Research Article

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Redesign of radiotherapy for prostate cancer: a proposal for universal healthcare systems

Ana Paula Beck da Silva Etges[1,2,3], Luciana Rodrigues de Lara[1], Stella Lisboa Sapper[4], Ana Von Frankenberg Berger[4], Melissa Streck[4], Laise Zardo[7], Armani Linhares[5,6], Marina Nassif[8], Angélica Zanotto[1], Marta Nassif Pereira Lima[8], Rafael Vargas*[,1,5,7] & Carisi Anne Polanczyk[1,3,8,9]

[1]National Institute of Science & Technology for Health Technology Assessment (IATS) – CNPq/Brazil (project: 465518/2014-1), Porto Alegre, 90035-903, Brazil

[2]Avant-garde Health, Boston, MA 02111, USA

[3]Graduate Program in Epidemiology, Universidade Federal do Rio Grande do Sul School of Medicine, Porto Alegre, RS, 90035-002, Brazil

[4]Crialab, Tecnopuc, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, RS, 90619-900, Brazil

[5]Department of Internal Medicine, Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, RS, 90619-900, Brazil

[6]Medicine course, Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA), Porto Alegre, Porto Alegre, RS, 90050-170, Brazil

[7]Hospital Santa Rita, Irmandade da Santa Casa de Misericórdia de Porto Alegre, Porto Alegre, RS, 90020-090, Brazil

[8]Universidade Federal do Rio Grande do Sul School of Medicine, Hospital de Clínicas de Porto Alegre, Porto Alegre, RS, 90619-900, Brazil

[9]Hospital Moinhos de Vento, Porto Alegre, RS, 90035-000, Brazil

*Author for correspondence: rafaelvargas@ufcspa.edu.br

Aim: This study was designed to recommend strategies to improve prostate patients' access to radiotherapy treatment in the Brazilian Unified Health System, along with a cost-tool to support radiotherapy care pathways' lead times and costs. **Methods:** Data was collected prospectively from patients with prostate cancer receiving radiotherapy in two Brazilian centers to provide data to apply design thinking and process reengineering techniques. The current status of the radiotherapy pathway was determined and the length of time taken for in-hospital activities was measured using data exported from ARIA®. Interviews with patients were used to estimate their waiting periods. This provided the data used to provide recommended strategies and the cost tool based on time-driven activity-based costing. The strategies were classified according to priority. **Results:** Data from 47 patients were analyzed. The mean interval from diagnosis to start of radiotherapy was 349 days (SD581), and the mean interval from seeking medical attention to starting treatment was 635 days (SD629). Twelve strategies affecting in-hospital processes and 11 impacting patients' care pathways and experiences are recommended, mostly focused on system improvement opportunities. A time-driven activity-based costing monitoring using data extracted from ARIA was coded and can be used by centers as a cost assessment guide. **Conclusion:** This study uses reengineering and design techniques to introduce priority strategies to allow more efficient and patient-centered radiotherapy.

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Keywords: costs • design thinking • prostate cancer • radiotherapy • value-based healthcare

Background

Prostate cancer is the second most diagnosed cancer affecting men worldwide. Approximately 1.3 million new cases were expected in 2018. The disease is also the fifth leading cause of death among men worldwide (359,000 deaths in 2018) and the leading cause of cancer death in 46 countries, particularly in sub-Saharan Africa and the Caribbean [1]. In Brazil, 65,840 new cases are estimated to occur each year from 2020 to 2022 [2]. In the city of

Porto Alegre, prostate cancer was the most common neoplasm among men and the leading cause of cancer death between 2015 and 2020 [3,4].

The main treatment strategies for intermediate-risk and high-risk prostate cancer are surgery and radiotherapy. No quality evidence has yet been produced showing the superiority of one treatment over the other, so shared decision-making between patients and clinicians is desirable, considering patient preferences and contraindications [5].

Cancer care pathways involve several and expensive therapeutic strategies, which underscore the power of using value-based management processes to deliver improved health outcomes without increasing costs. Looking for strategies that can result in better outcomes for everyone, the appropriate timing of treatment delivery to patients plays a decisive role in achieving favorable outcomes, highlighting the importance of establishing effective processes of care at all levels of the health system. Design thinking and reengineering techniques to achieve a more efficient care pathway have been increasingly used in research settings, where a reduction in the waiting time between diagnosis and treatment starting has served as a primary outcome measure [6].

