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Process Mining Applied to Lean Management Model Improving Decision Making in Healthcare Organizations

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Abstract

The paper introduces an innovative approach to model risks in healthcare finding possible solutions in organization models and about Human Resources (HR) managing. Specifically, the method is based on the application of the Business Processing Modelling and Notation (BPMN) workflows in healthcare environments merging Lean management methods and Artificial Intelligence (AI) decision making approaches. The discussion begins with a case study about risk management integrating AI to enable a Decision Support System (DSS) thus defining the innovative BPMN Process Mining (PM) models. The BPMN-PM models are based on AI risk prediction and AI risk classification suitable to optimise the whole HR organizational model. In the specific case study, the AI algorithms allows the optimization of risk assessment. Finally, the work discusses some theoretical BPMN-PM models to integrate in more complex healthcare processes managing efficiently HR. The proposed work provides information about the process design and the key-reading to interpret BPMN-PM workflows

Keywords – Business Process Modelling and Notation –BPMN-, Process Mining, Artificial Intelligence, Healthcare DSS

Paper type – Academic Research Paper

1 Introduction

The Business Process Modelling and Notation (BPMN) is a standard graphical notation (ISO/IEC 19510:2013) suitable to map processes (Massaro, 2021). In healthcare environments, BPMN is applied to design emergency care processes involving Human Resources (HR) (Pufahl, 2022) and is suitable for workflow simulations (Ongoo et al., 2018). BPMN is also an important tool to design Integrated Home Care (IHC) processes (Russo et al., 2015). On the other side, Process Mining (PM) is an innovative approach to optimize processes in industries, including organizational aspects, by means the integration of Artificial Intelligence (AI) algorithms in BPMN (Massaro, 2022 a; Massaro 2022 b): it is possible to integrate PM model into a BPMN workflow constructing an intelligent BPMN-PM decision making engine. The innovative aspect of the PM is the implementation of AI in the management processes enabling the automation of tasks and actions to perform in real time. The process automation is suitable to increase the efficiency in healthcare processes supporting the estimation of important Key Performance Indicators (KPIs). KPIs are defined in different application fields of healthcare processes including the basic ones such as costs, time delays, HR efficiency, and in general processes management. BPMN is also adopted to map Lean production processes in industries (Naciri et al., 2022). In healthcare, the Lean method is applied to solve organizational aspects (Bossone et al., 2022; Rosa, 2017). For the first time the proposed work shows the possibility to match BPMN-PM models with the Lean management approach by analysing a case study involving organization improvements of HR. This matching is possible because public institutions are moving quickly towards digital processes using software platforms allowing interoperability and data processing (digital transformation of public institutions and major availability of digital data to process). In this direction, the Covid19 scenario introduced a new approach tailoring processes by means of digital data and data analytics to decrease the pandemic risk (Elia, 2022). The need to merge organizational clinical procedures with the risk management processes using digital data, 'launched' the adoption of "digitised processes" enabling risk monitoring procedures and patient management processes. This aspect enhances the need to design and map processes integrating data processing methods. An important aspect to consider to map processes is the definition of procedure to perform. The procedure

adopted for the case study is based on the following standard steps typical of engineered school:

- **Step 1:** preliminary analysis institution's organigram to establish the actors to interview (first the sector managers, and then the individual workers);
- **Step 2:** mapping of the 'AS IS' process by means of interviews with responsible of a specific process to analyse (the questions are prepared before according to the case study to map representing a specific application field);
- **Step 3:** definition of the critical points emerging from the 'AS IS' analysis (critical aspects deducted from the interviews);
- **Step 4:** mapping (design) of the 'TO BE' workflow process enhancing solutions found for the critical points, and adding possible KPIs useful for the monitoring of the new designed workflow;
- **Step 5:** simulation of the 'TO BE' process to perform before the execution of the designed process;
- **Step 6:** execution of the 'TO BE' workflow by estimating KPIs (to be considered for a re-engineering of the whole process).

All the steps are included into a Plan Do Check Act (PDCA) model, where the Plan phase is the 'TO BE' process following the 'AS IS' one, the Do action concerns the execution of the 'TO BE' process, the Check is the process monitoring, and the ACT represents the final tailored process.

