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Modeling of processes, decisions and failures: an application in the context of services of the National Student Assistance Policy

Modelagem de processos, decisões e falhas: uma aplicação no contexto de serviços da Política Nacional de Assistência Estudantil

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Abstract
The National Student Assistance Policy has contributed to the academic development of students at federal educational institutions. However, like other public bodies, these institutions were faced with the challenge of providing services efficiently to citizens. The article aims to analyze failures in the clinical care process of the Dental Service offered by the student assistance segment to students at a federal educational institution. Due to its complementary nature, the FTA and FMEA techniques were used to analyze the failures identified from process models created through the BPMN techniques, which recorded the sequence of activities, and DMN, which recorded the logic that guides decisions, the which influence the behavior of the process. The results of this application were the actions proposed to improve the selected process and a method aimed at improving business processes through failure analysis.
Keywords: Business process modeling. Decision making. Failure mapping

Resumo
A Política Nacional de Assistência Estudantil tem contribuído para o desenvolvimento acadêmico dos estudantes nas instituições federais de ensino. No entanto, assim como outros órgãos públicos, estas instituições se depararam com o desafio de prestar serviços de modo eficiente aos cidadãos. O artigo tem por objetivo analisar falhas do processo de atendimento clínico do Serviço Odontológico ofertado pelo segmento de assistência estudantil aos alunos de uma instituição federal de ensino. Pelo seu caráter complementar, utilizou-se as técnicas FTA e FMEA para analisar as falhas identificadas a partir de modelos do processo criados por meio das técnicas BPMN, que registrou a sequência de atividades, e DMN, que registrou a lógica que guia as decisões, as quais influenciam no comportamento do processo. Os resultados desta aplicação foram as ações propostas para a melhoria do processo selecionado e um método voltado à melhoria de processos de negócio por meio da análise de falhas.
Palavras-chave: Modelagem de processos. Tomada de decisão. Mapeamento de falhas.

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1 INTRODUCTION

Public and private companies consist of large collections of processes. All important work carried out by these organizations makes up some process, whether it is aimed at providing a service or a good. With the market increasingly demanding in relation to the quality of products and services, it is necessary that institutions pay attention to the management of their processes to obtain competitive advantages. However, obtaining a competitive advantage does not apply in the same way to private companies and non-profit-making public bodies. These public institutions can gain a competitive advantage by following the concepts of efficiency, optimization and economicity (ARAUJO et al., 2017; DE PAULA; FREITAS, 2012; SOUZA; AMARAL; MELO FILHO, 2020; GONÇALVES, 2000; GONÇALVES; ZUIN, 2020). Oliveira (2018) highlights the challenge that public institutions have in providing services more effectively and efficiently, while emphasizing the need for greater concern in relation to social policies.

The National Student Assistance Program (PNAES) is an example of social policy that has been implemented in federal educational institutions. Some examples of PNAES actions are the granting of financial aid and the provision of health services to students enrolled in these institutions (ALMEIDA, 2019; BRASIL, 2010; ALMEIDA; OLIVEIRA; SEIXAS, 2019). Despite the effectiveness of PNAES, Barbosa (2019) reports efficiency problems, such as consequent delays in the provision of services. While Gonçalves & Zuin (2020) stress the need to improve the services provided in the field of student assistance.

The growing need to improve the reliability of products and services to achieve customer satisfaction has popularized various techniques aimed at minimizing/eliminating failures in product or process designs (FAGUNDES; ALMEIDA, 2004). Failures are events that come from the organization or its environment. And these events may or may not compromise the expected outcome of the process. Failures are usually associated with human actions and/or malfunction of physical components (OLIVEIRA; MARINS; ROCHA, 2012). Among the techniques for failure analysis, the Failure Tree Analysis (FTA) and the Failure Modes and Effects Analysis (FMEA) stand out, due to their wide use in the literature and their mention in technical standards, such as ISO 9004:2000 (Quality management systems - Guidelines for performance improvements) (OLIVEIRA; PAIVA; ALMEIDA, 2010). Together with FTA and FMEA, understanding the process is also necessary to perform the failure analysis. The representation of the process enables the identification of failures, since the understanding of how the flow of activities occurs provides the organization with the logic of how the process is performed (OLIVEIRA; MARINS; ROCHA, 2012; PINHO; LEAL; ALMEIDA, 2006). Rocha (2018, p. 88) argues that from the studies of the processes it is possible to outline strategies to “maximize the generation of results” and/or minimize failures and errors.

Capote (2018) motivates the construction of process models through the BPMN technique. First, because the model is the most complete level of graphical representation of a business process. According to, BPMN is a notation rich in symbols, complex, visually friendly and capable of representing one of the most important points of the process: decision making. Cavalcanti (2017) highlights that, despite its robustness, BPMN does not support the modeling of business rules, which contemplate the business logic that guide decisions. Given this aspect, it is necessary to use a specific technique, such as DMN.

This article aims to analyze potential failures of a business process of the student assistance segment of a federal educational institution, through FTA and FMEA techniques, based on models of this process created through BPMN and DMN techniques. The object of

study selected for this application was the clinical care process of the Dental Service offered by the Coordination of Student Affairs (CAE) of the Federal Institute of Minas Gerais (IFMG) - Bambuí Campus. The combined use of BPMN and DMN techniques aims to represent the process and decision logic of the object of study. Logic analysis may allow the identification of potential failures, either in the process sequence (registered by BPMN) or in decision making (registered by DMN). Applied in these potential failures, the FTA and FMEA techniques may not only record the logic of formation of these failures, but also how they interfere with the logic of the modeled process. It is expected that this objective of mapping failures in an integrated way to process modeling can facilitate the work of process management, enabling a clearer, more effective and efficient performance of the person(s) who acts and controls the chosen business process.

This work is limited to applying a systematic based on the combination of tools in order to understand the flow and existing decisions in the selected process, in order to propose improvement actions from the mapping of existing failures. The artifacts generated are not generic, so they may not be applicable in similar contexts due to the peculiarities of the modeled process.

2 REVIEW OF LITERATURE

2.1 Modeling and analysis of business processes

Campos (2014) defines “process” as a sequence of activities that are carried out with a specific objective. Cavalcanti (2017) explains that this objective is achieved from the transformation of inputs for the generation of a good or for the provision of a service. The author adds that these activities previously established in the organizational environment are called business processes and determine how the work should be performed. According to CBOK (2013), the execution of business processes can transcend functional and organizational limits, with few people in the organization understanding how the process works end-to-end. This understanding can be achieved through process analysis, as it “provides an understanding of the process activities and the results of these activities and processes in relation to their ability to meet their intended goals" (CBOK, 2013, p. 107).