According to data from Porto Alegre Oncology Panel [3], 87% of patients with prostate cancer (2019–2021) who were referred for radiotherapy waited more than 60 days to start treatment [7]. Identifying the bottlenecks responsible for the long waiting times is the first step toward a more efficient care pathway, and the application of design thinking techniques has provided evidence to achieve this goal and to design efficient and patient-centered health systems [8,9].

Strategies to redesign health services should result in better (or at least equivalent) health outcomes that do not increase costs [10]. Thus, it is necessary to establish an accurate measurement of costs along the entire length of the care pathway. Time-driven activity-based costing (TDABC) [11] is the gold standard method for cost assessment since it measures how resources are consumed along the patient's care pathways through the health system [12]. Since it is based on an understanding of the patient journey through the care continuum, TDABC can detect inefficiencies and guide interventions to improve care [13].

This study aims to recommend strategies to improve patients' access to radiotherapy treatment into the Brazilian Unified Health System, followed by a cost-tool to support radiotherapy care pathways' lead time and costs.

Methods

The multisectoral City Cancer Challenge (https://citycancerchallenge.org) aims to increase patients' access to the healthcare system and to optimize the financial coverage for prioritized diagnostic and treatment technologies. This project was an initiative to achieve these goals in the city of Porto Alegre. Design thinking techniques guided the project; after studying and measuring the current system, its main bottlenecks were identified, leading to proposals to increase efficiency. A cost management support tool was also developed based on the TDABC method. To carefully apply management techniques without overlooking essential clinical aspects of the disease, a multidisciplinary team of system designers, clinicians, and engineers was assembled. The project development was divided into two main stages: identifying extant challenges in the treatment pathway for prostate cancer patients and development of strategies to enhance radiotherapy access and the cost tool.

This study was approved by the research ethics committees of the Hospital de Clínicas de Porto Alegre (HCPA) (CAAE: 48521221810015327) and the Irmandade da Santa Casa de Misericórdia de Porto Alegre (ISCMPA) (CAAE: 38996020.8.1001.5335).

Identifying extant challenges in the treatment pathway for prostate cancer patients

Two hospitals from the public healthcare network (ISCMPA and HCPA) were invited to participate in the study. These hospitals performed approximately 85% of the radiotherapy procedures in patients with prostate cancer in the city of Porto Alegre between 2020 and 2021. Following the steps of reengineering, design, and TDABC studies, the process of mapping patient care pathways began at the two participating centers. Data from patients receiving radiotherapy for localized prostate cancer between March 2020 and May 2022 at either center were analyzed. Exclusion criteria were previous radical prostatectomy, non-curative treatment and refusal to consent.

When the initial care pathway mapping was concluded at each institution, a validation meeting was held between the researchers and the service coordinators. The final version guided the data collection process, which included interviews with the clinical staff followed by on-site observation. Subsequently, data were collected on the length of time required for in-hospital activities and the interval between the stages of the care pathway.

Data from ARIA® software (CA, USA), a system linked to radiotherapy equipment, were used to analyze in-hospital activities. The length of time required for an activity was defined as the difference between its starting

