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A patient-centric approach to improve health care services

Isaac Pergher[1], Vanessa Patzlaff Brandolf[2], Diego Augusto de Jesus Pacheco[3]* and Guilherme Luís Roehe Vaccaro[2]

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*Corresponding author: Diego Augusto de Jesus Pacheco, Department of Production Engineering, Centro Universitário Ritter dos Reis–UniRitter, Av. Orfanotrófio 555, Porto Alegre, Brazil
E-mail: diego_pacheco@uniritter.edu.br

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Tahir Nisar, University of Southampton, UK

Additional information is available at the end of the article

Abstract: This research proposes a diagnostics and improvement approach based on Total Quality Management to apply in cancer health care services systems. The proposed approach adopts the integrated use of process failure mode and effects analysis (PFMEA) and the current reality tree (CRT) from the Theory of Constraints Thinking Process. The utilization of those methodologies explores the strengths of each approach and it was implemented in two steps. Initially, CRT was built targeting the identification of the primary causes of low speed of service and the secondary elements that form the link between the focal problem and the primary causes. Next, the CRT data were utilized to create the PFMEA. To analyze the proposed model, a case study was applied in the radiotherapy service authorization process in a large Brazilian hospital. The main results permitted the definition of a set of actions to eliminate or reduce the failure modes in health care systems. In addition to that, one of the advantages of the approach proposed and applied is the identification of the root causes (RC) of the problem in flow management of patients, the undesirable effects of these causes and the prioritization of the improvement actions. The approach enables managers and decision-makers in health care systems to identify the global RC of

ABOUT THE AUTHORS

Diego Augusto de Jesus Pacheco is a researcher and professor in Operations Management, Production Strategy, and Innovation at UFRGS and UniRitter. He has about 140 papers published on Operations Management, Production Strategy, and Continuous Improvement.

Vanessa Patzlaff Brandolf is a professor and researcher in Clinical Research Oncology, manager of Mother of God Center Hospital acting Hospital Services Management and Clinical Research in Oncology.

Isaac Pergher is professor of Operations Management in Department of Production Engineering at FTEC College. His primary areas of research interest include Operations Management and Production Strategy. He has several articles published on Operations Management, Production Strategy, and Operational Research.

Guilherme Luís Roehe Vaccaro is a professor and researcher at Masters and PhD program in Industrial Engineering and Systems at University of Vale do Rio dos Sinos. His research focus is in Quantitative Methods and Operations Management, acting on the following themes: innovation, modeling, simulation, and multivariate methods.

PUBLIC INTEREST STATEMENT

Improving the efficiency and value of services is an import topic in health care systems field. However, there are in literature only few studies that have proposed methods to help the professionals of health to reach this goal. In this sense, in our research we proposed an approach to help the decision-makers, managers, and professionals of health to diagnose and improve health care systems focusing on the service to patient. The approach was applied in the radiotherapy service authorization process in a large Brazilian hospital. The results showed that our approach allows to define actions to eliminate or reduce the failures in the process in health care systems, as well as, allows identifying and prioritizing the root causes of the problems in the management of patients. Decision-makers and professionals of health services can use our approach to improve the patient management.

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problems and the prioritization of actions. The overall pattern of findings suggests that integration of PFMEA and CRT creates several benefits to increase the velocity of service to patient being treated for cancer in health care systems. Decision-makers can apply the approach to improve the velocity and the flow management of patients.

Subjects: Health & Society; Industrial Engineering & Manufacturing; Production Engineering; Public Health Policy and Practice

Keywords: health care; health services; PFMEA; CRT; performance; radiotherapy service; TQM

1. Introduction

Efforts to improve efficiency and value of services in health care systems can be found in literature. However, there are only few studies that have proposed methods that can be deployed by professionals of health systems. According to Bosworth and Cameron (2015), understanding the demand in health care services is important for health services management. It is possible to say that the success of an organization depends primarily on how it utilizes its resources to satisfy the customers (Dikmen, Birgonul, & Kiziltas, 2004). Determinants to improve the quality in health care systems were investigated by Fiva, Hægeland, Rønning, and Syse (2014) and Axon et al. (2015). In this sense, in hospital service processes, one of the main elements that contribute to the customer satisfaction is associated with the agility and reliability of the information given to the patient or his/her kin inasmuch as every piece of information will help to make a decision, which in turn, will trigger an action (Almeida, Sarti, Ferreira, Diaz, & Campino, 2013; Almeida, Travassos, Porto, & Labra, 2000). Hospital services incur costs that need to be offset by the patient himself/herself or by a public or private health system. Particularly, according to Zhu, Zhang, and Tsung (2007), the quality of the information is an important criterion for the construction of the brand in the service industry. Mühlbacher et al. (2015) demonstrated the complexity of patient decision-making processes regarding features of health care delivery systems.

The health plan operators have a peculiar market full of multifaceted rules defining when the patient is entitled to use the health services, constraints and other things that restrain the utilization of the services. In our case study, we observed that roughly 40% of the information given or documents submitted to the health plans are insufficient and are returned for completion, which slows down the authorization process. Besides, there are approximately 10% of cases where the treatment is denied due to particularities of the contractual relation between the operator and the insured person.

One of the main critical processes of hospital management is about the health plans. The process whereby a service request is reviewed and the resources are approved to carry out such service by a health plan is called "authorization." As a result of the authorization process, the hospital organization lets the patient know whether or not his/her health insurance plan covers the treatment cost, and case of denial, the patient is offered the choice to pay for the service out of his/her own pocket. However, in view of the required administrative procedures, the volume and the urgency of the required health services, the hospital organization often starts the service before the authorization from the health plan gets in, and assumes the risk and the necessary adjustments required by the collection process in the event of a service denial.

When the denial of authorization is communicated while the treatment is under way or near its completion, there can be losses relative to the customer dissatisfaction and the payment of the services rendered is delayed, which can generate negative consequences for the perception of service quality and sustainability of the hospital service. This scenario reduces the hospital organization's competitive capability and their potential to render good health services to the society. It is important to use continuous quality improvement to effectively enhance process quality in hospitals, and patient safety climate to improve patient safety outcomes (McFadden, Stock, & Gowen, 2015).