Being indicated when deviations in process performance are found, process analysis can be implemented through techniques such as business process modeling, a set of activities with the purpose of generating a representation of a real situation. This representation is constructed with the dimensions that interest the designer/modeler: such as inputs and outputs, interfaces with other processes, those involved with the activities developed and other information considered relevant. However, this representation will still be a partial reflection of reality due to the real complexity of the process. Process modeling contributes to the prevention of failures, and it is common to produce graphical representations (process flows) such as diagrams, maps or process models. A process model is more detailed than a map or a diagram, because its focus is to represent the flow with greater precision and richness of detail, aggregating and incorporating the knowledge obtained from the studied context. The process model is indicated to represent complex processes and is appropriate for any level of analysis (BALDAM; VALLE; ROZENFELD, 2014; CAVALCANTI, 2017; CBOK, 2013; PAES et al., 2017).

Campos (2014) explains that for the analysis of a business process it is necessary that the current state (*AS-IS*) of the process is modeled, that is, that it represents how the process is currently performed. According to the author, for the construction of process flows, business process modeling makes use of notations, which are languages that have a defined system of

standards and rules for representing a domain, such as BPMN. In addition to the flows of activities, another aspect present in the execution of processes are the decisions. Debevoise et al. (2014, p. 7) argue that "decisions are the result of the application of business knowledge to a set of data, whether input data for the decision or data resulting from previous decisions". These authors complement that decision models reflect the organization knowledge that is usually expressed as business rules. According to Cavalcanti (2017), these decision models can be developed through DMN notation, which can be used in conjunction with BPMN.

2.1.1 BPMN (*Business Process Model and Notation*)

Currently in version 2.0, BPMN is an open standard that can be used for free and that offers a variety of visual elements for business process modeling. The aim of BPMN is to be a notation that is easy to understand and, at the same time, to be a mechanism that ensures the complexity inherent in the processes, regardless of the type of business to which they belong (CAVALCANTI, 2017). Figure 1 presents the basic symbolism of notation.

BPMN elements are organized into five groups of objects, as illustrated in Figure 1. These symbols are arranged and chained in *pools* and *lanes* during the modeling of processes, whether for the construction of diagrams, maps or models of processes.

2.1.2 DMN (*Decision Model and Notation*)

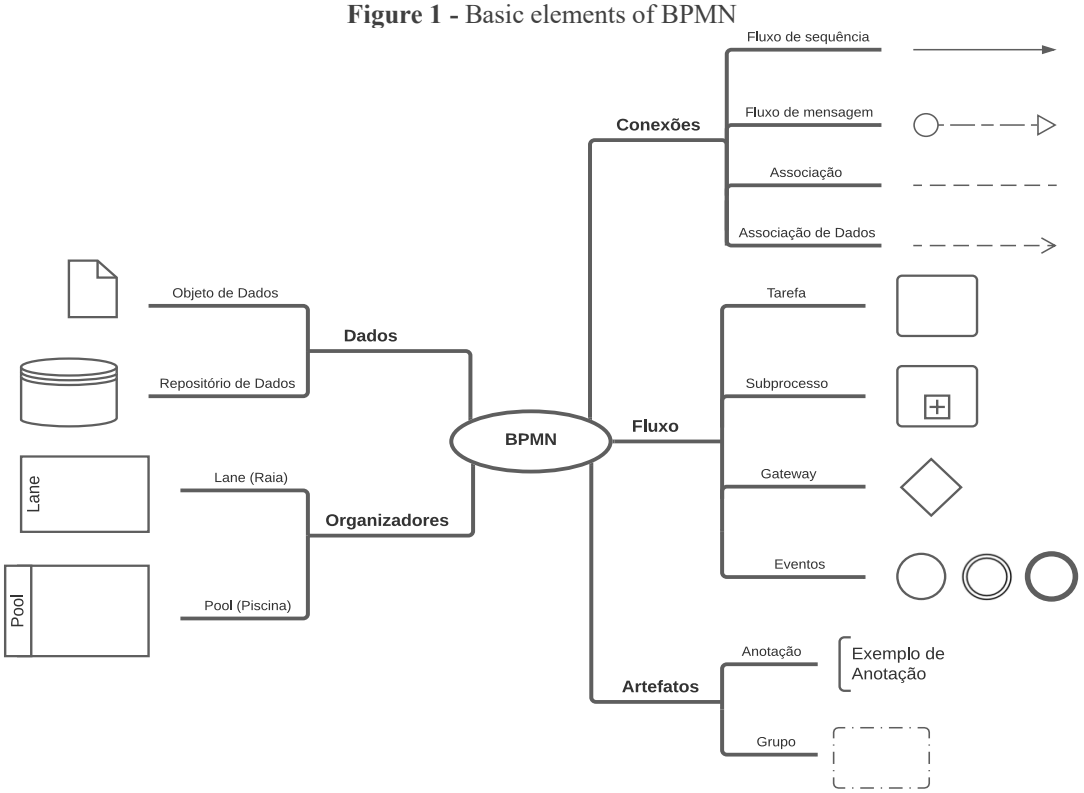
The DMN was proposed in order to be understandable to all audiences and offer the necessary support for modeling, standardization and formalization of business rules and their decision logic (CAVALCANTI, 2017). As BPMN, DMN is maintained by the OMG (*Object Management Group*) and its specification covers:

- Detailing of the requirements of the decision, through the symbology illustrated in Figure 2. These requirements are represented and connected forming a Decision Requirements Diagram (DRD);
- Outlining the decision logic, through decision tables that outline how the decision is made;
- Friendly language that allows the expression of different decision logics, regardless of the type of business.

In a decision table (Figure 3), the columns represent the inputs and outputs of a decision. While the lines denote the business rules. Each rule is a conjunction of basic expressions captured in a *Friendly Enough Expression Language* (FEEL). According to Figure 3, below the column name, the expected input type is specified, whether it is a *string*, *date*, *integer* or a *boolean* value: *true* or *false*. (CALVANESE et al., 2018)

Decision tables can contemplate multiple logical expressions, which makes it necessary for a mechanism to determine which output(s) that decision will provide. Present in the header of the decision tables, the *Hit Policy* attribute denotes how to elect rules of a decision table. For example, the *Hit Policy* "*Unique"* of the decision table Figure 3 determines that only one rule will be valid, so only one result will be accepted (HITPASS; FREUND; RUCKER, 2017).