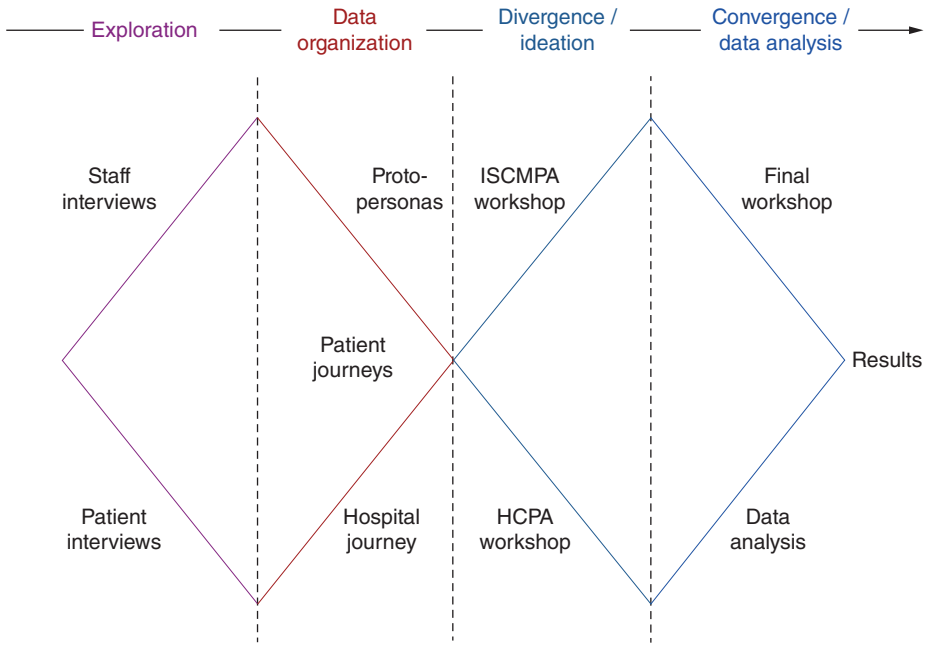

Figure 1. Methodology based on design thinking principles.

time and ending time in ARIA. Activities whose data could not be extracted from the software were assessed through on-site observation, followed by interviews with the clinical teams.

Once the interval between care pathway stages had been estimated, patients were interviewed. The interviews were conducted prospectively in person while patients waited to begin their radiotherapy sessions and retrospectively by telephone. For those who were interviewed by telephone, analyses of the medical records of patients who had already completed their course of radiotherapy complemented the interviews. Patients were asked about the following milestones: urinary symptom onset, when they first sought medical attention, when the care processes began, their first altered prostate-specific antigen results, when they first tried to schedule their second appointment, when their second appointment occurred, when they had their first consultation with a specialist (urologist), when the prostate biopsy was performed, when they had their second consultation with a specialist, when they had a consultation with a radiologist-oncologist, and when computed tomography for radiotherapy planning was scheduled and actually performed. Data about the treatment technology, fractionation, and the device used were extracted from the medical records and the ARIA system database.

The length of time per activity and the interval between treatment stages were analyzed descriptively, using means and standard deviations. The lengths of time of activities were the main input for constructing the TDABC-based tool, while the intervals between stages were used in the subsequent design thinking workshops aimed at identifying opportunities for improving the radiotherapy care pathway. Both results were also used to measure variability in care processes between centers, which was the agenda of workshops to co-create a gold standard radiotherapy service for the Brazilian Unified Health System.

Development of strategies to enhance radiotherapy access & the cost tool

Based on mapping and length of time measurements, design thinking workshops were held in each center and their results were used in a final workshop joining representatives from the two participating centers, the state, clinicians, and healthcare system policy experts. The Double Diamond design process model, developed by the British Design Council, was used to define the workshop dynamics [14], divided into the four phases (discover, define, develop and deliver) of the methodology. Each phase consists of a set of methods and objectives that guide the actions to be implemented. For this project, the phases were called exploration, data organization, divergence/ideation and convergence/data analysis [14]. Figure 1 presents the design thinking-based methodological sequence.

In phase I, Exploration, interviews were conducted with the clinical teams and patients to map the patient care pathway and the hospital processes of the radiotherapy service. Determining the hospital radiotherapy service

processes involved interviews with the clinical teams. Based on the results, the radiotherapy care pathway was outlined and broken down into clusters of important stages and/or processes: entry/first consultation, internal system (ARIA®), patient system (app/site), examinations, internal communication, patient communication, radiotherapy sessions and treatment completion. Understanding the hospital care pathway led to the development of the tool used in the ideation workshops with the hospital teams.

In phase II, data organization, fictional patients (personas) and care pathways were used. In phase III, Divergence/Ideation, ideation workshops were held with teams from the ISCMPA and HCPA to devise potential improvements in the radiotherapy service. The workshops were structured as follows: first, overviews of the patient journey, proto-personas, and the hospital journey were presented. Participants were then invited to share ideas about solutions for each cluster in the tool. In a targeted brainstorming session, the facilitators encouraged the participants to reflect on each step in the care process.

The workshops at each center brought together the clinical and administrative teams from the radiotherapy services, as well as project researchers. Each workshop produced recommendations for the short, medium, and long term, aimed to improve the patient treatment experience. The output at each center determined the dynamics of the final workshop.

Phase 4, Convergence/data analysis, corresponded to the final workshop, which encouraged discussions about the patient care pathway with representatives from all parties involved: patients, clinicians, policy makers, health professionals, health managers, and the researchers. At this meeting, the participants were initially divided into discussion groups and encouraged to present solutions for the main bottlenecks reported in prior workshops at each center. Each group was then invited to report their main findings in an environment of constructive and co-creative debate. Finally, the groups were invited to indicate on a care pathway map the stages at which their recommendations should be implemented, as well as to rank the recommendations in order of priority for achieving more efficient radiotherapy services for prostate cancer. The recommendations were categorized according to the object of impact (hospital or patient), the form of impact (procedure, communication, or systems), and the period in which the impact would occur (short term, long term, or unfeasible in the current format of the health system). Priority was analyzed as a matrix considering the domains of feasibility and impact on patient experience.

