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Managing Uncertainties in the Surgical Scheduling

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Abstract. Current surgical scheduling system has difficulties to handle unpredictable events or uncertainties. Source of uncertainties may come from the patient or the surgery itself, where several cases require immediate changes in data, such as when surgery delays or cancellation occurs on the same day. The study aimed to model the uncertainties for managing identified uncertainties during the continuous scheduling, framed by resilience concept to cope with the system fragility. In order to be able to control and adjust any changes which may affect the surgery schedule of the day, we provide alternatives of solution rather than strictly decide the best valued options. We identified dimensions of uncertainties and categorized them based on the resilience concept, computed the impact value of potentially conflicted resources as a result of schedule change. With the model applied, we would provide a list of most acceptable and less vulnerable alternatives for anesthesiologist as a scheduler to build resilience in the surgical scheduling.

Keywords. Surgical scheduling, uncertainties, resilience, patient safety

Introduction

Problems related to surgical scheduling mostly arise when changes occur on the surgery day, such as unavailable operating rooms, conflicted schedules of medical staff, patient unwillingness to change schedule due to waiting time, and the most important thing, is patient condition. Minimizing the risk of schedule modification requires concerted effort since decision making process should consider several aspects related to operational cost, good medical practice, patient condition, and safety in the surgical environment. From the previous research [1], an integrated scheduling system framework designed using cognitive work analysis has been introduced, which covers most important values to schedule a surgery, while in another study, author defined values that can improve situational awareness among the surgical team members upon executing their daily operational activities [2]. However, these previous studies have not implemented systematic structures to manage unpredicted events occur beyond the normal situation.

Uncertainties in surgical environment are unexpected conditions during normal operational activities. Uncertainties may come from the patient or the surgery, where several cases require immediate changes in data, such as when surgery delays occur,

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cancellation, or new surgery admission of an emergency case. Current system utilized in the general hospital in South Korea has covered nearly all management functions required for basic operational activities, such as managing patient information, treatment room, ward, and treatment support. However, current system has difficulties to handle unpredictable events or uncertainties occur on the same day. The hospital growth, complexity of cases, and unstable patient condition, become factors that affect uncertainties in daily hospital operations. Thus, creates a significant influence for decision makers. With these factors involved, the hospital hierarchical structure, and different views of each stakeholder, have prolonged the decision making process in handling such complex circumstances and frequent changes, which also highly depends on the user level of expertise and experience.

The objective of this study is to model the uncertainties for managing identified uncertainties in order to be able to control and adjust any changes which may affect the surgical scheduling, using resilience concept. From the interview with anesthesiologists who also have an important role as schedulers, we identified subject to uncertainty and categorized them based on the resilience concept, computed the impact value at of potentially conflicted resources as a result of schedule change. With the model applied, we would provide a list of most acceptable and less vulnerable alternatives for anesthesiologists as schedulers to build resilience in the surgical scheduling.

1. Methods

A method used in this research is a semi-structured interview consists of data collection and understanding on related theories to changes in scheduling include resilience theory and uncertainties. The interview was conducted with two 4th-year residents who work as anesthesiologists in a private university hospital located in Seoul, South Korea, which currently operates twenty operating rooms. It was aimed to get in-depth contextual knowledge about daily operational tasks related to scheduling issues and patient handling during perioperative period. Therefore, ten open-ended questions were classified into categories of surgery scheduling perspective, information sharing, organizational issues such as decision making, and system technology.

Resilience theory becomes the foundation for this research. Resilience itself is a situation in the way that individuals or groups may respond and find stability to reach the equilibrium state whenever perturbations occur. Although resilience concept is well accepted in engineering field, other high-risk industries such as healthcare services adopt the concept as well, as an institutional resilience which mainly focus on creating resilience checklist and identifying risks and hazards [3]. Additionally, research on the development and testing of several scales has been designed to measure aspects of resilience in the healthcare industry [4]. In another study, resilience concept was carefully applied in the case of clinical handover for more reliable approach to achieve patient safety [5]. With various studies on how resilience applied in the complex organizations, it is clearly seen that resilience is undoubtedly needed for strategic decision making, especially when uncertainties frequently occur in daily operations.