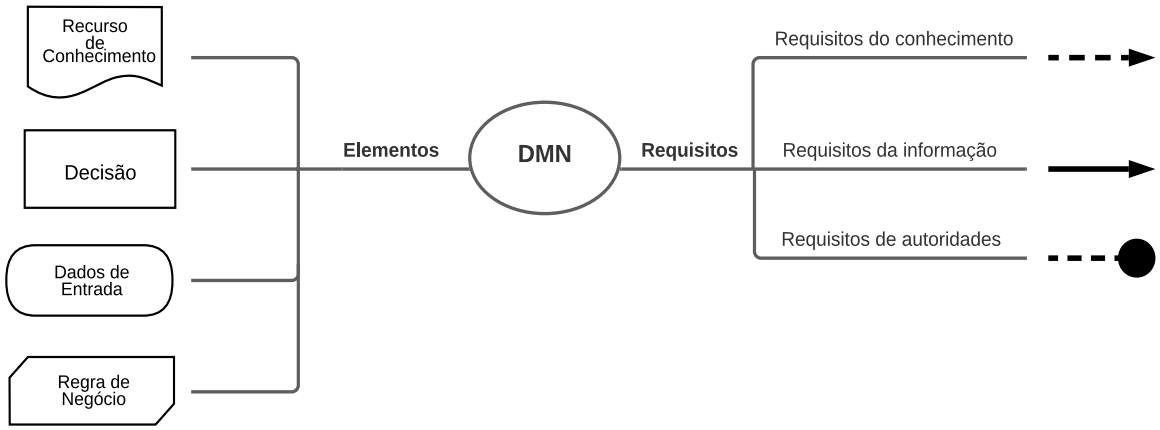
Figure 1 - Basic elements of BPMN



Source: adapted from Campos (2014)

<vertido da Figura>
Basic BPMN elements
Data object
Data repository
Lane
Pool
Data
Organizers
BPMN
Connections
Flow
Artifacts
Sequence flow
Message flow
Association
Data association
Task
Subprocess
Gateway
Events
Annotation
Group
Annotation example

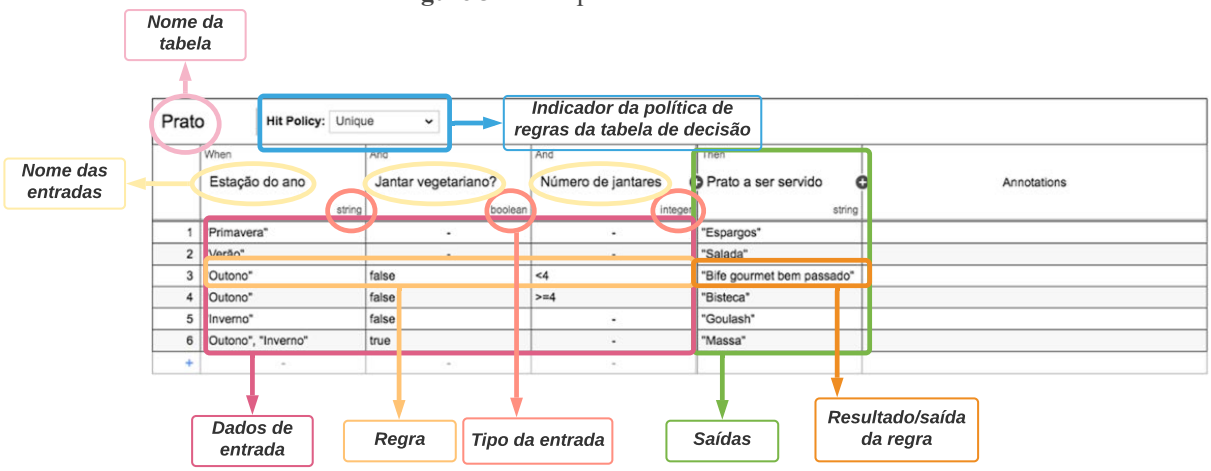
Figure 2 - Components of the Decision Requirements Diagram



Source: adapted from Cavalcanti (2017)

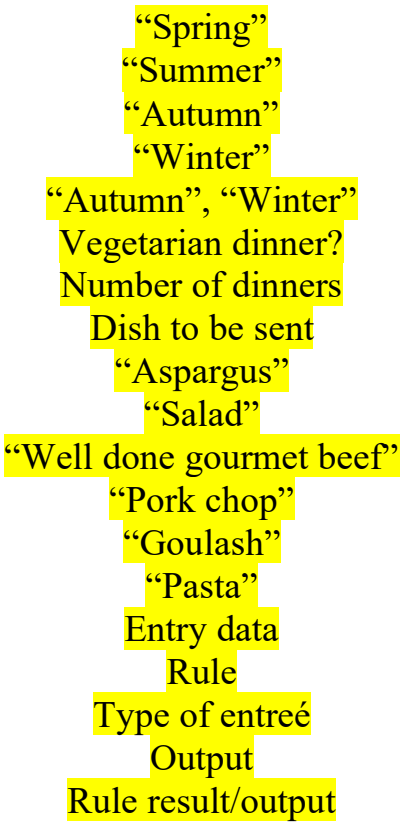
<vertido da Figura>
Knowledge resource
Decision
Entry data
Business rule
Elements
DMN
Requisites
Knowledge requisites
Information requisites
Authority requisites

Figure 3 - Example of a decision table



Source: Adapted from Hitpass, Freund e Rucker (2017) and Calvanese et al. (2018)

<vertido da Figura>
Table name
Dish
Indicator of the decision table rule policy
Entry names
Season



2.2 Failure mapping

For the mapping of failures in business processes, the FTA (*Fault Tree Analysis*) and FMEA (*Failure Mode and Effect Analysis*) techniques are usually used, either alone or together (OLIVEIRA; MARINS; ROCHA, 2012).

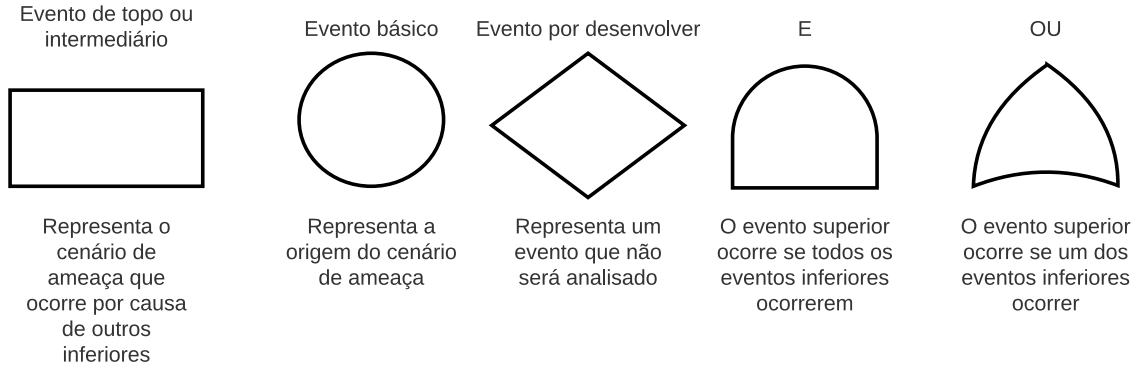
2.2.1 FTA

The FTA is a tool that assists in understanding the interactions of the causes that result in failure. This technique is generally used after the failure occurs in order to plan and apply corrective actions (YAMANE; SOUZA, 2007).

Through the graphical representation, the Fault Tree allows the analysis of the interaction of the causes that result in the significant failure, called the main event. Considered a *top-down* method and both qualitative and quantitative analysis, the FTA starts from a top event (the main event) and, from this, a logical chain of causes that are interconnected by the logical operators "AND" and "OR" develops (MONTEZO, 2020; OLIVEIRA; MARINS; ROCHA, 2012). Figure 4 presents the elements that can be used for the construction of a fault tree.

Intermediate events take on two functions in the tree: cause and effect. While the others have a unique identity. The FTA follows a Boolean logic (true or false) to combine the individual causes that result in the effect (YAMANE; SOUZA, 2007).