Based on the patient care pathway map and activities' mean length of time, a tool was developed in Microsoft Excel® for cost evaluation. To facilitate the on-site use of this tool, guidelines for financial data collection, data input, and suggested analyses were pre-coded.

The steps of the TDABC method were considered when developing the tool [15]. Based on the patient care pathway map, the resources consumed in each activity were identified and classified as infrastructure, staff, materials, or medication. Infrastructure includes all areas of the hospital in which patients receive treatment, while staff includes all classes of employees who spend time with patients. The mean lengths of time, which were mostly measured through ARIA, served as input to parameterize the tool and to estimate the cost per radiotherapy session and the cost of a complete course of treatment.

The total cost per patient care can be calculated by multiplying the time consumption of each resource by its cost per unit of time, plus the costs of materials and medication. The tool was coded to calculate the length of time of activities using automatically exported reports from ARIA, thus allowing automated cost estimation and monitoring at the centers that use the software. The median cost of care at each hospital, the median cost per resource, and analyses of the differences in median intervals between the stages of current and redesigned patient care pathways will be pre-coded as suggested analyses.

Results

Identifying extant challenges in the treatment pathway for prostate cancer patients

Data from 47 patients were collected over the study period. Most patients were treated with conventional fractionation (70.2%), were classified as high risk (44.7%), received their follow-up care through private health insurance at some point of the care pathway (63.8%), and had already been diagnosed with prostate cancer upon arrival at the specialized center (63.8%) (Table 1).

When the patient care pathways were mapped at each center, the greatest variability was found in registering patients into ARIA and in scheduling their treatment sessions. At HCPA, patients are registered into ARIA after referral for radiotherapy, whereas at ISCMPA they are registered after the computed tomography for radiotherapy planning. As for the scheduling of treatment sessions, at HCPA, the first treatment session is scheduled in advance

Table 1. Sample characteristics.

Characteristic	n = 47
Mean age (SD)	69.57 (5.29)
Fractionation type (%)	
Conventional	33 (70.21)
Moderate hypofractionation	3 (6.38)
(missing)	11 (23.40)
Technique used (%)	
3D	16 (34.04)
IMRT	20 (42.55)
(missing)	11 (23.40)
IGRT (%)	
No	33 (70.21)
Yes	3 (6.38)
(missing)	11 (23.40)
NCCN risk stratification (%)	
High	21 (44.68)
Unfavorable intermediate	8 (17.02)
Favorable intermediate	9 (19.15)
Low	1 (2.13)
Very high	4 (8.51)
(missing)	4 (8.51)
Follow-up care through private health insurance during the care pathway (%)	
Yes	30 (63.83)
No	12 (25.53)
(missing)	5 (10.64)
Arrival at the center (%)	
with diagnosis	30 (63.83)
without diagnosis	10 (21.28)
(missing)	7 (14.89)

IGRT: Image-guided radiation therapy; NCCN: National Comprehensive Cancer Network; SD: Standard deviation.

for 15 days after the computed tomography for radiotherapy planning, which may be rescheduled as needed by the patient, whereas at ISCMPA scheduling occurs after treatment approval.

The mean interval from diagnosis to start of radiotherapy was 349 days (SD, 581; median 141 [IQR, 82–257]), and the mean interval from seeking medical attention to starting treatment was 635 days (SD, 629; median 328 [IQR, 252–819]) (Figure 2).

Strategies to improve radiotherapy services for prostate cancer

A total of 21 strategies were recommended: 12 affecting in-hospital processes and 11 impacting patients' care pathways and experiences. Most involve systemic actions and can be implemented in the short or long term. Only 3 strategies, all of them affecting in-hospital processes, were considered unfeasible. These results are shown in Figure 3.

To prioritize the recommended strategies, their impact was weighed against the feasibility of their implementation. The top priority strategies included developing an informative book for patients and staff, creating a kiosk with a dashboard app containing individual patient information, and ensuring the presence of a navigator nurse (Figure 4).

Development of a cost management support tool

The tool and guidebook are provided in full in Appendix I.