In order to reach the optimal problem solution, the process may include some strategies to deal with uncertainties and healthcare domain understanding. As related to resilience concept, uncertainty has also become interests for many researchers. Studies have demonstrated the strategies by modelling uncertainty using the probability theory, due to the small occurrence but relatively affecting the normal activity processes [6-7].

The problem solving task in the healthcare domain has also been studied that the knowledge learning becomes an important factor to structure the problem solving based on the knowledge itself [8]. Furthermore, analysis about the surgical environment was conducted in order to have clearer identification and perspectives about the circumstances of surgical activities, as suggested in another study [9]. Some methods such as interviews with anesthesiologists and surgeons, and observations inside the operating rooms [IRB: Context Aware Surgical Environment Progress Evaluation, 2014-005], can support uncertainties identification process to model the uncertainties.

2. Results

The interview revealed that anaesthesiologists as schedulers are responsible to manage the operating room daily schedule, with the major problem faced by them is when conflicts arise from schedule modification activity on the same day. Conflicts may relate to resources availability such as staff and operating devices, or overlapped schedules. These are factors that in addition with uncertainties described in the previous section, make the schedule modification becomes more complicated yet challenging.

Uncertainties occur on the same day in surgical environment may affect the operational management issues, such as the surgical team staffing, operating room assignment, and recovery ward availability. Most importantly is the operational cost affected by changes which caused by uncertainties. Thus, it is required to manage uncertainties so the system can adapt with frequent changes and reach the stability.

2.1. Dimensions of Uncertainties in Surgical Scheduling

The major constraint identified is the connected activities among the medical staff, and how these activities are bounded by time, resources, and patient condition. By prioritizing patient condition in the first place, optimal time and resource planning as other main considerations in scheduling can be achieved. In handling daily procedures in the operating room, the surgery start time and duration may influence continuous scheduling and task planning among the medical staff, therefore affects other resources availability such as medical devices and operating rooms. Furthermore, from the hospital management perspective, time and resources also have significant impact on operational cost, creates the needs for effectiveness and efficiency.

Factors that mostly cause changes in scheduling are late start (unpunctual), prolonged surgery duration, and fluctuating patient condition. In this study, we identified these as sources of time intrusion of the surgical scheduling which leads to uncertainties. Table 1 briefly describes dimensions of uncertainties which consist of condition compliance, resources availability, and change consent.

Table 1. Dimensions of uncertainties that caused by time intrusion in scheduling.

Factors	Description
Condition compliance	The patient latest condition that marks a significant priority in making scheduling decision.
Resources availability	The existence of resources such as operating rooms, surgical devices, and medical staff (anesthesiologists, surgeons, nurses).
Change consent	Consent from the stakeholders affected by the change occurs in scheduling such as staff, patient and family, whether they would agree to the new arrangement.

Dimensions of uncertainties may affect the decision making process since the overall steps involved during the timeframe are counted as the final impact value, as shown in Figure 1 below.

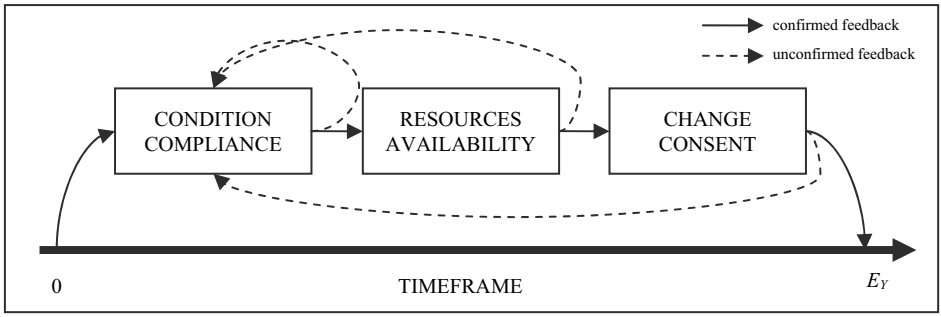

Figure 1. The decision making model with dimensions of uncertainties along the timeframe.