Figure 4 - Basic symbology for FTA application



Source: adapted from Montezo (2020)

<vertido da Figura>
Top or intermediary event
Represents the threat scenario due to inferior events
Basic event
Represents the origin of the threat scenario
Developing event
Represents an event which will not be analyzed
AND
The superior event occurs if all other inferior ones do
OR
The superior event occurs if an inferior one does

2.2.2 FMEA

The FMEA is a technique for failure analysis in order to "eliminate failure modes or reduce associated risks" in products and processes. While the product FMEA analyzes potential product design failures, the process FMEA is focused on determining "process variables that must be controlled to prioritize preventive or corrective action taking" (ARAÚJO, 2012, p. 5-6; OLIVEIRA; MARINS; ROCHA, 2012, p. 6).

The application of the FMEA occurs by completing a spreadsheet similar to Table 1. In the FMEA, the **step** corresponds to the activity of the process in which the failure occurs. **Failure mode** refers to the way the function/step failure occurs. The **effect** refers to the consequence(s) of the failure mode. And the **cause** is the reason for the failure mode occurrence. While the **current controls** are the means used to prevent the failure from happening or to detect those that have already occurred. The **indexes** are represented by numerical values linked to their respective criteria. A **severity index** (**column S**) is assigned to each effect according to its severity. The **occurrence index** (**column O**) is associated with a respective cause, according to the probability of occurrence of the primary event. The **detection index** (**column D**) indicates the degree of probability of detecting the cause of the failure mode before it happens. The **Risk Priority Number** (RPN) is the product of the three indices mentioned and determines the priority level for the implementation of the **action** that is reported in the last column of the spreadsheet (PINHO et al., 2008; ARAÚJO, 2012; COUTO; CARVALHO, 2015).

Table 1 - Worksheet for FMEA application

FMEA – Failure Modes and Effects Analysis									
Step	**Failure mode**	**Effect**	**Cause**	**Current Controls**	**Indexes**				**Corrective and/or preventive action**
					O	**D**	**S**	**RPN**	

Source: Adapted from Couto e Carvalho (2015) and Oliveira, Marins e Rocha (2012)

2.3 PNAES (National Student Assistance Program)

Governed by presidential decree No. 7234/2010, the PNAES aims to "expand the conditions of permanence of young people in federal higher education, through student assistance actions" (BRASIL, 2010, p. 1). The program's priority audience are students from the public basic education network or with a per capita family income (rfpc) of up to one and a half minimum wages (the socioeconomically vulnerable). In order to minimize the effects of social and regional inequalities, collaborate with the reduction of retention and evasion rates in federal educational institutions as well as contribute to improving the academic performance of students, the law governs that student assistance actions should be subsidized by the Executive Branch of the federal sphere and developed in the following areas: a) student housing; b) food; c) transportation; d) health care; e) digital inclusion; f) culture; g) sport; h) daycare; i) pedagogical support; j) access, participation and learning of students with disabilities, global development disorders and high skills and giftedness (BRASIL, 2010).

Among these areas, they Gonçalves e Zuin (2020) highlight the influence of health on the academic development of students. The authors mention the wear and tear caused by the university environment, which often results in mental illness, apart from problems related to oral health and food that interfere with the academic performance of students. Oliveira, Ponciano e Santos (2020) reinforce the importance of health care to
students in situations of socioeconomic vulnerability. The authors add that many students choose the leave of absence claiming health reasons.

According to the Nilo Peçanha Platform (PNP) - 41.59% of the 1,023,303 students enrolled in the Federal Network of Professional, Scientific and Technological Education in 2019 declared a minimum wage of up to 1.5 minimum wage (MEC, 2020).

3 METHODOLOGY

This study has an applied nature, since its realization involves the acquisition and generation of knowledge in order to apply them to solve a problem or a concrete need (APPOLINÁRIO, 2011; GIL, 2010). As for the objectives, the research has a descriptive and exploratory character. The descriptive objective is due to the fact that this research seeks to describe the flow as well as the logic of the work carried out through process and decision models. As for the exploratory aspect, through a bibliographic survey, the research seeks to investigate the knowledge about the techniques for modeling processes and decisions, mapping failures as well as how to combine them in order to achieve the objective of the research (ARAÚJO, 2012; GIL, 2010). Regarding the approach, this study can be classified as qualitative, due to the interest in describing, understanding and interpreting the facts and phenomena. In addition to the fact that the data are collected through social interactions and analyzed in a subjective way (APPOLINÁRIO, 2011; THEÓPHILO; MARTINS, 2009).

With regard to technical procedures, the research method used is modeling. Berto e Nakano (2000, p. 69) describe modeling as the "use of mathematical techniques to describe the operation of a system or part of a productive system." Considered one of the most important contributions in the scope of modeling, more specifically in the field of quantitative modeling, the work of Mitroff et al. (1974) suggests a problem-solving model using a systemic view based on a six-step cycle: conceptualization, modeling, model resolution, *feedback*, implementation and validation (CASTRO FILHO, 2010; WOLLMANN, 2014).

The conceptualization stage subsidized the modeling stage, but this first stage did not produce a conceptual model. The artifact produced in the conceptualization is the recording from data collection, which has information about the selected object of study. In view of the

Covid-19 pandemic and the recommendations of the World Health Organization (WHO), data collection was carried out through videoconference by Google Meet. Semi-structured interviews were used for data collection. This interview format involves the use of a script with pre-established questions and "a space for free and informal discussion of a given topic of interest to the researcher" (APPOLINÁRIO, 2011, p. 58).

The construction of the BPMN and DMN models occurred in the modeling stage, when the Camunda Modeler was used, a software for free use. Developed from the result of the conceptualization, these models were submitted to validation to assess the correspondence of the representations with the reality of the owner of the process (the dentist), since he/she knows the process in detail, especially at the execution level (CAMPOS, 2014).

The model resolution step was implemented through fault mapping. Achieved through the application of FTA and FMEA techniques, from the BPMN and DMN models, the solutions for the scientific models consist of proposals for corrective and/or preventive actions to improve the process chosen, which were listed at the end of the fault mapping. The implementation stage did not occur due to the delimitation of this study in only proposing improvement actions. The *feedback* was another step that was not carried out, as a conceptual model was not conceived for a coherence analysis with the solutions obtained.

4 APPLICATION

The dental care offered by the CAE of IFMG - Bambuí Campus is provided by only one collaborator: the dentist. This employee works from Monday to Friday, from 7:00 am to 1:00 pm, in the dental office located in the coordination building. The objective of this service is to perform curative-rehabilitative and preventive treatments and promote the health and well-being of students in relation to the dental aspect. Clinical care is performed individually and may involve prophylaxis procedures, fluoride application, guided brushing, small surgeries, treatment of gums and oral infections, in addition to dental emergencies. With regard to clinical care involving surgeries, the dentist requests the help of the sole nurse of the coordination (and campus), due to the need for a second professional to perform certain tasks. Student care is provided through prior scheduling or on the same day, in case of urgency according to priority.