In view of the aforementioned, this article discusses the diagnostics of failures and their causes in the context of hospital services management. The main objective proposed in this research is to reduce the harmful impact caused by the deviations of the administrative process, potential loss generators for the organization in the process of treatment authorization in health services such as in hospitals. Considering our objective to the research emerges the following research question: how to eliminate or reduce the harmful impact caused by the deviations of the administrative process in health services? The discussion is presented by means of a applied qualitative study based on data collected from a hospital service unit. The study proposes to identify the variables that significantly impact on deviations of the patient service management process and propose improvement suggestions.

The selected unit offers radiotherapy services in a large Brazilian hospital organization situated in southern Brazil. The radiotherapy unit serves 100 patients per month on average and when the research was made, accounted for roughly 55% of the hospital revenue. Although the procedures were followed, a relevant quantity of process deviations was observed, which caused rework and income losses due to the reduced fees received from the health plans, not to mention the reduction in the quality perception for the services rendered in the eyes of the users.

The Current Reality Tree (CRT), a tool of the Theory of Constraints (Goldratt, 2004) and Process Failure Mode and Effects Analysis (PFMEA), a tool of the Quality Engineering (AIAG, 2008) is used to complement each other. Firstly, building the CRT builds knowledge and provides the means to structure the information about the process problems faced by the professional team. Additionally, CRT produces knowledge to identify the root causes (RC) and their connections with undesirable effects (UEs) which permit us to relate the central problem with its RC. The information thus generated produces inputs that go into the creation of the PFMEA. With it, we can understand the failure modes and propose preventive actions. The main results of study permitted to define actions to eliminate or reduce failures, and also the prioritization of the improvement actions.

In order to investigate the integrated application of CRT and PFMEA for the diagnostics of service management, our research is structured as follows: Section Two shows the Conceptual framework. Section Three shows the justification and details of the methodological procedures used in the research and describes the environment and the operational flow of the process investigated; Section Four develops the outcomes and the discussion making the critical analysis of the application, and lastly, is presents the conclusions and suggestions for further research.

2. Conceptual framework

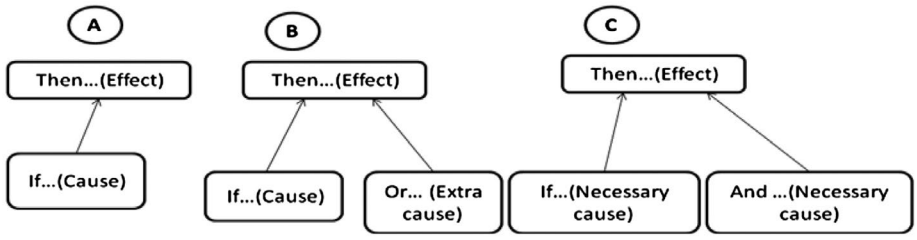
CRT is one of the five tools comprising the Thinking Process of the Theory of Constraints created by Goldratt (2004). CRT's purpose is to identify and characterize the central problems of a given system (Antunes, Klippel, Koetz, & Lacerda, 2004). CRT contributes to: (i) identify the impact of policies, procedures, and actions in a given area or across the entire organization (Boyd, Gupta, & Sussman, 2001); (ii) clearly and concisely communicate the causality of these policies, procedures, and actions; (iii) clearly identify the central problem in view of a situation (Choe & Herman, 2007); (iv) setup a work team to fix the problem. CRT describes the current/actual state of the system or a given reality (Antunes et al., 2004; Cox & Spencer, 1998).

The construction process of CRT starts from the identification of UEs and logical connections such as: "If ... , then ... " for the UEs. The process repeats itself iteratively during the CRT construction process until one or more root cause(s) are identified, and consequently, such efforts are made to identify the cause rather than the effects of the problem (Goldratt, 2004). Once the root cause is identified, a solution must be formulated to stop the root cause and eliminate the UEs.

According to Alvarez (1995), the arrangement represented by the letter A in Figure 1 is described as: if the cause occurs, the effect manifests itself. The arrangement of letter B makes reference to the existence of an additional cause, interpreted as follows: if the cause occurs or if the additional

Figure 1. How to interpret CRT.

Source: Alvarez (1995).



cause occurs, then the effect manifests itself. Lastly, the arrangement of letter C illustrates a sufficiency or insufficiency of cause, being understood: IF the cause occurs and the necessary cause, then the effect will occurs.

It must be noted, though, that all the information collected with the use of the CRT does not follow a specific allocation order of the diverse fields of the PFMEA. The PFMEA technique permits a structured approach to evaluating, conducting, and updating the development of projects and processes across the entire organization (AIAG, 2008; Palady, 1997). Sharma, Kumar, and Kumar (2008), Zhao (2011) and Puente, Pino, Priore, and de la Fuente (2002), state that FMEA is a method of project analysis utilized to identify the failure modes of a product or process and to determine the effect of each mode on the overall system performance. According to Ebrahimipour, Rezaie, and Shokravi (2010), FMEA is a method that helps with the analysis of potential reliability problems throughout the development phase of the project (product or process), and provides invaluable knowledge to future product and process projects (Nepal et al., 2007).

FMEA can be characterized into two major types: Project FMEA (DFMEA) and Process FMEA (PFMEA). In this research, only Process FMEA (PFMEA) will be employed. According to Aguiar and Salomon (2007), PFMEA is an analytical method for systematically and thoroughly detecting, eliminating and evaluating the failure modes of the production process and its causes and control mechanisms. In order to develop Process FMEA, the following steps must be completed (Helman & Andrey, 1995; Kumar, Poonia, Pandel, & Jethoo, 2011; Ravi Sankar & Prabhu, 2001; Teoh & Case, 2004): (i) determination of the process function(s); (ii) identification of the probable failure modes; (iii) definition of the effects of each failure mode to the people suffering the process impact; (iv) estimating the severity of such failures; (v) identification of the RC of the failures; (vi) calculating the probability of the failure occurrence; (vii) identification of the means for detecting the failure mode; (viii) estimating the probability of an early detection of this failure; (ix) determination of the priorities by means of the RPN calculation for each failure mode—Degrees of Risk Priority (Carbone & Tippett, 2004); and (x) defining the action plans to lessen the risk.

