#1	CC#2	CC#1	CC#2
Defined Expiration Time	0,02	0,02	0,03	0,03	0,01	0,01	0,02	0,02
January	1,30	3,70	1,10	0,00	0,00	0,00	0,00	0,00
February	1,40	5,10	1,20	0,00	0,00	0,00	0,00	0,00
March	1,73	1,00	1,28	0,00	-0,07	0,00	0,00	0,00
April	2,36	4,60	3,40	0,00	-0,02	0,00	-0,01	0,00
May	2,40	1,30	1,51	0,00	0,03	0,00	0,00	0,00
June	-0,64	0,00	1,42	0,10	0,00	0,00	0,04	0,00
July	-2,50	0,30	2,00	0,00	0,00	-0,10	0,00	0,00
August	-1,37	3,10	1,45	0,00	0,01	0,00	0,00	0,00
September	-0,90	0,80	1,78	0,00	0,00	0,00	-0,05	0,00
October	-2,83	2,10	1,10	0,00	0,00	0,00	0,00	0,00
November	-1,36	2,10	0,60	0,00	0,00	0,00	0,00	0,02
December	1,83	1,40	1,46	0,00	0,00	0,00	0,00	0,00

Figure 4: Days elapsed since preset date and time to perform tasks and the actual time to complete tasks.

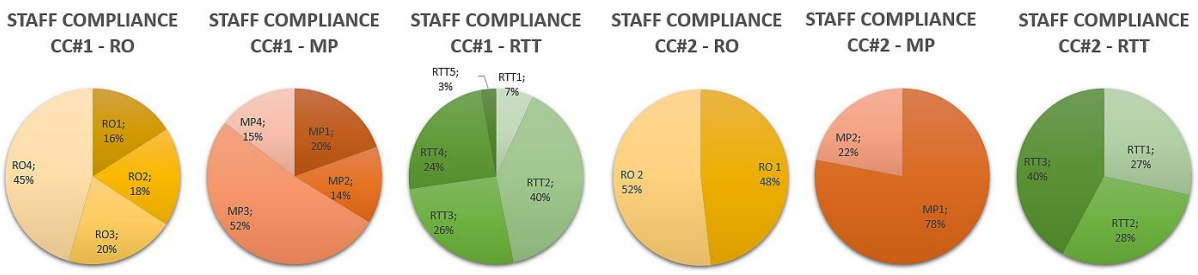


Figure 5: Annual average compliance of each RO-MP-RTT staff member (CC#1-CC#2) with the tasks planned for their reference category.

CONCLUSIONS

TASKS COMPLETED

The number of volumes shown in Table 1 consistently reflects the data collected.

The ratio between patient volume and staff employed, CC#1 and CC#2, is equivalent.

Measuring completed tasks allows us to define compliance with care paths, while the timing of tasks enables to determine areas for improvement. In this study, "Timeouts" are always performed on time, but the results of "Peer review" and "Treatment Approval" are not satisfactory.

Our goal is to reduce the number of tasks completed late, increasing the "on time" completion rate.

It is important to note that one area of improvement is to complete tasks before they expire. In fact, reducing the number of tasks completed ahead of time would increase the number of tasks completed within the default time window, while reducing the number of tasks completed beyond the time window (overdue).

The category of completed tasks could be used as an effective quantitative indicator to meet the different quality standards in cancer centers, and to improve the safety in the management of the various services provided to patients.

ELAPSED DAYS

The study focuses on identifying a correlation between qualitative and quantitative data to be used as quality indicators in radiation therapy.

As shown in Figure 4, it is possible to use elapsed days as a parameter to define a quality program: a defined delay time allows to track the tasks compared to their reference.

Measuring this gap in the unit can show if the delivery time of the various tasks is appropriate or if there is room for improvement. For example, in our study, the "Consult" activities in CC#1 are higher than our reference value, but in CC#2 they are optimal. Completion times must be improved in CC#1, but not in CC#2.

The time required for the RO to complete the "Peer review" tasks was higher than the preset reference value for completing the task. With this information, we were able to assess a change in the timing associated with the tasks that most showed a delay in completion.

STAFF COMPLIANCE

All analyzed data show that the procedures carried out in both centers and the relevant elapsed days differ from one task to another.

This means that the completion rate and timing depend on each staff member.

All categories can only be useful if all the staff involved in the unit's activities are willing to use the automated care path system.

As shown in Figure 5, there is no need to have a trend toward increasing completed tasks to achieve a result.

The purpose of reviewing "staff compliance" is to investigate whether the care paths are fast and easy to use in all their steps, not to determine the staff member with less performed tasks.

It is not mandatory that everyone should complete the same number of tasks, but that all tasks are completed by each associated group.

The division of the total number of tasks for each staff member allows us to detect who is not in compliance or who is responsible for the use of the care paths. This supports the quality improvement project and encourages the use of these automated paths, increasing the levels of safety at each step of the patient care process.

In conclusion, care paths are a good and efficient way to measure tasks in a radiation oncology unit, when used as a quality improvement tool.

The completed tasks and their completion times, elapsed days, and staff compliance are useful factors to analyze the different cancer centers regardless of their intrinsic differences.

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