The BPMN model Figure 5 represents the clinical care process provided by the Dental Service of the CAE. The process begins when the student makes the request for assistance by email, telephone or in person. The student seeks dental care spontaneously or by referring others, either by any of the professionals from the other health areas of the CAE (physician, nutritionist, among others), or by another individual(s) external to the campus, such as their parent(s) or legal guardian (s).

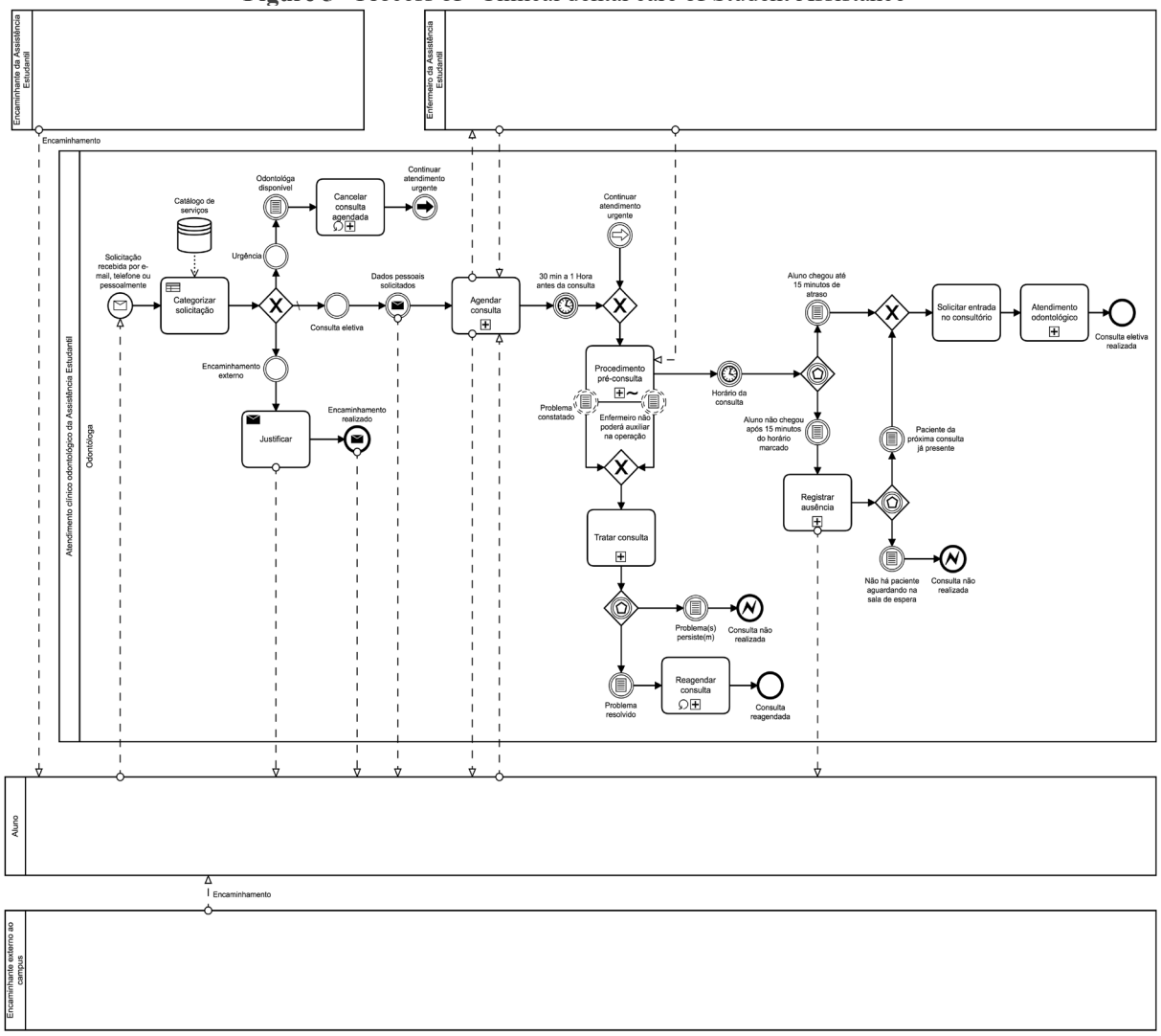
As soon as she receives the student's request, the dentist submits her to a decision making. Based on this decision, there may be: a) scheduling the student's appointment; b) the urgent care of the student; or c) the referral of the student, where the student is advised to seek an external professional under a certain justification. To perform urgent care, the dentist must be available, which involves the cancellation of other consultation(s) previously scheduled to continue the execution of this flow from the performance of the subprocess "Pre-appointment procedure".

The default process flow is elective query. In this flow, the student's personal data are requested and the appointment is scheduled. Thirty minutes to one hour before the scheduled time to start the student's appointment, the dentist performs the pre-consultation procedures, such as disinfection, antisepsis and sterilization processes. At the time of the consultation, the dentist requests the student to enter the office to start his/her care and, at the end, the clinical care process is completed.

During the execution of the sub-process "Pre-appointment procedure," the dentist may find some problem and/or be notified by the CAE nurse about the impossibility of assisting her in the operation that would be performed in clinical care. From the occurrence of one of these two events, the subprocess "Treat appointment" is executed. Subsequently, if the problem is solved, the appointment is rescheduled and the process is completed. If the problem(s) persists, the process is finalized with the appointment not being performed.

The dentist waits for the student to attend within 15 minutes after the scheduled time, and then starts the treatment. If the student has not arrived after 15 minutes of the scheduled time, the dentist records his/her absence. Then, if the patient from the next appointment has arrived, the professional requests his/her entry into the office and starts his/her care. If there is no one in the waiting room, the process ends with the appointment of the absent student not being carried out.

Figure 5 - Process of "Clinical dental care of Student Assistance"



(Source: Authors).

<vertido da Figura>
Student aid referral
Student aid nurse
Referral
Student aid clinical odontological service