PFMEA proposes the use of tables to guide the process of determining those indexes to facilitate the estimation of the severity, occurrence, and detection of each failure considering a frequency pattern and a predefined scale (Kumar et al., 2011). Based on the values found for severity, occurrence and detection, the RPN value for each failure mode is calculated. The calculation model is given by the multiplication of the severity, occurrence and detection rate. This indicator is utilized to set the priority of correction and improvement actions. Generally speaking, the priority criteria for improvement actions are: (i) for a failure mode presenting a high RPN value and low severity value; and (ii) for a failure mode presenting a high severity rate and may present or not, the greatest RPN value (Palady, 1997). In light of those guidelines, the improvement actions can be formulated with a view to minimizing the degree of consequences of the failure modes and increasing the probability of an early detection of the occurrence of each failure.

PFMEA is currently a consolidated and widely used approach, and for this reason, it is discussed within the diagnostics of this research. Zambrano and Martins (2007) have applied the PFMEA method to evaluate the environmental risk throughout the production process of small companies.

The case studies were conducted in six small-sized Brazilian companies in the following industrial segments: metal-mechanics, food, textiles, plastics, a manufacturer of diagnostics kits for a clinical analysis laboratory, and a quarry marble stone supplier. Rosa and Garrafa (2009) utilized FMEA as an auxiliary tool for the development of a methodology to prioritize failure modes and their associated effects in order to determine preventive actions to improve agricultural processes. Rotondaro (2002) developed a model called SFMEA (Analysis of the Effect and Failure Mode in Services), based on the FMEA technique and designed to prevent the occurrence of failures in the production of services. Chen (2007) proposes the use of FMEA in conjunction with *Interpretive Structural Model*, a methodology designed to provide a quantitative index called UPN which can be used in lieu of RPN to sequence the improvement actions.

Ho and Liao (2011) used FMEA to assess the risk of potential causes in the process of disposing infectious hospital waste. The application outcomes permitted the identification of major risks and a set of improvement actions. Oldenhof et al. (2011) used two work teams to apply the FMEA to validate medical analytical processes for medication quality control. The authors found inconsistencies when the two FMEAs were compared and they suggest the use of an experienced supervisor as a process facilitator to improve the process consistency. Supplementary applications of FMEA in the health service industry can also be found at Kumru and Kumru (2013), Barends, Oldenhof, Vredenbregt, and Nauta (2012) and Meyrieux, Garcia, Pourel, Mège, and Bodez (2012).

McFadden et al. (2015) present a research model that shows how transformational leadership, safety climate, and continuous quality improvement initiatives are related to objective quality and patient safety outcome measures. Both employees and external experts can contribute to the evaluation of the success of a quality management program, but in addition, future research needs to focus more on objective measures of clinical outcomes, customer satisfaction, and economic performance (Carman, Shortell, Foster, & Hughes, 2010). Dusheiko, Gravelle, Martin, and Smith (2015) suggest that 1% improvement in the quality of stroke care could reduce the annual number of deaths in England by 95%. To Carlin, Dowd, and Feldman (2015) moving a clinic system into a vertically integrated delivery system, resulted in limited increase in the quality of care indicators.

Dawes et al. (2014) linked clinical and administrative records to differentiate patients continuously enrolled in Medicaid from those receiving coverage at the time of their cancer diagnosis and identified that continuous enrollment in Medicaid for at least 6 months prior to diagnosis improves survival. Quality improvement can achieve significant reduction in disparities in a wide range of clinical domains which can be sustained over time (Balicer et al., 2015). Mühlbacher et al. (2015) applyed four discrete choice experiments to measure patient preferences for 21 health system attributes. Cost attribute, trust and respect, multidisciplinary care, and shared decision-making were judged as most important. The relative importance of out-of-pocket cost was consistently lower in the hypothetical context of a new lung cancer diagnosis compared with diabetes or the patient's current health.

3. Method

With the purpose of investigating the integrated application of the CRT and PFMEA for the diagnostics of service management, this research adopts the case study strategy. According to Yin (2001), this strategy has a distinct advantage to a question such as "How" or "Why" over a contemporaneous set of events, over which the researcher has little control. In terms of objectives, the research can be classified as exploratory since it deals with little known problems, and it is designed to define hypotheses or propositions for future research. Given the focus presented herein, the specific results obtained cannot be generalized without further studies, although they can be used for future analytical generalizations (Eisenhardt, 1989; Eisenhardt & Graebner, 2007), giving rise to abstractions with similar cases.

The hospital service was chosen for the research by convenience since it is accessible to the authors, and because of its size, as it is the largest radiotherapy in operation in Brazil. The radiotherapy

service was selected because it is an essential health treatment for patients with cancer and also because it was recently acquired by the hospital under study, besides it required attention and review of its processes for the purpose of qualification and improvement of its performance serving the health insurance plans. The data were collected based on direct consented observation, documental data about the systems and records of the hospital service, and interviews of radiotherapy attendants and managers.

The first step of the work method involved the bibliographic research, which produced a wealth of information evidencing the joint use of FMEA and CRT in the management of health services and the main concepts about such methodologies. The researched articles in the databases were LILACS, MEDLINE, PubMed, Science Direct and Elsevier.

The next step of the research work involved training the hospital staff that made up the project team. The main concepts associated with the analysis techniques utilized were presented, and three reception attendants, an authorization clerk, a nurse technician, a staff nurse, a medical physicist, and a physician. The purpose of the training was to provide the team with the theoretical elements they needed to carry out the other research step.

