An Investigation to Identify Factors that Lead to Delay in Healthcare Reimbursement Process: A Brazilian case ☆

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A B S T R A C T

Healthcare reimbursement has had a tremendous impact on healthcare institutions and the economy. The healthcare reimbursement process consists of coding, billing, and payment based on the care provided to the patient. The rapid development of new medical treatments and procedures and changes in regulations and policies have been increasing the complexity of the reimbursement process, resulting in financial, operational, and care delivery issues for healthcare institutions. Therefore, methods of process analysis, such as process mining, have been used as a basic strategy to improve the organizational effectiveness of healthcare institutions. In this context, the main objective of this study is to propose an approach to investigate the factors that may cause delays in the reimbursement process using a combination of process mining and data mining techniques to extract information from the process data and support decision-making. To accomplish this analysis, process mining is applied to map the reimbursement process from the event log and to determine possible bottlenecks. In contrast, data mining is used to identify frequent patterns and interesting associations in the process data. Finally, by applying the proposed approach to a real case of a healthcare institution in Brazil, we extracted valuable insights regarding process execution and confirmed the effectiveness and potential of combining process mining and the association rules mining techniques.

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1. Introduction

The healthcare reimbursement process is considered vital for the efficiency of healthcare institutions. The reimbursement procedure includes obtaining payments for the services provided by the care institutions from the patients, insurance companies, and government programs [1]. However, the rapid development of new medical treatments and procedures as well as frequent changes in regulations and policies are increasing the complexity of the reimbursement process, and consequently resulting in financial, operational, and care delivery issues for healthcare institutions [2]. For instance, in 2015, the Centers for Medicare and Medicaid Services set an improper payment rate of 12.1% or $43.3 billion for Medicare [3]. Additionally, in 2011, the complex reimbursement

processes failed to prevent more than $90 billion of annual fraud, abuse, and related financial issues [4]. Problems associated with the reimbursement process also delayed the performance of diagnostic tests and treatments, causing difficulties in care delivery [5].

Healthcare institutions are adopting new methods to improve their reimbursement processes to avoid these related issues [6,7]. Although, improving them is not an easy task because there is always the need to reduce the cost of services, improve capabilities to meet growing demand and reduce patient waiting times. According to [8], process mining is a widely accepted method that has been successively used to enhance the healthcare organizational effectiveness.

Process mining focuses on discovering, monitoring, and improving real processes, and not assumed ones, by extracting knowledge from event logs readily available in the information systems. An event log is a set of traces, with each trace representing the activities executed for a particular process instance. Event log data are not simply limited to the data from systems, such as process-aware information systems [9], because various other systems can also provide useful data regarding process execution. Furthermore,

data relating to a complex process may originate from more than one source of information [10].

The application of process mining in healthcare can improve the organizational effectiveness of care institutions and the care delivery [8]. For example, it can be used to compare clinical guidelines and the treatment process in order to detected deviations [11]; to better understand the real-life clinical pathways of chemotherapy patients for aiming the patient care and outcome improvement [12]; and also to measure the effects of a new building in a hospital in terms of consultation wait time, time spent per task, and outpatient care processes [13].

Additionally, the combination of process mining with data mining can provide further insights [14]. For the healthcare process analysis, some studies present methods to exploit the above-mentioned combination to achieve better results or discover new knowledges in the process execution. Suriadi et al. [15] apply process mining to improve the efficiency of the insurance invoicing process. First, the authors categorize the event log into four performance indicators: simple and slow, simple and quick, complex and slow, and complex and quick. Next, they focus on understanding the process of the simple and complex categories through the analysis of the control flow and frequently-taken paths of the discovered models. Finally, they use classification techniques to obtain a set of rules that provide preliminary insights into the reasons for the lengthy processing times for the simple and slow category. Lismont et al. [16] propose a methodology utilizing process mining techniques and some techniques derived from data mining to apply process analytics to healthcare processes. The methodology consisted of seven discrete steps: log preparation, log inspection, abstraction and selection, clustering, process mining, and validation. In summary, the methodology aimed to deal with some healthcare process characteristics such as the unstructured and irregular processes, appropriate level of abstraction and time granularity of the data, and overflow of the medical activities that may distort the analysis.