2.2. Model of Uncertainties in Surgical Scheduling

From the definition stated in resilience theory [10], resilience is the ability to cope with events which may cause negative consequences. According to the occurrence of events, there are three different types of events which may influence the resilience: normal, fluctuating, and unprecedented events. Thus, categorizing dimensions of uncertainties respectively. Following this concept, suppose that we have a set of resources of surgery X which includes operating rooms, devices, anesthesiologists, surgeons, and nurses, we calculate the impact (E_Y) as the value that describes how much effect caused by the change of surgery Y, as the addition of dimensions of uncertainties: Resources availability (A_X), condition compliance (C_P), and change consent (C_O), as described in formula (1).

$$E_Y = C_P + A_X + C_O \cdot \tag{1}$$

We observed that two types of change occur during the scheduling. The first one marked as CANCEL which may cause the surgery be eliminated and no longer on the list, thus, making one more slot available for another surgery and automatically sets E_Y to 0. The second one is DELAY which may cause other surgeries moves Forward or Backward of the schedule ($E_Y > 0$), also depends on C_P and C_O that affect the decision making.

3. Discussion

According to our proposed model explained in the previous section, we simulated the case within department as illustrated in Figure 2. This simulation depicted the schedule changes and how our method may provide several alternatives solution. The first stage showed that conflict at P3 caused by P1 with four resources will be affected, thus provided a probable solution to move P3 backward the schedule to 30 minutes later, assuming that there were no issues on patient condition (C_O), and also no consent issues from both patient and staff (C_P). For the second stage when P1's delay was added, it showed conflicted resources at P4 and P5. At this stage, scheduler needs to

consider whether to substitute A1 of P4 to another anesthesiologist, or move P5 to another available operating room outside the department.

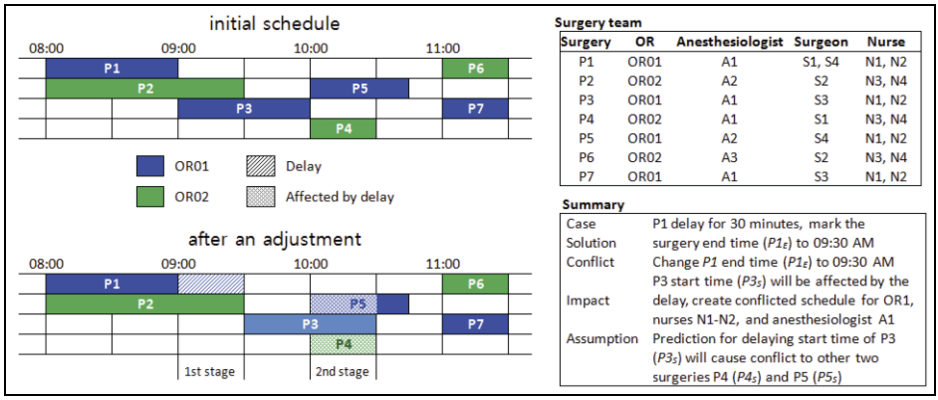

Figure 2. Providing alternatives solution to resolve conflicts emerging from schedule modification.

4. Conclusion

This study has presented a method to model the uncertainties in order to provide optimal alternatives for surgery schedule changes. With the data example given by the scheduler for one day simulation, related tasks were generated to support the model computation proposed for scheduling on the same day. In further study, we will define more details on each dimension and the system will be designed for mobile use to accommodate the schedulers mobility.

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