During the data collection phase, the database was built about the flow of the authorizations and treatment in the department under study. The following guiding questions were employed in the conduction of the data collection process: (i) How does each of the 8 steps of the radiotherapy authorization process shown in Figure 2 fall short of performing its tasks (failure)?, (ii) What are the possible UEs from the occurrence of the failure modes identified in each step of the process?, (iii) Does the radiotherapy process utilize devices that contribute toward the early detection of a failure mode?, (iv) What are the RC that bring about the failure modes in each step of the process?

In the CRT and PFMEA development phase, the information generated in the three steps to establish the relationship between the RC and the UEs brought about by the occurrence of those causes, considering the following central problem: okaying the patient to begin the radiotherapy in advance of the health insurance plan authorization. The option for CRT in this research is based on its methodological characteristic, i.e. to help with the thinking and decision process to get to understand the RC that contribute to the occurrence of the main failure of the authorization process, called "okaying the patient to begin the radiotherapy in advance of the authorization from the health insurance plan." The outcome was presented to the hospital team for refining and accreditation. The final outcome of this step was the identification and connection of the UEs with the RC, which led to the understanding of the links that have the greater impact on the problem in question. Following that, the PFMEA study was conducted in the light of the learning generated from the CRT construction exercise and with the information collected in Step 3 to get to understand the failure modes and propose possible prevention actions for them.

The use of PFMEA aimed at prioritizing the more influent failure modes in the patient authorization process in order to facilitate the organization of the team to carry out the improvement actions. Again, the outcomes were presented to the hospital team for refinement and accreditation. The severity, occurrence, and detection values for each failure mode were identified by the team taking into consideration the tables of the FMEA Manual, 4th edition. Lastly, the fifth step of this research consisted of the presentation of the outcomes reached with the application of CRT and PFMEA, and the difficulties overcome as the proposition of this research was carried out. Based on those results, improvement proposals were drawn up in conjunction with the hospital team. RPN and the existing degree of severity were utilized to set the priorities in order to minimize the losses originated from the focal problem.

4. Results and discussion

The process studied consists of eight major steps as shown in Figure 2. Figure 2 also illustrates the sequence of activities to be performed and the points where waiting in the process takes place.

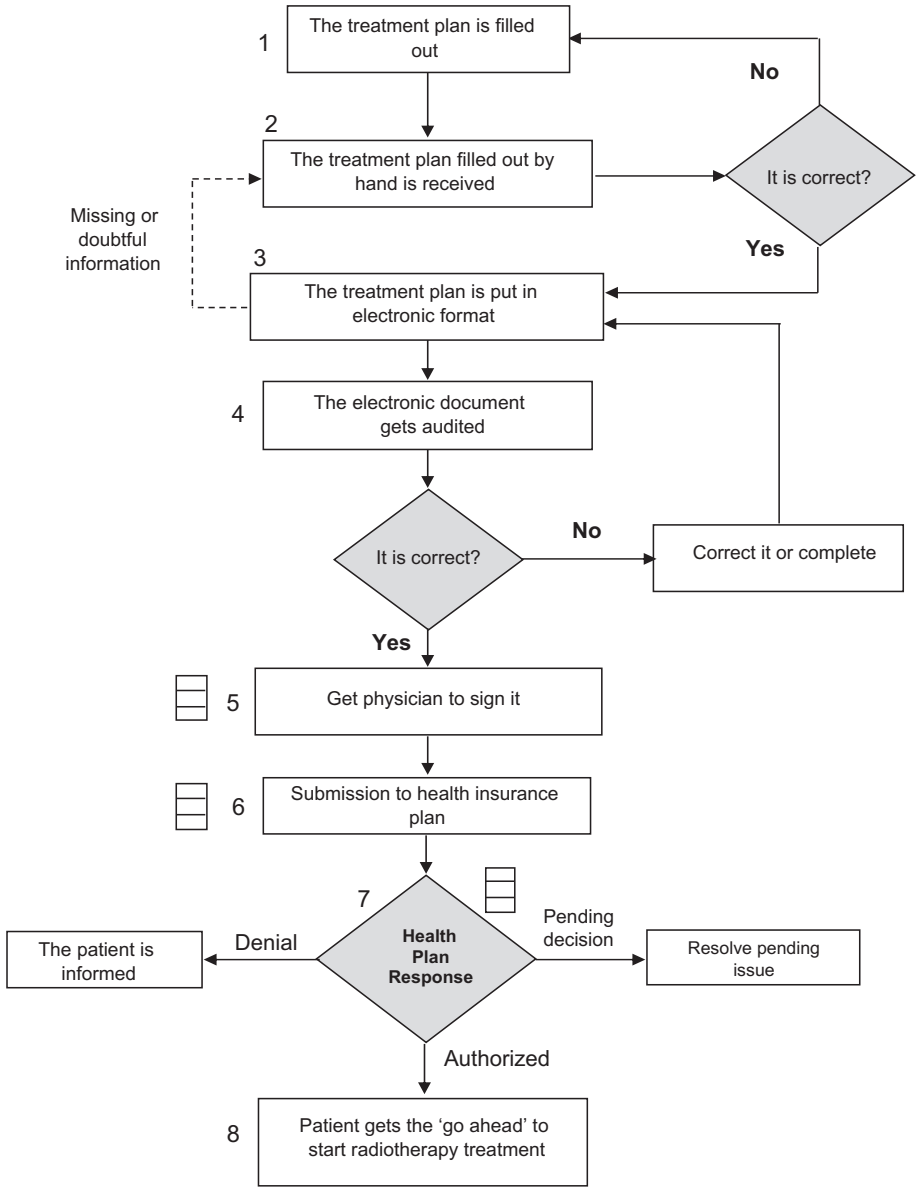


Figure 2. Process flow: radiotherapy authorization.

Source: Authors (2016).