The coded tool allows each institution to estimate its current costs with radiotherapy for prostate cancer and to identify activities from this care pathway which could be the focus of actions to increase efficiency. By using the tool, the lengths of time can be automatically updated at each institution by extracting a report from ARIA, facilitating

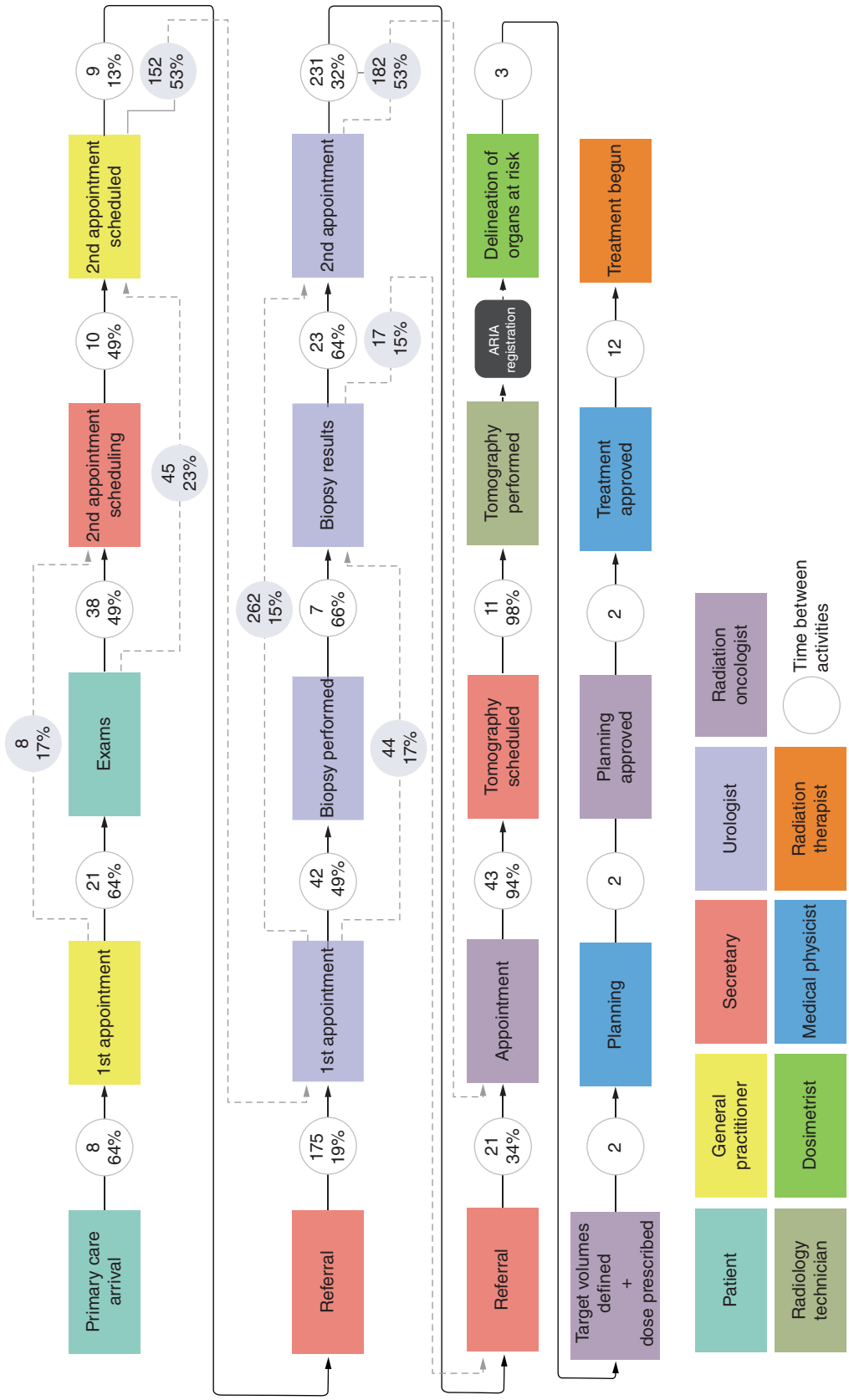

Figure 2. Mean interval between activities and the percentage of patients undergoing each activity. Time is expressed in days. The percentages represent the proportion of patients that were submitted to each activity.

