

# Methodology for the study of Hospital Processes through Process Mining Techniques in an Emergency Room

Rojas, Eric., Arias, Michael., Munoz-Gama, Jorge., Sepúlveda, Marcos., & Capurro, Daniel.  
Pontificia Universidad Católica de Chile

International Workshop on Process-Oriented Data Science for Healthcare (PODS4H) – Success Case



The UC CHRISTUS Health Network is the most important private health care network in Chile. It is also a broad clinical environment in which the doctors of tomorrow are trained.



Includes 11 medical centres, 1000 doctors and 4000 professionals. Data used in the study was extracted from the Hospital Information System Alert ADW Phase I. Data is from January to July 2014 and it includes 39.003 episodes with 1.754.000 events.

Medical centers execute a large number of processes, which constitute an essential part of the provision of suitable care to visiting patients (e.g. those entering the emergency room (ER)). In order to successfully provide the most suitable care to patients, these processes must be executed in the most effective and efficient way possible. At present, hospital information systems store large amount of information related with patients attention.

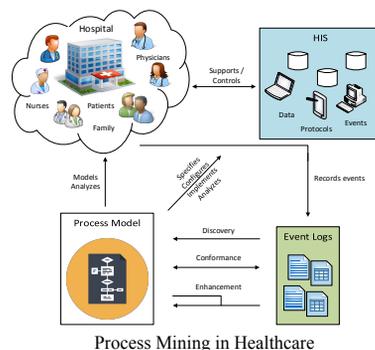
Examples of distinct types of analysis that can be carried out through the use of medical information are:

- Ascertain the current state of a process
- Analyze social interactions taking place between resources
- Verify process performance
- Explore additional details with regard to their execution.

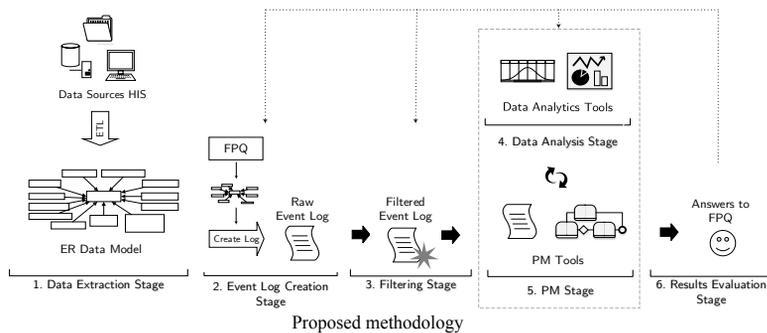
These analysis helps to identify distinct points of process improvement.

Process mining is a research discipline that, by means of the application of its distinct techniques, is able to discover process models, understand the interaction between resources and analyze their performance. It use does not only facilitate an understanding of the natural complexity of hospital processes and what these genuinely entail, but it also generates improvement opportunities in relation to care services. In order to deeper investigate these processes, process mining techniques can be particularly useful.

However, their correct usage and implementation is a complex task that requires the clear definition of a series of steps and guidelines. These steps and guidelines could help to generate results that enhance the overall understanding of the processes involved and which, in turn, can have a positive impact on improving care services.



A new multi-perspective methodology is presented to identify process models and analyze the organizational component while also studying the performance of processes. These analysis also included a study of the particular characteristics of the emergency room, considering triage and the destination of the last discharge. This new methodology was successfully tested using real data from UC CHRISTUS Health Network in Chile, where it was able to demonstrate the usefulness of both the methodology and its distinct components.



Rojas, E., Munoz-Gama, J., Sepúlveda, M., & Capurro, D. (2016). Process mining in healthcare: A literature review. *Journal of biomedical informatics*, 61, 224-236.

Rojas, E., Sepúlveda, M., Munoz-Gama, J., Capurro, D., Traver, V., & Fernandez-Llatas, C. (2017). Question-driven methodology for analyzing emergency room processes using process mining. *Applied Sciences*, 7(3), 302.

Alvarez, C., Rojas, E., Arias, M., Munoz-Gama, J., Sepúlveda, M., Herskovic, V., & Capurro, D. (2018). Discovering role interaction models in the Emergency Room using Process Mining. *Journal of biomedical informatics*, 78, 60-77.