Step 1, filling out the treatment plan, takes place when the need to use radiotherapy in the patient is identified. The physician fills out the treatment plan by hand, which is attached to the patient's record sheet and consists of the following data: (i) identification data filled out when the patient is admitted; (ii) specific data regarding the diagnostics; and (iii) physician supplied treatment specifications. The treatment plan was laid out based on information required by the health insurance plans with the purpose of improving the completion process of the electronic form which comes later in Step 3.

After the completion of Step 1, the physician hands the treatment plan over to the secretary (Step 2) and she checks it over to make sure it has all the necessary information to transfer it to the electronic format (Step 3). The flow of the treatment plan can take one of two directions: it can be forwarded to the typing department when it is fully compliant with the standards or it can be referred back to the physician for correction in case of missing or doubtful information. In this case, after it is corrected, the plan is sent back to Step 3.

The data entry department receives the treatment plan, filled out by hand, from the secretary and puts it in electronic format. In this phase, the specifications of the characteristic codes of each health insurance plan are included. In case of missing or doubtful information in the plan completed in Step 1, it is sent back to the physician's secretary (Step 2) for correction of those elements (Step 1), and later it is referred back to the typing department.

As soon as the typing is done, the plan is sent to the audit department where the information is checked for conformance (Step 4). In this step, the data about the type of treatment prescribed by the doctor are checked. As Figure 2 shows, when the audit department approves the typing process of the plan, the plan is sent back to the typing department. The Typing department gets the physician to sign it (Step 5). Delays may occur in Step 5 due to the lack of full-time physicians at the radiotherapy unit. In those situations where the audit department rejects the process performed in Step 3, the treatment plan is referred back to the typing department for correction of the mistakes.

Following the physician's signature (Step 5), the plan is finally referred to the authorization department. This department submits the plan to the health insurance plan (Step 6) by telephone, facsimile, or over the web pursuant to the requirements of every health plan. After submittal of the plan, the waiting time is up to 72 h, but this information presents a high degree of deviation from the standards.

The health insurance plan's response (Step 7) can be in three ways: authorization denied, authorization given, or authorization pending a final release. When the health insurance plan denies the treatment requested, the patient or his/her kin should be notified at once. The authorization pending a final release occurs when the health insurance plan requires further information, so seeking the additional information is of essence. After the additional information is received by the health insurance plan, it takes another 72 h to give the response. When the treatment is approved, the patient can make the appointments to begin the radiotherapy treatment (Step 8). When all the radiotherapy sessions are given, which takes from 5 to 8 weeks on average, the patient's bill is sent to the billing department for collection.

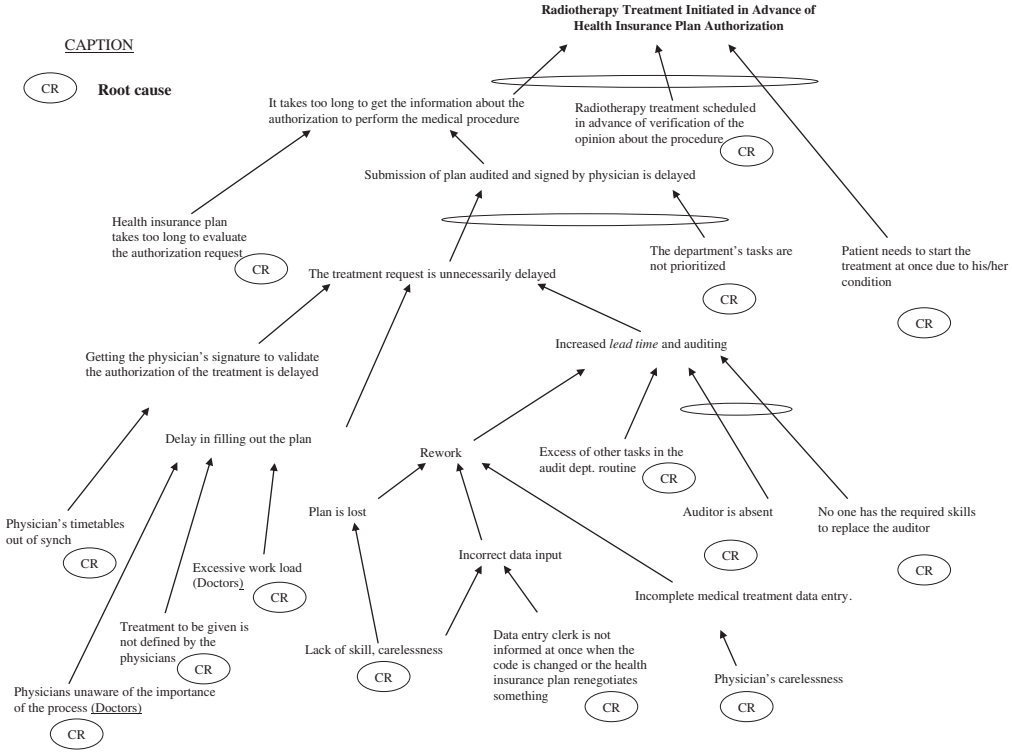
Figure 3 shows the structure of the CRT. As the cause and effect relationships are analyzed via CRT, it becomes evident that the main effect "Radiotherapy treatment begins in advance of health insurance plan authorization" occurs because the Radiotherapy treatment is initiated soon; it takes a long time to get the authorization and the patient needs the treatment urgently due to his/her current condition. The use of the CRT let the team understand the relations between the activities that are not necessarily perceived as integrated, beginning with failure such as treatment plan not completely filled out; lack of communication to the data entry clerk about the change in codes or new negotiations with the health insurance plan; treatment performed without the record of medical guidance; and lack of synch of the physician's timetables. Those failures, though apparently simple, relate to activities typically dependent on human action and non-automated in the information systems. Besides, they compete with other routine tasks performed by the teams involved in the process. This understanding was presented as an upside of the CRT application from the team's standpoint.