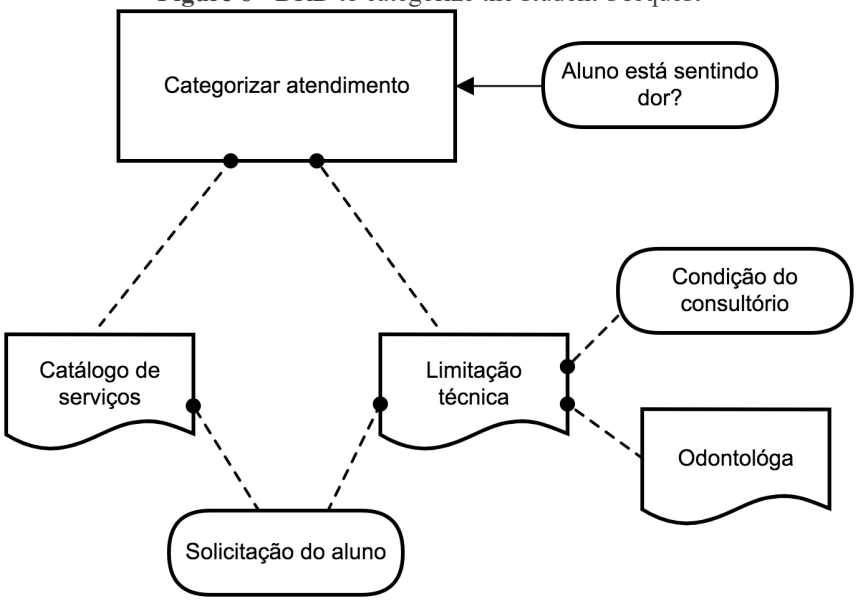
Request received by e-mail, telephone or i person
Service catalog
Categorize request
Available odontological service
Urgency
External referral
Justification
Sucessfully referred
Cancel scheduled appointment
Proceed with urgent service
Elective consultation
Requested personal data
Schedule appointments
30 min to 1 hour prior to consultation
Pre-consultation procedure
Identified problem
Nurse will not be able to aid in the procedure
Treat the consultation
Problems remain
Consultation not performed
Reschedule consultation
Consultation time
Student arrived with up to 15 minutes of tardiness
Student failed to arrive after 15 minutes of tardiness
Record absence
Request entry to the doctor's office
Odontological treatment
Performed elective consultation
Next patient is already present
No patient is in the waiting room
Consultation is not performed
Student
Referral from outside the campus

In addition to recording the moment when the dentist makes a decision, the business rule task "Categorize request" also associates with the BPMN model of Figure 5, the decision model composed of the Decision Requirements Diagram of Figure 6 and the decision table of Figure 7.

The DRD Figure 6 presents the necessary requirements for decision making: the categorization of the student's request. It is observed that for this decision making, in addition to needing to know if the student is experiencing any pain, the dentist also needs to consider the student's request: a) if the procedures necessary to perform the care are contemplated in the catalog of services offered by the sector; and b) if there are technical limitations related to the conditions of the office, the technical capacity and the state of the professional.

The aspects outlined in the DRD Figure 6 consist of the entries in the decision table Figure 7 that, in turn, make up the business rules, whose respective results correspond to a given decision. As only one of these outputs should be considered for the continuity of the process, the *Hit Policy* of the decision table is set to *Unique*. Thus, only one business rule can be considered. For example, in order for the student's request to be classified as "Elective appointment," the student cannot be feeling pain, there can be no technical limitations for the execution of the service and the procedure(s) to be performed must be contemplated in the service catalog.

Figure 6 - DRD to categorize the student's request



(Source: Authors).

<vertido da Figura>
Categorize service
Is the student in pain?
Service catalog
Technical limitation
Office condition
Dentist
Student's request

Figure 7 - Decision table to categorize the student's request

Categorizar atendimento | Hit Policy: Unique

	When	And	And	Then	
	Solicitação_contemplada_no_Catálogo_de_Serviços? boolean	Limitação_técnica? boolean	Aluno_está_sentindo_dor? boolean	Direcionar_atendimento string	Annotations
1	-	false	true	"Consulta urgente"	
2	-	true	-	"Encaminhamento externo"	
3	true	false	false	"Consulta eletiva"	
4	false	-	false	"Encaminhamento externo"	
+					

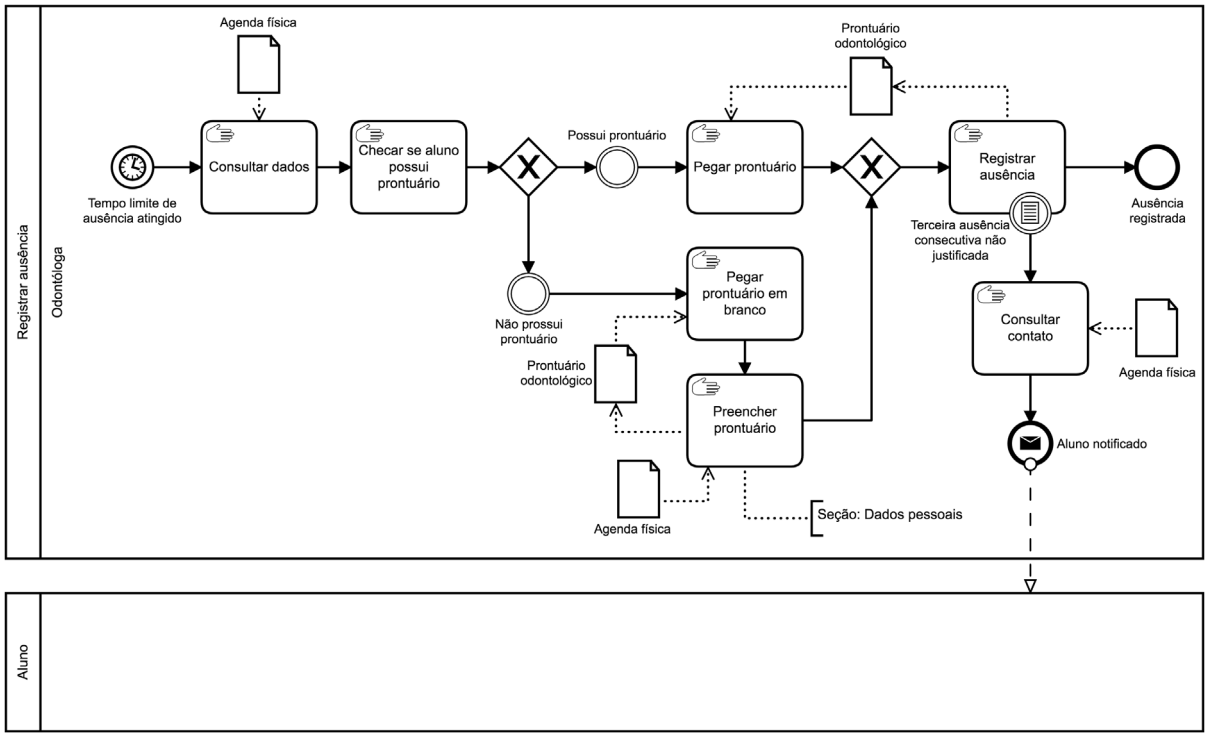
Source: Authors

<vertido da Figura>
Categorize service
Is the request included in the Service Catalog?

Technical limitation?
Is the student in pain?
Direct service
Annotations
“Urgent consultation”
“External referral”
“Elective consultation”

Some potential failures were identified after the validation of the process and decision models with the dentist. One of the failures mapped from the BPMN and DMN models was the ineligible student service failure. According to the BPMN model Figure 8, when the time limit for the student’s attendance at the waiting room is reached (15 minutes), the dentist consults the student’s data in her physical schedule and then searches the dental record (physical document) of that student. If the student does not yet have a medical record, the dentist takes a blank medical record and fills in the “Personal data” section. Subsequently, the server records the student’s absence and the subprocess ends with this record. However, if, when recording the student’s absence, the professional finds that it is his/her third consecutive unexcused absence, she adopts a disciplinary stance: she consults the student’s data in order to notify him/her that he/she will no longer be able to enjoy dental service until the end of the current semester. However, when analyzing the BPMN model again Figure 5, it is observed that only the service catalog is consulted for decision making. The dental record is not associated with the business rule task “Categorize request.” In addition, when examining the decision model encapsulated by this activity, it is clear that the number of consecutive unexcused absences of the student is not considered as one of the criteria to categorize their request for care. Therefore, if a student submitted to the disciplinary measure of the dentist makes a new request, it will not be denied, because the decision model does not include the necessary aspects to refuse care and direct such request to the appropriate flow in the BPMN model Figure 5. In addition, this failure also reveals that the act of notifying the student about the ineligibility of service is a meaningless activity since its purpose is not really achieved under the current business rules.

