

Helping Nurses to Improve Their Work Organisation Using Process Data

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Abstract

Today, hospitals face increasing care demands and budgetary constraints, which challenge the delivery of high-quality care. In addition, most organisations suffer from a chronic nurse understaffing. To address these challenges, hospitals are looking into ways to improve the work organisation of nurses. However, current research on nursing work organisation predominantly relies on self-reported data and observational studies, both of which present significant limitations, such as data quality concerns (e.g., the Hawthorne effect in observational settings) and the added burden on participating nurses. This research aims to provide hospitals and nursing staff with data-driven insights into current work organisation practices, enabling more informed decision making. To this end, task execution data will be automatically collected through a combination of hospital information system (HIS) data and real-time location system (RTLS) data, gathered from both nurses and mobile equipment in hospital wards. This research focuses on two primary challenges: (i) the integration of HIS- and RTLS-data and (ii) the identification and visualisation of work organisation patterns. Through addressing these challenges, this research will offer hospitals deep insights into nursing work organization without imposing additional burdens on healthcare staff, facilitating evidence-based decision making about how to best organise nursing work.

Keywords

Process Mining, Healthcare, HIS-data, RTLS-data, Nurses, Work organisation

1. Introduction

Currently, hospitals are challenged with providing high-quality care while facing limited resources and increased care needs (e.g. due to the ageing population) [1]. In addition, a key struggle in many countries is chronic nurse understaffing [2]. Given the context of these tight budgets and the significant shortages in nursing staff, hospitals are looking into ways to improve the work organisation of nurses (i.e. the way tasks are organized and coordinated [3]).

Work organisation improvement ideas can be generated through organising workshops with nurses [4]. However, caregivers experience difficulties in objectively expressing how their work is organised and in stating how much time they spend on tasks [5]. In order to improve ideas generated in these workshops, the discussion among nurses can be enriched with data-driven insights into the current work organisation.

To provide these insights, data on how nurses perform tasks and how they organise these tasks is needed. In nursing literature, this data is often collected through self-reporting tools and observations [6, 7, 8]. These methods are time-consuming, potentially add an extra burden on participating nurses and come with their own specific limitations (e.g. the Hawthorne effect that may occur in observational studies [5]).

Because of the limitations of currently used methods, this research project aims to provide data-driven support to nurses as they generate work organisation improvement ideas using *automatically* recorded task execution data. This data will be collected from hospital information systems (HIS) and real-time location system (RTLS) data, which is sensor data recording the location of nurses or mobile assets at particular points in time [9]. Data-driven insights will be generated by integrating both data sources and analysing it using process mining.

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2. Related work

Research efforts on process mining in healthcare soared over the past decade [10]. The discovery of patients' care pathways, indicating the order in which care interventions are delivered to a patient, remains the most dominant use case. Process mining in healthcare has also been used to predict the occurrence of events. A third application of process mining in healthcare aims at providing answers to time-related questions [11].

While HIS systems are a common data source for process mining in healthcare [12, 13], multiple data quality issues have been reported [14, 1, 15]. In general, common data quality problems encountered when using HIS-data for nonclinical purposes are accuracy, completeness, consistency, credibility, uniqueness, correctness, concordance and timeliness [16, 17]. These inaccuracies in collected data result in a fragmented and incomplete view of how nurses actually work.

To overcome the limitations in using HIS-data, this research will consider RTLS-data as an additional data source of automatically recorded information about task executions. The collected timestamps from RTLS-data are linked to locations rather than tasks. As a result, the necessary context of the specific executed task is missing which is a key limitation when relying solely on this data [18].

From the previous, it follows that both HIS- and RTLS-data have their specific data quality challenges, however they exhibit significant synergies. Whereas RTLS-data provides detailed information about timing and location but lacks context information, HIS-data provides the necessary context [19].

This research will address two fundamental research challenges to provide data-driven insights in the work organisation of nurses: (i) a method has to be created to integrate HIS-data and RTLS-data and (ii) starting from the combined data, process mining algorithms have to be build to identify and visualise work organisation patterns.

3. Methodology

This research addresses two main challenges, both of which will be approached with their own methodology as described below.

Challenge 1: The integration of HIS-data and RTLS-data

This objective will be reached through four successive stages. First, a taxonomy of nursing tasks will be created by conducting a literature review and observational research. Each identified nursing task will be mapped to its potential to leave a trail in the HIS- and RTLS-data. To this end, an observational study was conducted at two acute care wards of a Belgian hospital. Data was collected after approval of the medical ethical committee and obtaining a written informed consent from participating nurses. Preliminary results of the observational study can be found in section 4.

During the second stage a method will be created to integrate both data sources. This will iterate over two stages: (i) Task footprints (i.e. a representation that matches a nursing task to data points it generates in the collected data) will be constructed for each nursing task and (ii) Occurrences of the task footprints in the HIS- and RTLS-data will be automatically identified in the data. Each identified occurrence will generate one entry in a nursing task log.