Specifically, the example discussed in the paper is related to the 'TO BE' process of an Italian public healthcare institution concerning patient fall risk assessment improved by a lean management approach supported by data analytics and PM. Starting to the case study the paper develops correlated BPMN-PM theoretical models based on a Lean management approach. The work is structured as follows:

- description of the symbols used for the BPMN workflows facilitating the process reading;
- presentation of the BPMN-PM model of a case study related a risk management model in healthcare (case study implementing the BPMN-PM model);
- developments of further theoretical BPMN-PM models improving the 'TO BE' healthcare organization deducted from the analysed case study (structuration of the organizational model);

- conclusions discussing advantages and perspectives about implementations of BPMN-PM approaches.

2 Main BPMN Symbols Mapping workflows

The symbols adopted for the BPMN models are the following:

- '*Pool*' containing the symbols of a process or of a sub-process;
- Event '*Start*' defining the begin of a process or of a sub-process;
- Event '*Start with a notification*' defining the begin of a process or of a sub-process following a request;
- '*Task box*' representing the actions to perform into the workflow;
- '*Timer*' event indicating a periodicity of an action to perform;
- '*Database*' symbol (local data repository or big data system);
- '*End*' event (end of a process/sub-process);
- '*Message End*' (end of a process/sub-process with a message/notification);
- '*Exclusive Event based*' gateway expressing decision making logics;
- '*Arrow line*' indicating the fluxes of the processes;
- '*Dashed line*' indicating the interconnections between two or many different '*Pools*'.

In order to facilitate the reading of the workflows are adopted for the '*Task boxes*' different colours having the following meaning:

- orange colour indicating the digital data;
- green colour indicating a matching with lean management procedures;
- red colour enhancing the DSS engine integrating the PM model or the AI algorithms improving the decision making actions.

As further symbols adopted to model task are used the dashed line '*Task box*' for an assessment of a particular condition, and the bold edges of box to enhance an important task. The '*Task box*' superimposed between two pools indicates an action to be executed by two processes or sub-processes (two different '*Pools*' executing the same task).

3 BPMN-PM Model Applied to an Italian Case Study

The first step adopted to design a 'TO BE' process for the case study, is to map the actual 'AS IS' process providing important information about critical points. In the specific analysis, a critical point is found in the risk management process

about the falls in the hospital rooms. In Fig. 1 is illustrated the 'TO BE' BPMN workflow optimizing risk assessment procedures and sketching the PM model. As previously discussed, the BPMN is typically adopted to model processes by allowing the possibility to simulate all the sub-processes. This is an important aspect to comprehend the whole studied scenario by considering all the cases involved in the sub-processes. We observe that the proposed BPMN diagram is a simplification of a more complex workflow which takes into account other system actors (in the proposed example there are only three '*Pools*' indicating the three main actors of *Risk management Unit*, *Operative Unit*, and *Medical Direction*). The model considers the following important tasks improving the fall risk management procedure:

- introduction of a tablet or of a mobile app for the digital traceability (digital transformation of the 'AS IS' process) of all events about patient fall conditions and cases (recording of digital data useful for data analytics);
- a new procedure about the reorganization of resources and nurses to improve the organization about the monitoring (lean management of the risk monitoring);
- a HR learning plan able to optimize the checks of the events and the risk assessment (lean management approach about learning organization);
- a new approach for the monitoring of corrective actions by the introduction of effective corrective elements as outputs of the optimization of the organizational management;
- the check of the electronic health records to update the Conley tab (Guzzo et al., 2015) initially filled when the patient enters the hospital room (important aspect to update information useful for the monitoring procedure);
- an advanced data analytics performed by the Decision Support System (DSS) engine implementing AI algorithms (supervised self-learning algorithms used for prediction and for classifications, and unsupervised ones adopted for data clustering).

The main innovative aspect of the model is represented by the DSS highlighted in red in the figure, enabling advanced data analytics (correlation results and data clustering), risk prediction, and risk classification. The workflow of Fig. 1 indicates also the tasks involving directly the lean management approach (green colour)

and the digital data sources (orange colour). The decision making could be therefore optimized by finding by AI algorithms 'hidden' correlations between risk's variables, by classifying new classes of risks, and by predicting the risks. The further advantage of the DSS is the possibility to compute different variables by optimizing the predictive results by training the model through the processing historical dataset contained in the backend of the management platform (database of the software platform).

