A Process Mining Application for the Analysis of Hospital-at-Home Admissions

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Abstract. This article proposes the analysis of the admissions to hospital-at-home service within the framework of process mining. In addition to conventional modeling in standard languages, relying on interviews and continuous improvement, we propose the adoption of an automatic process discovery technique based on data collected by the hospital information system. We focus on the patient admission process, in which staff discriminate cases of interest for the service. Our methodological framework starts with the extraction of process information from the existing dataset. Once obtained meaningful data for an event log analysis, we propose the adoption of a process discovery algorithm by using a specific tool for process mining. In the context of Business Process Management, we suggest a practical application to be explored in order to improve standard modeling, opening the way to perform business process simulation with scenario analysis.

Keywords. Business Process Management, Process Mining, E-health, Hospital-at-Home

1. Introduction

In Medicine, one of the important aspects to investigate is the organization of health processes, by considering an holistic and systemic approach. In this direction, computer science gained a relevant role for technical hardware and information systems improvements [8]. This is the case of Business Process Management (BPM) [7], a discipline combining data science and management studies to perform business process improvement, modeling and simulation [19] for decision-making [2], also in healthcare [12,15]. Modeling usually adopt standard languages, e.g, BPMN[2,] as well as relevant data collected from Process-Aware Information Systems [8], properly stored with the recent XES format [3]. Such workflow analysis facilitates the detection of inefficiencies, bottlenecks, constraints, and risks [20,5,18].

In this paper, we explore the adoption of a process discovery technique from Process Mining [9], a recent and promising field of study, in order to automatically extract

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[2]See OMG, Business Process Model Notation: https://www.omg.org/spec/BPMN/2.0/About-BPMN/

relevant information from event log data concerning the patients workflow [1]. We focus on a specific healthcare service, the Hospital-at-Home service (HaH) in Torino, one of the largest city of Italy, to investigate the admission process[3].

The availability of real data about the service is at the core of healthcare business process mining perspective [13,16]. Nevertheless, the adoption of Process Aware Information System (PAIS) in most hospitals is not yet achieved, and healthcare managers more often deal with conventional aggregated information. A large part of hospital information systems actually is not well equipped for process analysis, whereas data can be difficult to extract, including several well-know problem concerning data quality [14].

This work focuses on two research problems: i. Can we derive digital information even in the absence of an information system that accurately collects data? ii. On this basis, can we automatically derive an healthcare process, e.g. the HaH admissions? We improve similar works which addressed the specific topic of modeling home-care services [17], by applying process discovery technique to data of the service.

In the following of the paper, we introduce our use case, dataset and the methodological framework in Section 2, while Section 3 includes the output of process mining. We draw some conclusions in Section 4.

2. Use case, data and methodology

The scientific literature as well as the practical experiences have already recognized the usefulness of domiciliary cares, pushing hospitals to operate with integrated territorial services [21].

2.1. Description of the use case

In the context of HaH carried out since 1985 by the main hospital in Torino, one of the biggest city in northern Italy, we focus on the experimental project of geriatric home hospitalization, in Piedmont region. This service started in the Molinette Hospital within the "City of Health and Science" of Torino, which actually is one of the largest public health hub in Europe[4]. This innovative service ensures cares mostly for elderly and fragile people in acute disease. In addition to institutionalized services for patients, HaH provides a relevant support to caregivers and their relatives. This avoids the improper accesses to Emergency services, contributing in the reduction of the consistency of waiting lists. The main interest of hospital managers to investigate HaH by adopting a process-oriented perspective relies in the evaluation of benefits to further extend this kind of service.

2.2. Business process modeling and data analysis

In Figure 1 we provide a brief overview of HaH service, focusing on admission process, whose diagram is on the left part. Eligible patients for the service are interviewed by a Case Manager (CM), to investigate and evaluate the existing conditions to apply for HaH.

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[3]This research is part of the project "CANP - CAsa Nel Parco" of Regione Piemonte funded by POR FESR PIEMONTE 2014-2020. Web site of the project: http://casanelparco-project.it.