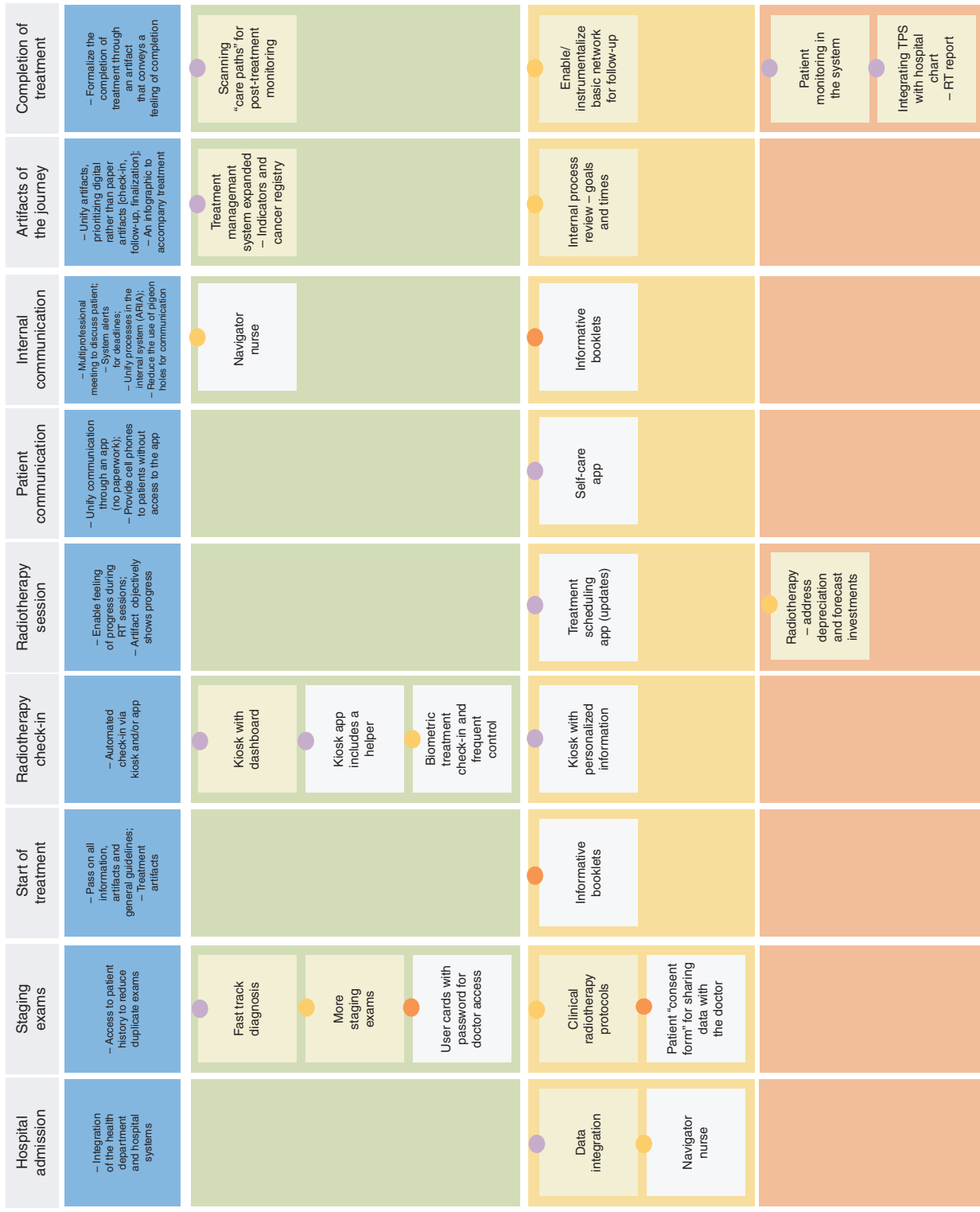

Figure 3. Categorization of the recommended strategies.