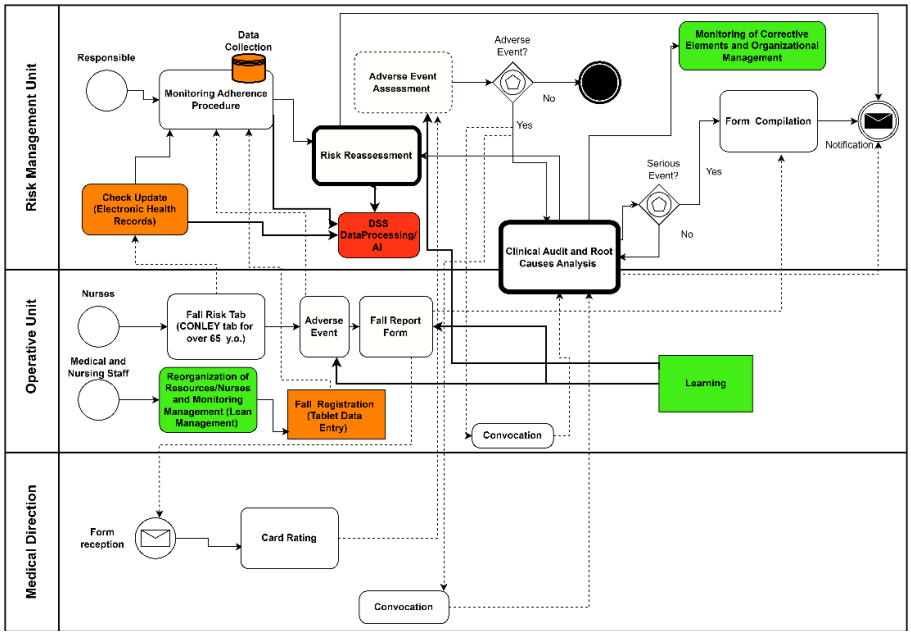

Figure 11. BPMN 'TO BE' model of the fall risk assessment (orange colour indicates digital data, green colour represents tasks involving lean management solution, and red colour highlights the DSS engine implementing Process Mining).

4 BPMN-PM Models and Healthcare Organization Improvements

The case study discussed in the previous section allows to develop new BPMN-PM models supporting HR organization in healthcare environments. Possible 'TO BE' improvements in organizations is described by the BPMN-PM workflow of Fig. 2 defining the AI risk assessment linked to the analysed case study. Specifically, the designed workflow is explained as follows (workflow simulation performed by analysing the use cases):

- if the risk assessment provides a high risk score, will be required urgent interventions about a reengineering plan of HR allocation, consecutively updating the organizational plan;
- if are not checked risk conditions, it is enabled the AI engine providing risk predictions (condition enabling AI data processing);
- if are predicted risks, will be applied interventions (non-urgent interventions) about the HR allocation, consecutively updating the organizational plan;
- if are not predicted risks no actions will be performed;
- the risk assessment is performed periodically according to the indications contained into the updated organizational model.

We observe that the workflow of Fig. 2 is a self-adaptive model: the feedbacks allow to update periodically the organizational model according to the risk assessment and to AI risk prediction results supporting the reengineering of the HR organization in the medium-long period.

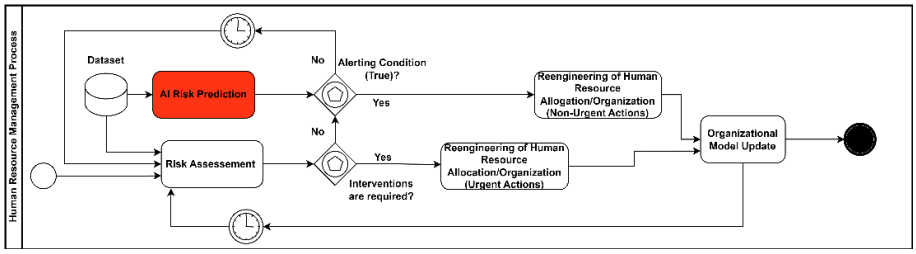

Figure 2. BPMN 'TO BE' model of the HR organisational model construction by means of risk assessment and AI risk prediction.