Delias et al. [17] propose a methodology to represent complex process models that have limited practical applications, by delivering a small number of simpler process models by the application of clustering techniques. Their study focused on creating a similarity metric for reducing the effect of noise and outliers present in a complex process. To provide clearer process models and help the analysis of complex processes, the authors used the developed metric with the spectral clustering technique. Djenouri et al. [18] present a framework to extract knowledge about business processes from event logs using frequent itemset mining. The proposed framework consists of three steps: preprocessing, frequent itemset mining and pruning. The first step involves the creation of categorical attributes based on the existing attributes, and also the creation of several transaction databases, one concerning the events and the others from each attribute present in the event log, to provide multiple perspectives on the data. The second step consists of extracting frequent itemsets from the several databases. The last step comprises filtering the frequent itemsets to show a reasonable number of relevant frequent itemsets to decision-makers. To this end, the authors presented a coverage pruning function which selects a small group of itemsets that cover the maximum number of events.

In this study, we describe an approach to support decision-making in the healthcare process through a combination of process mining and data mining techniques. In contrast with the current reports in the literature of clinical healthcare processes [12,11] that are aimed at advancing the medical treatments and procedures to achieve better results for patients, and the lack of studies concerning the healthcare reimbursement processes topic [5]. The focus of this investigation is to identify factors that require more attention from the managers to improve the efficiency of healthcare reim-

bursement. In summary, the key objectives of this study are to (1) use process mining to map the reimbursement process from the event log and to determine possible bottlenecks, (2) extract information from the discovered process model, and (3) use the Apriori algorithm to identify frequently appearing patterns and interesting associations in the process data.

The approach is validated by a study case involving a private insurance company in a non-profit Brazilian hospital. Based on the obtained results of the study case, we believe that with certain adaptations concerning local characteristics, this kind of approach can also be applied to other similar scenarios.

The rest of the paper is organized as follows. Section 2 provides a brief background of the healthcare reimbursement process and the process mining and association rules techniques. In Section 3, we describe the methods used to identify the factors that can delay the reimbursement process. The approach is analytically presented together with the results in Section 4. Section 5 discusses the results, while Section 6 presents the main conclusions of the work.

2. Background

This section presents the basic concepts related to the scope of this study, that is, healthcare reimbursement, followed by a general view of the process mining premise and the strategy behind the Apriori algorithm.

2.1. Healthcare reimbursement

Healthcare reimbursement can vary owing to the wide variety of institutional environments. However, it primarily consists of three main steps: coding, billing, and payment [5]. In the coding process, a licensed care provider files the medical record of the patient including the services provided and items supplied during the treatment of the patient. Subsequently, the medical record is transferred to a professional coding staff who are responsible for identifying the set of appropriate codes representing the medical diagnoses, procedures, and materials. In the billing step, the billers generate codes that conform to the requirements of a specific payer to describe the medically necessary services. The third and final step, namely, the payment process, entails filing an invoice to the payer. However, the payment to a care provider can be denied, for instance, because of billing or coding errors, an invoice that did not satisfy the documentation or other insurance coverage requirements.

There are different methods of payment, each one having its own advantages and disadvantages for the care institutions, healthcare insurances, and patients. The most used method in the U.S. and various other countries is called Fee-For-Service (FFS). In this method, the payment is linked to specific procedures, treatments, services, and care settings. Consequently, the process can become more complex, time-consuming, and expensive depending on the number of procedures and services provided, regardless of their contribution to achieving better results for the patient [19,20].

2.2. Process mining

The starting point for process mining is an event log [14]. All process mining techniques assume that it is possible to sequentially record events such that each event refers to an activity and is related to a particular case, that is, a process instance. Event logs may store additional information about the events such as the resource executing or initiating the activity, a timestamp of the event, or data elements recorded with the event, such as the size of an order, and whenever possible, process mining techniques use such extra information.