[4]Cfr. City of Health and Science, http://www.cittadellasalute.to.it, as well as: http://shorturl.at/bosz3

Figure 1. On the left: business process analysis in BPMN. On the right: Arrivals of patients at the HaH service in 2017 and 2018 in the different months.

The diagram describes the output of a conventional approach with BPMN. Due to lack of relevance in this paper, we avoid to detail all the tasks and passages, better presented in [4]. In addition, we perform traditional data analysis to contextualize the process of interest. The histogram in the right side of Figure 1 summarizes the arrivals of patients in last two years by months, with peaks corresponding to the periods of flu (January and Autumn), and less requests near Italian festivity days (i.e. April for Easter festivities).

2.3. Log of the process

To promote a business process analysis, we need more information about the patients' flow. An initial step in the construction of the admission process includes the exploitation of data registered in the hospital information system. As in the log example presented in the following paragraph, we extracted information including: patient's numeber (ID), corresponding case (SDO), provenience (PROV), first call to the CM for the evaluation (CALL), admission date (HaH1), type (OUT) and date of dismission (END).

> *ID, SDO, PROV, CALL, HaH1, OUT, END*
> *045, 2017500110, SPEC, 02/02/17, 06/02/17, ORD, 14/02/17*
> *048, 002017500552, PS, 21/06/17, 27/06/17, TRASF, 09/07/17*
> *045, 2018500025, MDB, 04/01/18, 04/01/18, DEC, 25/02/18*

2.4. Process Mining in Health

To perform the discovery of the process from the log we adopted PALIA Process Discovery algorithm [10]. In particular, we apply PALIA algorithm for discovering the process of HaH events described in previous section. PALIA Algorithm has been successfully used in several medical problems like surgery [10], Emergency Rooms [11], or Diabetes [6], among other health solutions. Process Mining can support healthcare professionals in the real understanding of the process, not only by discovering the process but also performing assessments for enabling the application of Value based healthcare [11].

3. Results

The result of our process mining technique is the model presented in Figure 2, whereas the admission process has been automatically extracted from raw data.
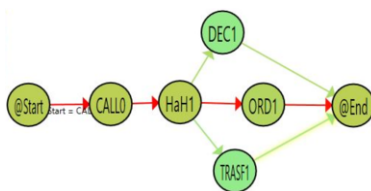
Figure 2. Output of the admission process

The process starts with the patient admission (HaH1) preceded by a call by the Case Manager (CALL0), and followed by three types of output: the ordinary management of HaH activities (ORD) until the dismission (END), the transfer of the patient - e.g. surgery or the recovery to an Hospital department (TRASF); or the patient's death (DEC).

A second model is presented in Figure 3, describing also the amount of occurrences. Here, the color reflect the frequency of each event: as occurrences increase, arrows and circle tend to red color. As clearly stated by the figure, the most frequent output is patients hospitalization (only once time) and then the ordinary discharged.
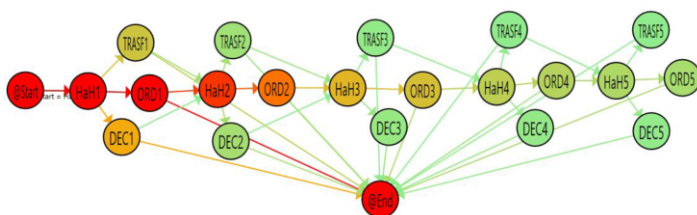
Figure 3. Process discovery from HaH admission dataset.

By investigating our dataset, we immediately observe how the service performs well, in general, as most patients are discharged in an ordinary way. In fact, a further investigation identifies how most patients, once discharged, do not return to the hospital. In addition, it can be observed that the number of re-hospitalization is not very relevant.

4. Conclusions

We applied process mining to data about the admission of patients in healthcare service. One point of interest is to demonstrate the ability to perform an healthcare process analysis, by automatically deriving information about processes from not well structured data (i.e., data not registered in standard event log XES format), as actually most hospital information systems are still not process-aware. We believe that the understanding of the advantages of using process mining techniques will push towards a wider adoption of PAIS in the near future, as it is actually happening in Industry. As a matter of fact, the methodological framework here presented allows to compare traditional process analysis with the emerging techniques of process discovery, opening the way to perform conformance checking and enhancement.

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