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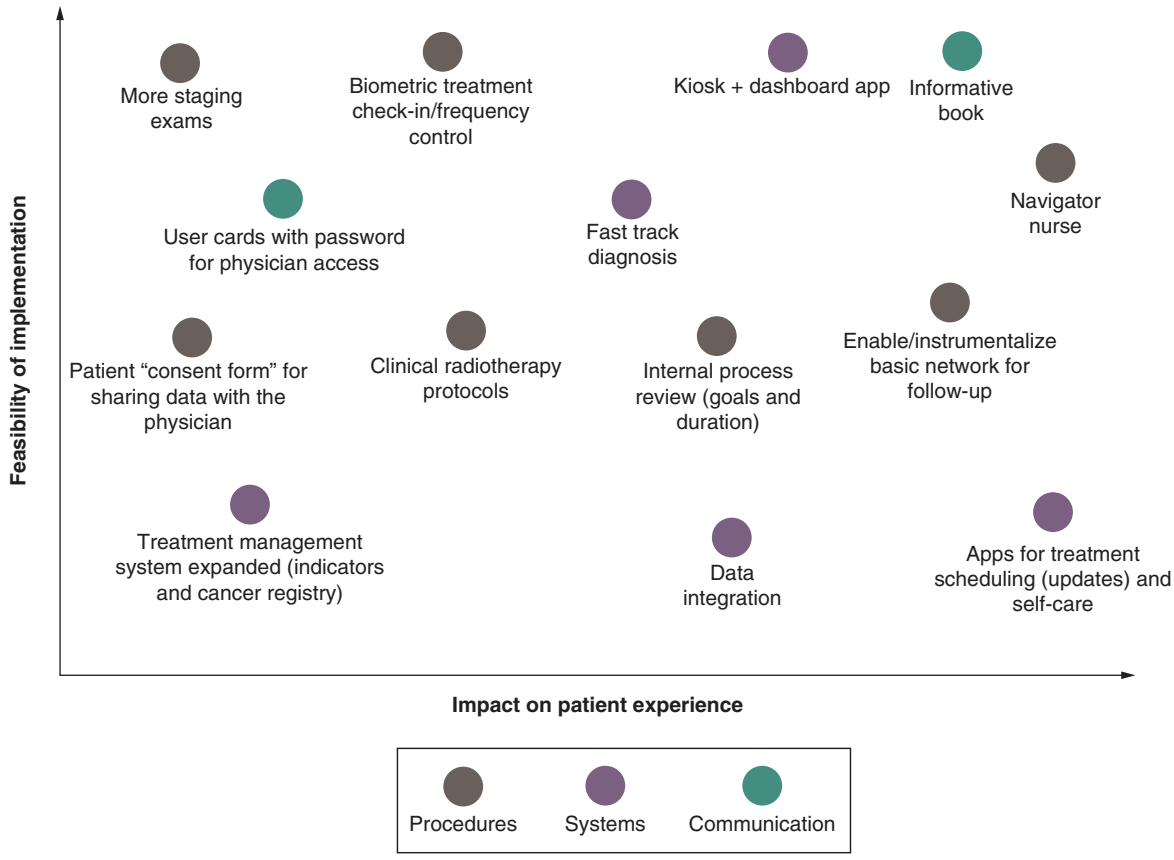

Figure 4. Recommendation priority matrix.

the use of the tool by healthcare managers. Graphs of cost analyses per patient, per radiotherapy session, per activity and their respective cost composition were pre-coded to facilitate the use of the tool in other centers. Stratification of the analysis considering clinical characteristics are also recommended to identify cost drivers justified by patients clinical conditions.

This tool can also be used by other cities involved in the City Cancer Challenge project, although the stages of the care pathway should be adapted to each region.

Discussion

This study innovates by using reengineering and design techniques to introduce priority strategies driven to establish more efficient and patient-centered radiotherapy services for prostate cancer. The results can guide health policy makers from universal healthcare systems toward informed action to provide more efficient, timely, and patient-centered services.

Treatment delay can increase patient morbidity and mortality. Retrospective data from patients with prostate cancer treated at three US hospitals between 1992 and 2001 showed that high-risk patients were more likely to have biochemical recurrence if the delay between diagnosis and the start of treatment was >2.5 months versus <2.5 months (55% vs 39%; p = 0.014) [16]. In addition, prolonged wait times for cancer treatment may have other deleterious effects on patients, such as anxiety and impotence in the case of prostate cancer, which may be particularly stressful in men [17]. Therefore, actions to improve the efficiency of screening and referral of patients with cancer are essential for value-based cancer care delivery, such as those presented in this study by exploring the capabilities of current radiotherapy technologies (e.g., ARIA software).

This study demonstrated the value of using design techniques involving multiple stakeholders, including patients. The successful application of these techniques allowed us to identify feasible short-term actions that may impact the overall experience of patients and lead to more efficient services. A distinctive feature of design thinking is the possibility of recommending strategies through input from all parties involved, including patients [18]. This project

was able to achieve transparency in communication between all parties at all stages of its development and to align the delivery of health services with patient needs, despite the difficulty posed by the involvement of multiple parties with different goals and skills.