Figure 8 - Subprocess "Register absence" (represented collapsed in Figure 5)



(Source: Authors).

<vertido da Figura>
Register absence
Dentist
Student
Physical agenda
Reached absence limit time
Consult data
Check if the student has records
Has records
Take records
Register absence
Odontological records
Registered absence
Has no records
Take a blank record
Fill the record
Section: Personal data
Third unjustified consecutive absence
Consult contact
Notified student

Like the other identified failures, the failure to attend ineligible students was submitted to the FTA technique and then to the FMEA technique. The product of the FTA was the fault tree illustrated by Figure 9. While the artifact produced with the application of the second technique was the FMEA spreadsheet (Table 3). To define the occurrence, severity and

detection rates during the completion of the FMEA spreadsheet, the parameters presented in were used Table 2. Regarding the integration of FTA and FMEA techniques, the intermediate and primary events of the fault tree Figure 9 subsidized the failure modes [and their causes] of the FMEA spreadsheet. The application of both tools was carried out collaboratively with the dentist through Lucidchart and Google Docs, both for free use. Lucidtable diagramming software was employed for the construction of fault trees. While the Google Docs text editor was used for the preparation and completion of FMEA spreadsheets.

Observing the failure tree of Figure 9, the ineligible student service failure is the result of two concurrent events. The first event is the
absence of a centralized basis defined for querying information about the student, such as an electronic spreadsheet. And the second event is the fact that the dentist does not consult the student's medical records after receiving her/his request for care. Both events hinder or prevent access to information that can be used in decision making that may result in the student's request being refused.

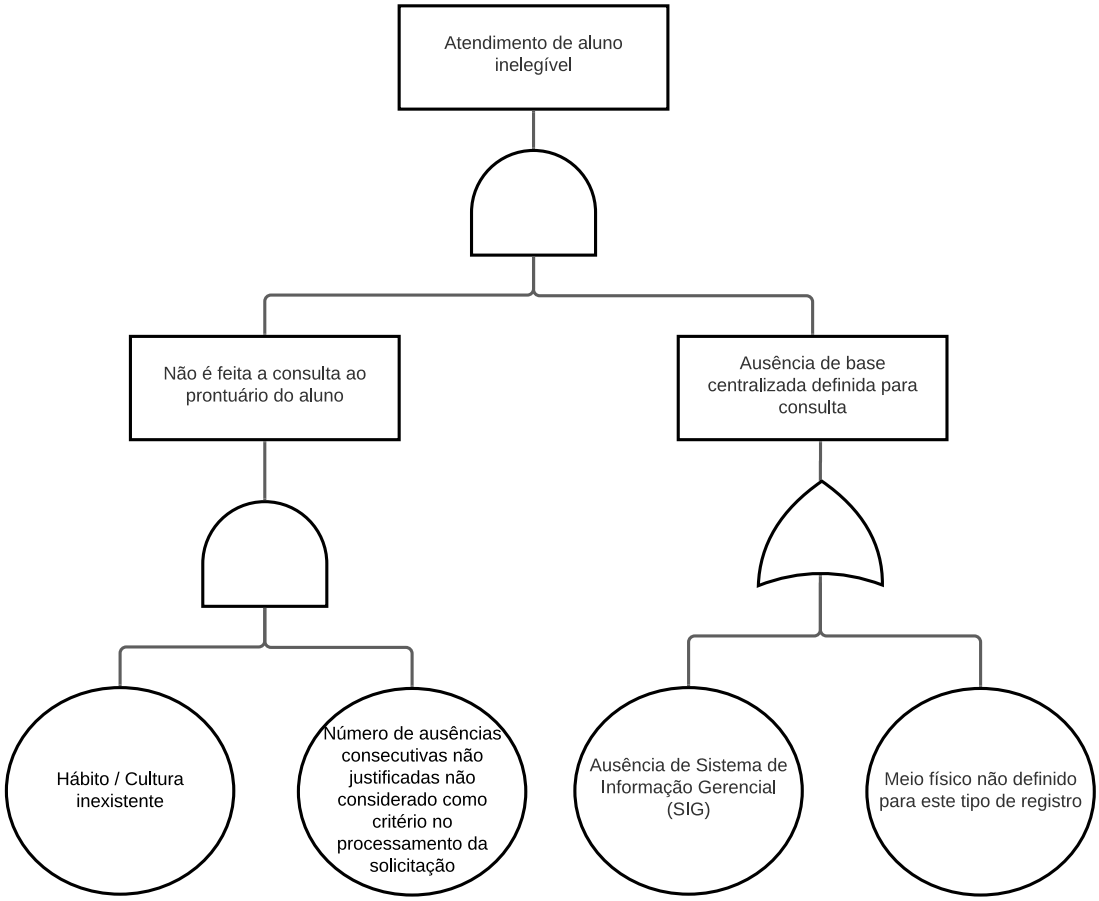
The intermediate failure not to consult the student's medical record is a consequence of a simultaneous occurrence of two primary events. The first primary event is the fact that the dentist does not have the habit/culture to perform this consultation to the student's medical record. As for the second primary event, in her daily work, the dentist does not consider the number of consecutive unjustified absences of the requester as a criterion when processing request for care, despite being information registered by the employee in the sub-process "Register absence" (Figure 8) in order to be used in a disciplinary measure.

The other intermediate failure presented in the failure tree of the Figure 9, the absence of a centralized basis defined for querying information about the student is the result of the occurrence of only one of its root causes. Currently, there is no Management Information System (MIS) for exclusive use of the Dental Service or shared use with other areas of CAE health. In addition, there is no definition by the dentist as to the physical environment for registration of students ineligible for care, such as a list. This source of information could facilitate the query of data during the processing of the request. Even, as can be seen in Table 3, an action proposed during the application of the FMEA to circumvent this failure mode cause was the semiannual creation of an electronic document where students classified as ineligible for service would be registered. This document could be created in Google Docs and, for practicality, consulted via *smartphone* during the categorization of the student's request.

During the application of the FMEA (Table 3) preventive and/or corrective actions were also proposed for the other primary events of the fault tree Figure 9. For example, in relation to the dentist's non-existent habit/culture of consulting the student's medical record, it was suggested to organize the medical record files in order to optimize the process of searching for information. Another proposed action was the definition of a policy of assistance to the student of the Dental Service, which would consider as a criterion the number of consecutive unexcused absences of the student during the semester for the processing of request. This policy would be considered in decision making, as a DRD knowledge resource, where the amount of unjustified absences of the student would be another entry in the decision table.