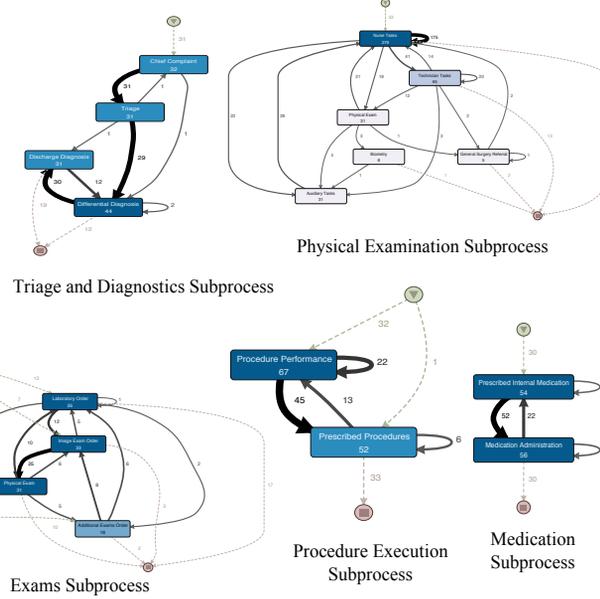
Rojas, E., Cifuentes, A., Burattin, A., Munoz-Gama, J., Sepúlveda, M., & Capurro, D. (2018). Analysis of Emergency Room Episodes Duration through Process Mining. In Int. Workshop on Process-Oriented Data Science for Healthcare 2018 (PODS4H18).

# Control Flow or Discovery Analysis *What activities are carried out and what process is followed in providing attention to ER patients diagnosed with appendicitis?*

**Process model discovery:** an event log was created including all ER episodes during July 2014. The focus relates to the sequence of activities carried out in ER in attending the patients (e.g. the activity of taking their vital signs, the medical imaging requested, the medication prescribed, and the inter-consultations solicited). Process model took place for 33 cases included in the event log.

**Subprocesses:** activities were classified into three important subprocesses, in conjunction with the ER expert: **(1)** subprocess that contains the triage and diagnosis activities corresponding to the tasks in which the seriousness of the condition of the patient is determined. **(2)** subprocess that contains activities relating to treatment, which includes four subtypes grouped into their own subprocesses, as follows: the patient's physical examination subprocess; the procedure execution subprocess; the subprocess of taking exams; and the medication subprocess. **(3)** subprocess that includes the activity associated with clinical discharge.

Subsequent to obtaining the data, characteristics and models for the analyzed cases, an evaluation was conducted with an expert in the ER. This evaluation was undertaken by means of an interview with open questions in relation to the results obtained. The respondent provided affirmative answers, with the expert confirming that the data and process models can be used to understand the process followed.

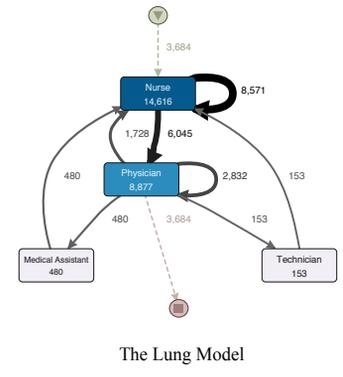


## Are there role interaction models in the Emergency Room? **Organizational Analysis**

The organizational perspective aims to discover the relationships among resources, to explore if they collaborate among themselves, and to discover the existence of social networks among them. Role interaction models that describe the collaboration among ER professionals who treat patients in an ER process were discovered.

**Role interaction model:** we have called the *lung model*. This model describes how the roles interact with each other in most of the episodes (see figure in the side). We found four roles: physicians, nurses, technicians and medical assistants. Physicians and nurses appear in 100% of the episodes, while medical assistants appear in 12.5% of the episodes and technicians appear only in 3.7% of the episodes.

The general role interaction model reflects the overall execution of an episode in the ER. The ER expert confirmed that the *lung model* is followed in most episodes and describes the most common role interaction patterns.



## Performance Analysis *Why some episodes take longer than others?*

The aim was to analyze the ER episodes behavior determining which activities, subprocesses and their interaction in the ER process are the reason for the process to get stalled and have longer episode duration. This analysis gives hidden information to decision makers that will allow them to take action over existing inefficiencies of the process to decrease waiting times, reduce patient congestion and increment the quality of provided care.

We split the event log in two groups: one group corresponds to the half fastest episodes, while the other half group includes the episodes with the longest time, and its process model (see figure in the side). A **Back loop** between Examination for Prediction and Treatment was identified on. This loop could occur several times in one instance of the process. Every time this loop happens the process time increases (considering a discrete average of one hour), impacting significantly the episode time. This concludes that the Examination-Treatment activities extends the episode duration every time it repeats.