Next in the sequence of research findings comes PFMEA shown in Table 1 and developed by the same team as the CRT team. In the Functions Performed by the Process Field, the eight steps of the Authorization process are presented. Those eight steps together represent the assessment of the treatment authorization requested for the patient. The remaining fields were filled out using CRT data and the team's experience, as follows:

(1) Filling out the treatment plan: the failure modes identified in this process are incomplete medical data entry. Someone has to push someone for the missing information or the plan is not filled out, in which case the treatment plan is not referred to the data entry department. The creation of an audit point for this process would increase the overall lead time adding to the already long waiting time for the patient. Such failures can be attributed to the physician's

Figure 3. Current reality tree.

Source: Authors (2016).



carelessness when he/she fills out the information, excessive work load, and unawareness of the importance of this procedure for the overall authorization process. The paperwork is a necessary evil in this case since the physician is the only person in a position to indicate the suitable treatment, a fact that physicians often fail to understand. They believe that their job is the treatment alone, and that this administrative chore is not part of it. In some cases, the physician may be uncertain about the ideal treatment for the patient. They may be waiting for some lab tests, for instance, and for this reason they do not fill in the information when they send out the form, leaving the missing information to be supplied later on. The existing control in these steps of the process consists in the physician's secretary reading them to see whether the fields have been filled. The recommendations to cope with these situations are: definition of a specific place to keep the plans awaiting the definition of the treatment, training for the secretaries to precisely identify at the origin the incomplete plans and an action to build awareness of the medical and administrative staffs of the importance of carrying out all the tasks thoroughly.

(2) Receipt of the treatment plan filled out by hand: the failure mode identified in this process is that the plan filled out by hand gets mislaid because there is no standard place to keep it while the data entry clerk is away from his/her workstation. Currently there is no control over this operation since the data entry clerk does not know which plans have been filled out and must be put in the electronic format. The recommended action for this process is to define a specific place to keep the plans with admittance restricted to the data entry clerk.

(3) Conversion of the plan filled out by hand into the electronic format: the failure mode identified in this process is the incorrect data entry, which causes rework, correction, and re-entry of the data after the plan is audited. The causes identified are carelessness of the data entry clerk, lack of specific training for this task, and the lack of a procedure that would communicate the new codes when the health insurance plans change their codes. The recommended actions to eliminate this failure include training the data entry clerk to quickly identify the incorrect data entries, awareness of the importance of this procedure and make the new codes available to

Table 1. FMEA of the radiotherapy authorization process

Failure Mode and Effect Analysis–FMEA

Process: Radiotherapy Treatment Authorization **In charge of the process: _____** **FMEA N°: 01/xxxx**

Team: _____ **Date: ___/___/____** **Pages: 1 to 2** **Data FMEA**

(Beginning): 03/12/xxxx **Prepared by: the Authors**

Type	Jobs	Failure modes	Effects	Severity	Causes	Occurrences	Controls	Detection	RPN	Recommended actions
1	Filling out of the treatment plan	Incomplete data entry	It must be filled out again	4	Lack of awareness of the urgency of the process	3	Physician's secretary quickly reviews the filled out plan without a procedure and required reviewing skills	8	**96**	To train the secretary to identify the data more thoroughly
			Generate audit point	6	Physician's carelessness	6			**288**	Physicians become more aware of the importance of filling out the plan thoroughly
					Physician's excessive work load					
		Incorrect data entry	Submission of plan to health insurance plan is delayed	10	Physician's carelessness	6	Secretary checks it over	6	**360**	To define a method to control the open plans without defining the type of treatment
					The type of treatment the patient should receive is not clearly defined					
2	Receipt of the plan filled out by hand	Plan is lost or misplaced	Submission of plan to health insurance plan is delayed	10	There is no suitable place or storing identification method	3	Nonexistent	10	**300**	To define a suitable place to put the plan and train the team
3	The treatment plan is entered in an electronic form	Wrong data entry	Rework	5	Standardization of forms and codes	5	There is an audit department in place already to check this failure	4	**100**	To check whether they can be standardized
					Lack of skills, carelessness	6			**120**	To build team awareness of the importance of correct data entry
					Lack of a procedure to advise data entry clerk at once when a code is changed or the health insurance plan renegotiates	4			**80**	To communicate the code changes and negotiation by email
4	The electronic form is audited	Application of controls	Submission of plan to health insurance plan is delayed	9	Excess of tasks in the auditing department's routine	5	Nonexistent	10	**450**	To create an indicator to measure the throughput time
		Authorization of reviewed treatment is delayed			Lack of skilled person to conduct the audit in the absence of the auditor	6		10	**540**	To train the data entry clerk to check this over when the plan is digitally filled out
5	To get the physician's signature	Go ahead for the already signed plan is delayed	Submission of plan to health insurance plan is delayed	9	Physicians' timetables are out of synch	6	Nonexistent	10	**540**	To create a digital signature for every physician

(Continued)

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Table 1. (*Continued*)

Type	Jobs	Failure modes	Effects	Severity	Causes	Occurrences	Controls	Detection	RPN	Recommended actions
6	To submit the form to the health insurance plan	Submission to health insurance plan is delayed	Response from health insurance plan is delayed	7	Tasks are not prioritized	6	Nonexistent	10	**420**	To create a task list with priorities on top
					Team is unaware of the importance of the process	6				To allocate this task to another work post
										To build awareness of the importance of timely submittal of the plan to the insurance health plan
7	The health insurance plan's response	Health insurance plan's response is delayed	Treatment is initiated in advance of response from health insurance plan	10	Deficiencies in the internal processes of the health insurance plan	6	Nonexistent	10	**600**	To create a indicator to monitor the health plan's turnaround time
8	Patient gets the go ahead to start making the radiotherapy appointments	The opinion about the procedure is not verified before the radiotherapy sessions are scheduled	Treatment is initiated without authorization	10	Lack of a procedure to manage this failure mode	6	Nonexistent	10	**600**	To set up a process to check this over prior to scheduling sessions and train the team

Source: Authors (2016).

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the data entry clerk as soon as they are communicated to the company. Possible solutions were discussed, but although potentially effective, they would call for an expenditure that the hospital could not afford at the time of the research.