Thirdly, the created method will be evaluated using both artificial and real-life data. Artificial nursing task logs with their associated task footprints and their corresponding HIS- and RTLS-data will be generated. Subsequently, the developed method will be applied, allowing a comparison between the artificial task log and the created task log. Real-life data will be collected in collaboration with a participating hospital. Ethical approval for this study was obtained from both the central ethical committee at Hasselt University and the local ethical committee at the participating hospital. Prior to data collection, informed consent will be obtained from participating nurses: (i) consent to extract a predefined list of entries made by the nurse into the HIS and (ii) consent to gather RTLS-data from designated areas within the hospital ward.

Finally, the benefits of combining HIS- and RTLS-data will be assessed. Four different scenarios will be compared (i) using only HIS-data, (ii) a combination of HIS-data with RTLS-data from mobile devices,

(iii) a combination of HIS-data with RTLS-data from nurses' tags and (iv) the combination of HIS-data with RTLS-data from both nurses' tags as well as mobile devices. For each scenario a nursing task log will be created after which a set of metrics is calculated to quantify their information value.

Challenge 2: Identifying and visualising work organisation patterns

After tackling the first challenge, the created nursing task log will be analysed for specific work organisation patterns.

First, a conceptual framework of work organisation patterns among nurses will be created through a literature review. Every discovered pattern will be assessed for its ability to be detected in the created nursing task log.

Secondly, a series of novel algorithms will be created to detect the identified patterns in the created log and to visualise them. Since the method will include a broad spectrum of work organisation patterns, connections between patterns can also be investigated. Explicit attention will be attributed to the visual output representation.

Finally, the algorithms will be evaluated and the benefits of presenting the analysis results to nurses will be assessed. Artificial nursing task logs will be used to evaluate the developed algorithms. To assess the benefits of the addition of data-driven insights during workshops to generate work organisation improvement ideas, two groups of nurses will be brought together to generate ideas. The control group will use traditional brainstorming techniques, while the discussion in the treatment group will be enriched with data-driven support. The output of both groups will be compared for both quality and quantity of generated ideas.

4. Preliminary results

To get an overview of the different nursing tasks performed at the hospital ward participating in this research, a cross-sectional observational study with nurses as participants was conducted at two Belgian hospital wards. Data about both the execution of nursing tasks and the registration of information in the HIS was collected. Observed tasks were mapped to nursing interventions as described in the Nursing Intervention Classification (NIC). The NIC is a comprehensive, research-based and standardized classification of interventions performed by nurses. The classification offers a broad spectrum of interventions, ranging from direct patient care (i.e. nursing interventions performed in the presence of patients and/or their families) to indirect care (i.e. nursing interventions performed away from patients but on their behalf), like administrative functions and supply chain management [20]. A total of 63 distinct interventions and 43 unique types of data entries into the HIS were observed. Noteworthy is that some interventions are never registered in the HIS. Furthermore, a complex relationship was observed between interventions and their HIS registrations. For example, a single intervention could be documented under multiple types of HIS entries, and conversely, a single HIS entry could correspond to multiple interventions. Finally, a significant discrepancy in the timing of the execution of interventions and their registrations was observed, with only 13.9% of interventions being registered simultaneously with their execution. These findings will be critical throughout the remainder of the research project. For instance, some interventions may leave a trail only in RTLS-data, as they are not captured in HIS. Additionally, when analyzing HIS-data, careful consideration must be given to the correct corresponding interventions to ensure accurate interpretation of findings. Finally, the study resulted in an overview of the different rooms in which nurses perform their interventions, the mobile equipment they use during their activities and the entries they make in the HIS. This list was added to the file submitted to the medical ethical committee in order to get their approval for the remainder of the research project.

A first literature research was conducted in an effort to conceptualise work organisation patterns and to list existing patterns into a framework, thereby tackling the second research challenge. However, first results seem to indicate there is not yet a clear description about what constitutes as a work organisation pattern. Already described and investigated patterns are scattered among different research domains and are mostly studied in isolation. Further literature research is needed to support this claim and will be conducted during the project.

5. Research next steps

The recently received approval from the medical ethical committee indicated a next stage in this research project. Currently, practical arrangements are being made to set up data collection. This includes the installation of the equipment needed for the RTLS-data at the hospital ward and setting up the data extraction from the HIS in collaboration with the hospital's IT department. Simultaneously, the nursing team will be thoroughly informed about the research and informed consents will be gathered. Once completed, data can be collected for several time periods.

Meanwhile, the previously described task footprints in section 3 will be constructed based on the data gathered on nursing interventions and their registrations during the observational study.

In addition, the literature review on work organisation patterns will be continued. The objective of this research is to conceptualise the term *work organisation pattern* and develop a framework that identifies and categorizes distinct patterns within this concept.

6. Conclusion

This doctoral research aims to aid nurses in generating work organisation improvement ideas by offering them data-driven insights in their current work organisation. These data-driven insights will stem from the analysis of a nursing task log that will be constructed using both HIS- and RTLS-data gathered from nurses and mobile devices. The combination of these two data sources will allow us to investigate the synergies between them in an empirical way. Moreover, this research will aid in understanding work organisation patterns among nurses, their impact on work organisation in general, how to detect them and how to visualise them in a usable way for nurses.

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