Proceedings of the 2024 Winter Simulation Conference
H. Lam, E. Azar, D. Batur, S. Gao, W. Xie, S. R. Hunter, and M. D. Rossetti, eds.

MODELING INTRA-HOSPITAL TRANSFERS: THE EFFECT OF CARE-SPATIAL INFORMATION ON DECISION-MAKING AND PATIENT FLOW

Momoko Nakaoka[1], and Ajith Parlikad[1]

[1] Dept. of Engineering, University of Cambridge, Cambridge, CB3 0FS, UK

ABSTRACT

An Intra-hospital transfer (IHT) refers to the patients' movement between hospital units, which includes changes in a patient's location and the care responsible. Therefore, an IHT workflow involves interactions between clinical and non-clinical staff. Hospitals with beds shortage often experience a sequence of IHTs to create an available bed on a right place at the right time for an boarding ED patient. Group decisions on priority setting and resource allocation for IHTs can unintentionally disrupt patient flow without the necessary information or insight into the potential impact. Observational study and review revealed a lack of care-spatial information(CI) in the current systems used for IHT decisions. We proposed a modelling method to demonstrate the process of information exchange between teams using Discrete event simulation (DES). This showed that CI can support IHT decisions and suggested the potential of DES to quantify the impact of acquiring care-spatial information on patient flow.

1 INTRODUCTION

In a hospital, inpatients are often moved between hospital units, considering patient safety and system efficiency, which is called an Intra-hospital transfer (IHT). An IHT involves activities of care coordination, bed management, clinical handoffs, and patient transfer by multi-disciplinary teams including physicians, nurses, hospital mangers, administrative staff, and porter teams (Abraham et al. 2020; Abraham and Reddy 2013). Hospitals with scarce resources often rely on multiple IHTs to manage bed availability efficiently, which requires coordination across hospital units and teams (Blay et al. 2017). While poor IHT management can harm patient safety and staff workload, effective management enhances care transitions and improves the readiness of patient flow (Blay et al. 2017; Trovó et al. 2021). While studies analyzed IHT outcomes, the decision-making process has been overlooked. Therefore, this study combined an observational study and a simulation study to identify the bottleneck of the decision-making process and explore the solutions.

2 PROBLEM DEFINITION

We conducted job shadowing and interviews with support service teams (e.g., porters, estates, security, housekeeping) and the Bed Management Unit (BMU) at an NHS hospital in the UK. The hospital includes major departments such as the Emergency Department (ED), Acute Assessment Unit (AAU), General Medicine Units (GMU), and a Discharge Waiting Area (DWA) for patients needing general medical care. Observing ED patient boarding revealed a complex scenario involving three intra-hospital transfer (IHT) networks: GMU-to-DWA, AAU-to-GMU, and ED-to-AAU. Task prioritization and resource allocation within teams sometimes created bottlenecks in downstream IHT activities, disrupting patient flow. Through interviews and workflow analysis, we identified key decisions and information needs, mapped using sequence diagrams. In this study, care-spatial information (CI) refers to data on the spatial and logistical attributes of hospital resources, including real-time information on capacity, flexibility, and suitability for patient placement and transfers. Analysis showed that crucial Capacity, Flexibility, and Suitability (CFS) information—such as bed availability in infectious rooms, local mealtimes, and electrical failures—is not effectively communicated to relevant teams through current bed management systems. We developed two hypotheses: that CFS information would improve decision quality and that CFS-based decisions would enhance key patient flow metrics (e.g., ED boarding time, staff utilization, and avoidable adverse events).

3 SCENARIO ANALYSIS SIMULATION MODEELING

This study selected simulation techniques over analytical and meta-heuristics methods, as they better represent the complexity of an ED than analytical methods and meta-heuristics often focusing on just one objective (El-Zoghby et al. 2016). Discrete event simulation (DES) was chosen for modeling, as it effectively captures patient flows, processes, and resource constraints within multi-facility systems (Gunal and Pidd 2007; Matta and Patterson 2007). In this study, the decision-making process involving the action "Find/release the ward with a future bed" was demonstrated using the simulation software Simio. Patient flow from ED arrival to hospital discharge was modeled to represent the exchange of CFS info in both the planning and execution processes of IHT. ED boarding time was used to measure the effectiveness of the IHT sequence, and the number of transfers to infectious rooms was recorded to assess IHTs with adverse events as a measure of effectiveness. The proposed scenario, which includes CFS info (unavailable beds in an infectious room), enables the cancellation of all relevant bed reservations in any room where a patient is identified as infectious. In the scenario without this information, bed reservations persist until an ED nurse contacts a ward nurse, creating unnecessary tasks for both the ED nurse and BMU staff and potentially prolonging ED boarding time or increasing adverse events. This DES model demonstrated a method to integrate an information delivery process into a patient flow process and to evaluate how the availability of physical capacity information impacts the effectiveness and efficiency of the IHT planning process.

4 LIMITATION AND FUTURE RESEARCH

This study highlighted that segmented information in IHT management hinders smooth decision-making and presented a scenario where care-spatial information improves information exchange. It also demonstrated the potential of using DES to model information exchange processes with and without care-spatial data. However, the care-spatial information used in this study was too simple to require computational geospatial reasoning. More complex scenarios, such as ‘nearest staff to a patient,’ would better illustrate its benefits. While the analysis showed how CFS info can improve decision-making, it did not explore its impact on outcomes. Future research should evaluate how CFS info affects patient flow by linking simulation results to KPIs under different prioritization and resource allocation policies.

REFERENCES

Abraham, J., S. Burton, and H. S. Gordon. 2020. "Moving Patients from Emergency Department to Medical Intensive Care Unit: Tracing Barriers and Root Contributors". *International Journal of Medical Informatics 133*:1-8.

Abraham, J. and M. C. Gordon. 2013. "Re-Coordinating Activities: An Investigation of Articulation Work in Patient Transfers". In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*, February 23-27, San Antonio, Texas, 67-78.

Blay, N., M. A. Roche, C. Duffield, and R. Gallagher. 2017. "Intra-Hospital Transfers and the Impact on Nursing Workload". *Journal of Clinical Nursing 26*(23-24):4822-4829.

El-Zoghby, J., H. A. Farouk, and K. S. El-Kilany. 2016. "An Integrated Framework for Optimization of Resources in Emergency Departments". In *6th International Conference on Industrial Engineering and Operations Management*, March 8-10, Kuala Lumpur, Malaysia.

Gunal, M. M. and M. Pidd. 2007. "Interconnected DES Models of Emergency, Outpatient, and Inpatient Departments of a Hospital". In *2007 Winter Simulation Conference (WSC)*, 1461-1466 https://doi.org/10.1109/WSC.2007.4419757.

Matta, M. E. and S. S. Patterson. 2007. "Evaluating Multiple Performance Measures across Several Dimensions at a Multi-Facility Outpatient Center". *Health Care Management Science 10*(2):173-194.

Trovó, S. A., D. F. Cucolo, and M. G. Perroca. 2021. "Transfer of Patients in Hospital Units: Impacts on Nursing Workload". *Revista Da Escola de Enfermagem Da USP 55*:1-7.