(4) Audit of the electronic form: the failure modes identified in this process involve a late handover of the reviewed plan, which increases the lead time and delays the submission to the health insurance plan. This audit is performed by a strategic staff professional that performs other diverse activities. If the data entry clerk were trained to perform this task, a step of the process would be eliminated reducing the overall process lead time. The creation of an indicator that could measure the throughput time of the process is an improvement idea that was discussed.

(5) Getting the physician to sign the plan: the health insurance plan requires that the requesting physician sign the plan. As the physicians do not work full time at the hospital, the plans are often overdue for signature, which delays their submission to the health plan operators. There is no control over this process. An improvement option would be to create a digital signature for the physicians. This would speed up the process of sending the plan to the health insurance operators. In addition to that, measuring the time it takes to sign the plan would constitute a control method.

(6) Submitting the plan to the health plan operators: the steps so far involved the preparation of the plan for submission to the health plan operators, a critical step for the authorization of the radiotherapy procedure. A late submission generates a late turnaround and a slow authorization. As this job is done by the hospital reception clerks at the front desk, where all the other patients come in for admittance, the preparation of the plan is not a priority. The incoming patients and telephone calls are the priority. The recommendations identified in this process are to move this task to another work post that could prioritize the submission of the plan to the health care operator and make the team aware of the importance of this activity. There is no control over this process.

(7) Response from the health insurance plan: after the plan is sent to the health plan operator, the hospital awaits the authorization to perform the requested service. Sometimes the response can take longer than expected due to a late submission of the plan, carelessness of the health plan operator who mislays the documents and does not ask for a resubmission. In view of that slow turnaround, the treatment may begin in advance of the authorization. When the health insurance operator is overdue for a turnaround, the Radiotherapy service calls to ask what is taking them so long and indicates that the plan is not under examination. There is no control over this process, so it is necessary to track all the plans submitted to the health care operators to identify which ones are overdue for a response.

(8) Patient gets the “go ahead” to schedule the radiotherapy treatment: the first radiotherapy sessions are scheduled in advance of the authorization from the health insurance operator so the treatment begins without authorization. In this case, it is indicated that the health insurance operator has not authorized the treatment although the patient has begun the treatment. When this problem is identified, the patient is notified at once and a feeling of dissatisfaction and frustration sets in because the information came in after the treatment had already begun. As there is no control over this process, the patient should be informed in advance so that he/she could decide about beginning the treatment. This process is extremely critical and it is suggested that actions be taken to create awareness for the team and eliminate this process failure.

In the view of the hospital staff, the PFMEA development set the focus on the most impacting failure modes of the process. With this focus, improvement actions were defined as follows: if the

Table 2. FMEA of the radiotherapy authorization process

Type	Failure modes	Severity	RPN	Recommended actions	Priority sequence
1	Incomplete data entry	4	**96**	To train the secretary to identify the information better	**5**
		6	**288**	To build team awareness about the importance of filling out the document	
	Filling out of the plan is delayed	10	**360**	To define a control method for the open plans for which the type of treatment has not been defined	**2**
2	Plan is mislaid	10	**300**	To define a suitable place to put away the document and train the team	
3	Wrong data entry	5	**100**	Verify if it is possible to standardize	**6**
			120	To build team awareness about the importance of entering the correct data	
			80	To communicate the code changes and negotiations by email	
4	Increased process lead time	9	**450**	To create a indicator to measure the throughput time	**3**
	The reviewed plan takes too long to go ahead		**540**	To train the data entry clerk to perform this audit when the plan is filled out in electronic format	
5	Delay in moving ahead the plan already signed	9	**540**	To create a digital signature for every physician	
6	Late submission of the plan	7	**420**	To create a task list with priorities on top of it	**4**
				To allocate this task to another work post	
				To build team awareness about the importance of promptly submitting the plan to the operator	
7	Response from the health insurance plan takes too long	10	**600**	To create an indicator to measure how long the health insurance operator takes to respond	**1**
8	No verification of the opinion in advance of scheduling Radiotherapy sessions	10	**600**	To establish a verification process in advance of scheduling radiotherapy sessions; to train the team	

Source: Authors (2016).

failure mode presents a high RPN value and low Severity value, or for a failure mode presenting a high severity rate, whether or not it illustrates the higher RPN value. Table 2 presents a set of improvement actions recommended according to the diagnostics proposed in this study. It begins with the development of a process to ascertain the health insurance operator's response prior to scheduling the treatment sessions and the creation of an indicator to monitor the turnaround time for the authorization request, and the possibility of setting up standard work and creating team awareness about the importance of entering the data correctly and informing the code changes and negotiations by email.

As it concerns the process of hospital services, and the type of information generated in this environment causes significant impacts on customer satisfaction and late receipt of the hospital service fees, the improvement actions were implemented in parallel by teams selected to implement one or more actions. Such strategy was possible because most of the actions defined do not require significant outlay.

An examination of Table 2 will reveal that the following actions are priorities to minimize the main undesirable effect: (i) to implement the verification process before scheduling the sessions and train

the team; (ii) to create a control method for the open plans with type of treatment still undefined; (iii) to implement a indicator to measure the throughput time of the process; (iv) to adopt a digital signature for the physicians; and (v) to enhance the training for all stakeholders. According to evidence stated by the department personnel, the prioritization and understanding of the necessity of such actions was possible thanks to the joint application of CRT and PFMEA. CRT helped to understand the intermediary relationships of cause-effect between the activities and permitted to identify the RC. PFMEA contributed to systematize the actions to block the UEs hierarchically.

In a wider overview, the proposal to integrate the CRT and PFMEA approaches to improve health care processes is based on the perception of an application gap, as it is highlighted in the methodology sections and in literature, according to evidence presented by Kumru and Kumru (2013), Barends et al. (2012), Meyrieux et al. (2012) and Ho and Liao (2011). Based on the field study conducted and on the analysis of the references consulted, this section seeks to explain the conceptual scheme proposed in the research. Hopefully, still under the judgment of a systematic validation process to be carried out by other research jobs around the world, this research will contribute to improve the management of health services. Figure 4 presents an overview of this conceptual approach proposed, more thoroughly discussed below.