The low severity indexes attributed to each of the effects of the failure modes can be observed in Table 3. This is due to the fact that the student is not aware that that failure occurred, since this request was processed and he/she was attended by the Dental Service, despite his/her ineligible condition for care.

Figure 9 - FTA of ineligible student service failure



(Source: Authors).

<vertido da Figura>
Service for ineligible students
The consultation is not registered on their records
Lack of a centralized base for consultations
Non-existent habit/culture
Number of unjustified consecutive absences is not considered as a criterion in processing requests
Absence of a General Information System (GIS)
Physical means yet undefined for this type of registry

Table 2 - Parameters for determining occurrence, detection and severity indexes

Index parameters					
Occurrence (O)		**Detection (D)**		**Severity (S)**	
1 - Remote	Hardly the cause that leads to failure occurs	1 – Very High	Almost certain to detect the cause of the failure by the controls	1 - Minimum	The customer barely realizes that the failure has occurred
2 – Low	The cause of small-scale failure occurs	2 - High	High chance of cause of failure being detected	2 – Low	Slight deterioration in performance with slight customer dissatisfaction
3 – Moderate	Sometimes the cause that	3 – Moderate	The control is unlikely to detect	3 – Moderate	Significant deterioration in the performance of a

	leads to failure occurs		the cause of the failure		system with customer dissatisfaction
4 - High	The cause of the failure occurs with a certain frequency	4 - Low	The cause of the failure is unlikely to be detected by the control	4 - High	The process stops working and there is great customer dissatisfaction
5 – Very High	The cause of failure occurs at various times	5 - Very low	The cause of the failure will rarely be detected, or there is no control	5 – Very High	Affects the safety of the customer who has great dissatisfaction

Source: adapted from Pinho et al. (2008)

Table 3 - FMEA of ineligible student service failure

FMEA – FAILURE MODES AND EFFECTS ANALYSIS									
Step	**Failure:** Ineligible student service			**Current Controls**	**Indexes**				**Corrective and/or preventive actions**
	Failure Modes	**Effects**	**Causes**		**O**	**D**	**S**	**RPN**	
Categorize request (BPMN of Figure 5)	Consultation of the student's medical record not performed	Request categorized / processed erroneously	Non-existent habit / culture	Non-existent	5	5	1	25	Create the habit and define the medical record consultation process.
					5	5	1	25	Organize medical record files in order to optimize the consultation process.
		Time spent on ineligible student care	Number of consecutive unexcused absences not considered as a criterion in the processing of the request	Non-existent	4	5	1	20	Consider aspect in decision making regarding the categorization of request. Consequently leading to the rewriting of business rules.
									Define a policy of assistance to the student of the Dental Service, considering this criterion for service of request. Such a policy would be another aspect of decision making.
	Absence of centralized base defined for consultation	Consultation of the student's condition not performed	Absence of Management Information System (MIS)	Non-existent	5	5	1	25	Submit to the CAE coordination the need for a MIS for the Dental Service.
									Use electronic spreadsheet to account for unexcused absences and present to those ineligible for care in the current semester.

		Request categorized /improperly processed	Instrument not defined for this type of query	Non-existent	5	5	1	25	Define the student's medical record as the standard physical consultation instrument and create a consultation culture at the time of processing the request.
									Create an electronic document every six months where students categorized as ineligible for service will be recorded.

(Source: Authors).

5 FINAL CONSIDERATIONS

In order to contribute to the improvement in the provision of a public service, as well as with the literature on this subject, this article achieved its objective by mapping the failures of the clinical dental care process offered to students of the IFMG-Bambuí Campus, through FTA and FMEA techniques, based on models built through BPMN and DMN notations.

The performance of the semi-structured interview through an institutional multiplatform videoconference tool with recording resource was presented as an effective method of data collection for the modeling of processes, regarding the representation of activity flows and decision making. During data collection, there were times when aspects of the business processes that were not conceived by the interviewer were mentioned by the dentist, which did not affect the information gathering stage since the semi-structured interview is a flexible technique in relation to the possible course changes that may occur during its application. The interactive dialogue allowed the interviewer to scrutinize the process, thus collecting a wealth of details about the *modus operandi* with the interviewee. The exchange of information intensified when the interviewer found a disjunction of flows in the process, since usually in these moments there is a decision making, which directly influences the logic of operation of the business process. The frequent exchange of information on these occasions is justified by the need to know the requirements for such decision-making and the business rules, the results of which consist of decisions.

The harmonious integration between BPMN and DMN was another fact observed during the application of the techniques. While the decision models complement the process models, in order to supplement the decision logic in the flow of the business process, it is also possible to present and analyze the contexts separately. Understanding the process logic through the BPMN models, at first and then understanding the decision logic through the DMN models. Although there is no obligation to elaborate decision tables when building DRD's and vice versa, the use of both forms of design of decision making provided a more comprehensive view regarding the logic of decision and its influence on the functioning of the clinical dental care process.

The expectation with the end of the process and decision modeling stage was that the BPMN and DMN models developed and validated subsidize the failure mapping stage, since they reflect the rationality present in the execution of the business process. The result of this approach was the elaboration of a list of failures identified and presented by the participants in the meeting for the schematization of the fault trees. The fault mapping allowed us to see how the FTA and FMEA techniques also integrate harmoniously. At the same time that the FTA artifacts contribute as a subsidy to the application of the FMEA, this latter technique enabled a

deepening in the analysis of failures that it would not be possible to perform only with the fault trees. However, although the RPN of the FMEA spreadsheet indicates the causes of failure that require greater attention, the logical visualization provided by the FTA also allows identifying the failures that depend on the simultaneous eventuality to occur and those with greater sensitivity of occurrence, that is, that only one cause occurs to succeed the failure.

The analysis of the interaction of the artifacts produced validated the integrated functioning of the presented framework. Thus, at the end of this article, a combined method was obtained based on the joint application of tools aimed at improving business processes through failure analysis.

For future work, it is suggested that all student care processes carried out by other health areas of the CAE be submitted to the same application in order to obtain a list of proposals for common actions for all these sectors. These actions can raise the quality of the services provided and, perhaps, to an economy in relation to the costs and efforts required. Another suggestion for future work is the use of the 5W2H technique in applications that consider implementing the actions raised through fault mapping. The purpose of this integration would be the textual drying of the FMEA spreadsheets, since each action plan prepared through the 5W2H technique would be indexed in a given cell of the column referring to corrective/preventive actions. In addition, such action plans would offer documentary support for the implementation of each proposed action (JUNIOR; GONÇALVES, 2019). Finally, in relation to the modeling method used to carry out this article, it is suggested as future works, the development of modeling procedures aimed at mapping/modeling processes, since the adaptation of the model of Mitroff et al. (1974) to the context of this research showed that there is no great compatibility of this method in applications such as this study.

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