Figure 3 'explodes' an example of the organizational model indicated in Fig. 2. The workflow is characterised by the following three levels of actions:

- **Action 1**: enabling a learning plan and actuating it;
- **Action 2**: enabling a re-allocation of HR;
- **Action 3**: adding action of HR.

Action 1 is executed when it is evaluated that is enough a formative plan to solve a problem associated to a risk. If after the execution of the formation plan the problem is not solved, it is checked the possibility to activate Action 2 and Action 3 in sequence. For the particular case that also the Action 3 is not required, it is performed the re-analysis about the AI risk classification. Starting to the update of the risk classification (merging

information about risk assessment), it is again followed the iterative cycle.

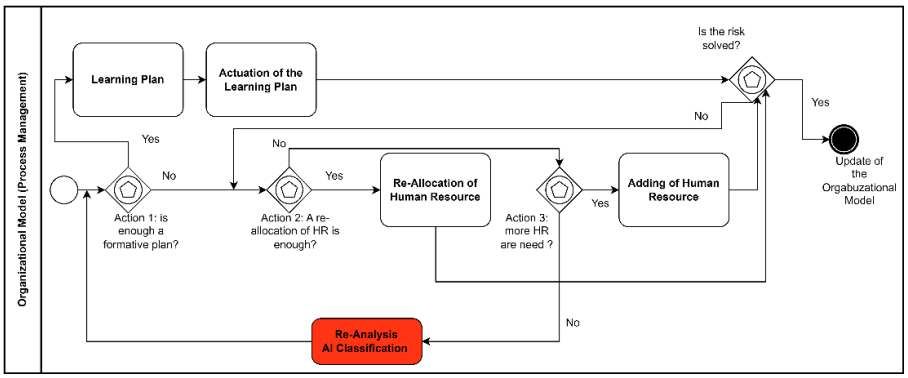

Figure 3. BPMN 'TO BE' model of the human resource organisational model construction by means of a sequential combination of different processes (Learning, Re-allocation, and Adding HR).

The learning plan must be designed after a check of the HR availability and of all competences. This allows to intervene with precision in each single process. The plan is addressed mainly to the upskill of HR. The allocation of HR should be managed according to feasible solutions and real needs.

5 Conclusions

The goal of the proposed process is to optimize the risk assessment procedure by decreasing the falls in the hospital rooms by adopting a dynamic process able to update efficiently the risk evaluation criteria and the corrective elements. The used approach merges different concepts and methods such as the lean management approach, BPMN mapping, and PM models. Starting to the analysis of a case study, the proposed work defines intelligent organizational models enhancing the AI role in risk decision making. The advantages of the BPMN-PM models can be summarized in the following main points:

i) a clear definition of the responsibilities and roles in the process to be executed,
ii) the formulation of new procedures to follow avoiding possible risks and process failures;
iii) possibility to simulate the process before to be executed (testing of the process analysing all the workflow cases);

iv) possibility to check dynamically the correct execution of the process (as for synoptic dashboards able to monitor in real time the performed tasks for each phase of the process);
v) possibility to translate listed procedures by means of a graphical workflow;
vi) improvement of procedure quality;
vii) improvement of process efficiency (monitoring KPI in different stages of the process);
viii) automated updating of the plan managing HR;
ix) a significant decrease of risks;
x) a clear indication of the AI role in the whole decision making process;
xi) the assessment of risk levels updating the risk classification;
xii) a possible decrease of costs (related the specific mapped process);
xiii) a simple way to update quickly the process visualizing their characteristics (process re-engineering).

The perspectives of the BPMN-PM model about lean management in healthcare applications are mainly in a new 'concept' to manage HR and related processes. A possible implementation of AI in decision making could reduce drastically the patient's risks and optimize the whole management of HR. AI algorithms are able to find possible correlations between risk variables thus updating the risk assessment criteria and the risk classification. The international standard notation BPMN is a good way to fix the correct execution of advanced processes characterized by AI analytics. Future works will be addressed on specific data processing and KPI estimation.

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