The resulting conceptual scheme obtained from the previous research steps and the post-case study validation formulates a proposal to integrate CRT and PFMEA in TQM process. A contribution of the scheme to improve the management of health services is the approach proposed to identify the root cause of problems using the UEs currently affecting the hospital service management and the prioritization of the actions that must be taken to eliminate the problems. The conceptual scheme is an alternative that contributes to fill the gaps identified in studies about improving the management of health care services (Barends et al., 2012; Carman et al., 2010; McFadden et al., 2015; Meyrieux et al., 2012; Paparella, 2007; Puente et al., 2002; Spath, 2003).

We believe that the research presents a relevant contribution to the traditional literature about PFMEA, traditionally applied in industrial environments, and CRT, which does not have in its application steps any approach to prioritize the RC identified. According to Carman et al. (2010), process

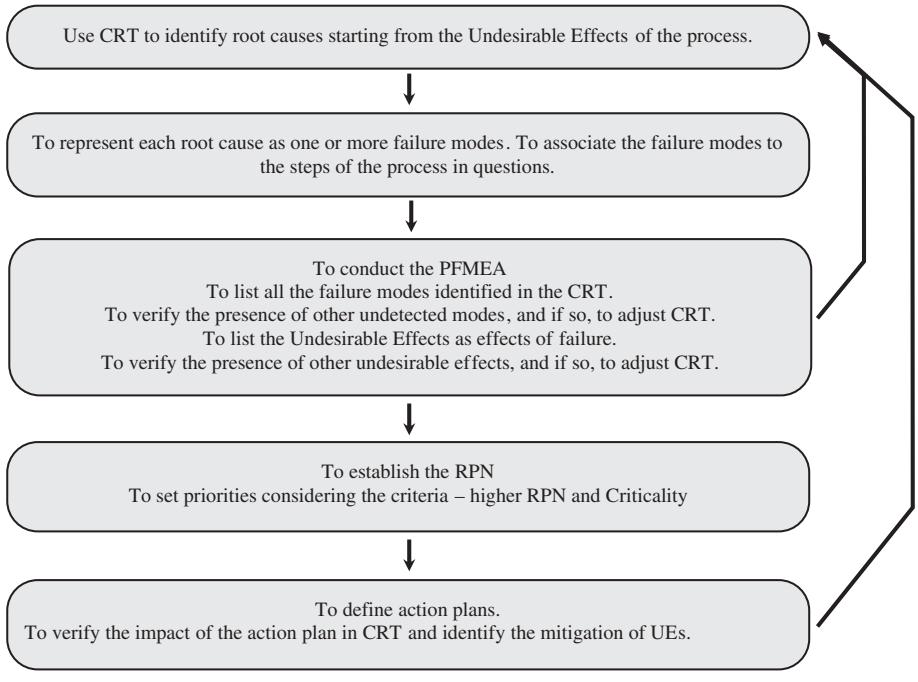

Figure 4. Proposed approach scheme and application.

Source: Authors (2016).

improvements lead to efficiency improvements and that process improvements and an empowered work force produce improved customer satisfaction and improved efficiency.

5. Conclusions

The results showed that our approach allows to define actions to eliminate or reduce the failures in the process in health care systems, as well as, allows identifying and prioritizing the RC of the problems in the management of patients. The outcomes show that the team involved with the problem was able to better understand the problem and its causes.

The study put together concepts widely used in production environments and services of the hospital environment. It is understood that this is one of the major gains achieved by the application in the hospital context. Our research also permitted the suggestion of a way to combine the techniques utilized as shown in Figure 4 to improve health care systems.

The utilization of CRT as a tool to identify the effects of failure modes is considered relevant, particularly as it offers guidelines for the process of building the PFMEA. The combination of those techniques substantiates the understanding of the problem and its possible connections (CRT contribution) and helps to setup the process of prioritizing and selecting improvement actions (PFMEA contribution).

It also supplements deficiencies that both techniques present when they are utilized individually: CRT's potential lack of structure and prioritization for the improvement actions and PFMEA's potential lack of full understanding of the relations between UE's and their causes were identified. Therefore, the outcomes of this study contributes to the advancement of other research on the prioritization of critical actions for health care services conducted in Kumru and Kumru (2013), Barends et al. (2012), Meyrieux et al. (2012) and Ho and Liao (2011).

Additionally, although it has not been explored in this report, there is a general understanding that CRT could be utilized to validate the sequence in which the recommendation actions should be performed, as well as the use of other TOC tools such as the Future Reality Tree and the Evaporation of Clouds (Goldratt, 2004). This discussion is left here as a proposal of future research work. Besides, there is an intention to expand the analysis made through this study, utilizing the method that emerged from other hospital processes in order to refine and expand it. The combination of the Systemic Thinking methodology and PFMEA is a good alternative for future research. We believe this study has laid a solid foundation for improving the flow management of patients in health care systems.

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Author details
Isaac Pergher[1]
E-mail: isaacpergher@gmail.com
Vanessa Patzlaff Brandolf[2]
E-mail: vanessa.onco@maededeus.com.br
Diego Augusto de Jesus Pacheco[3]
E-mail: diego_pacheco@uniritter.edu.br
Guilherme Luís Roehe Vaccaro[2]
E-mail: guilhermev@unisinos.br
ORCID ID: http://orcid.org/0000-0001-9992-7380
[1] Federal University of Pernambuco, Av. Professor Morais Rego, 1235-Cidade Universitária, Recife 50670-901, PE, Brazil.
[2] University of Sinos Valley-Unisinos, Av. Unisinos, 950, Bairro Cristo Rei, São Leopoldo, RS, Brazil.
[3] Department of Production Engineering, Centro Universitário Ritter dos Reis–UniRitter, Av. Orfanotrófio 555, Porto Alegre, Brazil.

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