The search for the best-value service also requires measuring and managing costs along the entire length of the care pathway, and TDABC has shown favorable results in this regard [15,19]. In the context of radiotherapy, a value measurement system has been developed that recommends the use of TDABC to measure costs, in addition to including 10 health outcome measures [20]. In comparison with traditional allocation methods used in studies estimating the cost of radiotherapy for prostate cancer, only TDABC analysis could identify the differences in costs between the different radiotherapy modalities, since the method allows a detailed understanding of how resources are consumed along the radiotherapy pathway [21]. A strong criticism is that the implementation of a TDABC system is complex [12]. Despite its complexity, however, TDABC is suitable for measuring the true cost of care delivery along the pathway, and the TDABC-based cost-tool developed in this project might help centers implement the accurate measurement of costs as a routine practice and make optimal use of the wealth of real-life data available from their systems.

Limitations

There are limitations to our project. The data were collected from only two centers and, therefore, the results cannot be considered representative of the Brazilian population, but only in the city of Porto Alegre and referring areas, and in the public healthcare system. Future analysis including private units, can be considered. We did not estimate the impact or the cost of implementing the recommended strategies, the cost tool or evaluate the implications of implementing the strategies in a real-world context, which is extremely recommended as the next step of this study. Only by developing applied case studies reporting cases of the strategies implementation it will be possible to accurately estimate the potential impact, from a healthcare system perspective, of the strategies adoption.

We also acknowledge that the qualitative nature of the study, involving content analysis, may limit the reproducibility of the method in other settings, leading to different recommendations and priorities.

Conclusion

The strategies recommended and the cost-tool developed in this study can be used by several centers and universal healthcare systems, contributing to improving the efficiency of radiotherapy services. The combination of reengineering and design techniques proved innovative and critical to the development of priority strategies to achieve more efficient and patient-centered radiotherapy services for prostate cancer. Future studies should be designed to assess the impact of implementing the recommended strategies and to extend the findings to other cancer care pathways that provide radiotherapy services.

Summary points

- This study examined ways to enhance patient access to radiotherapy within the Brazilian Unified Health System.
- Data was prospectively collected from prostate cancer patients undergoing radiotherapy in two Brazilian centers.
- The current radiotherapy pathway was evaluated using ARIA® data and patient interviews.
- A total of 12 strategies for in-hospital process improvement and 11 for enhancing patient experience were identified.

Author contributions

AP Beck da Silva Etges: designed the study, guided the data collection frames, coordinated the data collection, analyzed data and lead the writing process. LR de Lara: managed the data collection, analyzed data, contributed to the writing process. SL Sapper: managed the data collection, analyzed data, contributed to the writing process. AV Frankenberg Berger: managed the data collection, analyzed data, contributed to the writing process. M Streck: managed the data collection, analyzed data, contributed to the writing process. L Zardo: contributed to the study design, managed the data collection. A Linhares: managed the data collection, analyzed data, contributed to the writing process. M Nassif Pereira Lima: managed the data collection, analyzed data, contributed to the writing process. A Zanotto: contributed to the study design, managed the data collection, contributed to the writing process. MN Pereira Lima: managed the data collection and analysis, contributed to the writing process. R Vargas: designed the study, guided the data collection frames, coordinated the data collection, analyzed data, contributed to the writing process. CA Polanczyk: designed the study, guided the data collection frames, coordinated the data collection, analyzed data, contributed to the writing process.

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Competing interest disclosure
The authors have no financial and/or nonfinancial competing interests or relevant affiliations with any organization/entity to declare that are relevant to the subject matter or materials discussed in this manuscript. This includes employment, grants or research funding, consultancies, membership on scientific or other advisory boards, honoraria, stock ownership or options, paid expert testimony, patents received or pending, or royalties.

Writing disclosure
No writing assistance was utilized in the production of this manuscript.

Ethical conduct of research
This study was approved by the research ethics committees of the Hospital de Clínicas de Porto Alegre (HCPA) (CAAE: 48521221810015327) and the Irmandade da Santa Casa de Misericórdia de Porto Alegre (ISCMPA) (CAAE: 38996020.8.1001.5335). All methods were carried out in accordance with relevant guidelines and regulations (Declaration of Helsinki). Informed consent was obtained from all subjects and/or their legal guardian(s).

Data sharing statement
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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