SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

The study objective was to examine via simulation models the influence of operating room design on patient safety, measuring surgical team contacts (disruptions) and movement.

Operating room design using agent-based simulation to reduce room obstructions

Taaffe, K., Ferrand, Y. B., Khoshkenar, A., Fredendall, L., San, D., Rosopa, P., Joseph, A., 2023 | Health Care Management Science. Volume 26, Issue 2, Page(s) 261-278

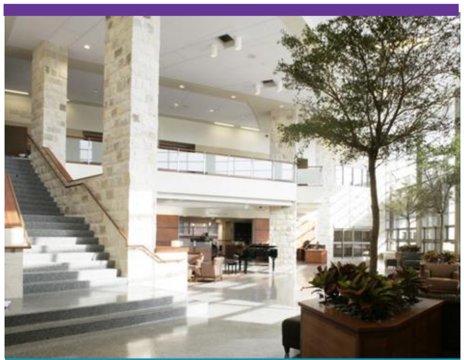
Key Concepts/Context

Research shows that the operating room layout and design can play an integral role in how a procedure is carried out and how flow disruptions can be minimized to optimize outcomes. Despite past research aimed toward improving room layout and providing recommendations to minimize surgical site infections, there remains a lack of evidence demonstrating how these physical environment factors affect safety and efficiency performance.

Methods

Researchers used hybrid simulation modeling in three phases:

1. **Data collection, coding, and video analysis:** 23 surgical cases from a 700-bed academic hospital in the Southeastern United States were evaluated via video data. These were consecutive cases in four separate operating rooms equipped with video cameras in the corner of each room. The Noldus software allowed for recording of multiple camera views simultaneously and the application of a pre-defined code for each subject (workstation zones, tasks performed in each zone, materials and supplies, information exchange).
2. **Development of an agent-based, discrete event simulation model:** Two simulation models were constructed in this study: a playback model and a generalized model. The playback model was created from video recordings of 23 different surgical cases from a large, 700-bed hospital. The information was coded and categorized by working 'zone' of the room as well as type of task (e.g., patient-related task). The playback model was the initial model and was used to create the generalized model. The generalized model reduced the dataset to only destination zones where an activity occurred rather than all intermediary travel around the room. The individual surgical teams (agents) could then select the best feasible route in the room.



The Center for Health Design: Moving Healthcare Forward

The Center for Health Design advances best practices and empowers healthcare leaders with quality research that demonstrates the value of design to improve health outcomes, patient experience of care, and provider/staff satisfaction and performance.

Learn more at www.healthdesign.org

3. **Statistical analysis summarizing both descriptive and predictive results:** Variables included room size, room shape, OR table orientation, circulating nurse workstation location, team size, number of doors, and procedure type. Occupancy metrics included total distance traveled (TDT) and total number of contacts (TNC), with TDT being the total distance walked inside the OR by all team members and TNC being the number of contacts with other team members which may lead to disruption between tasks.

Findings

The overall simulation model has TNC as the dependent variable and the following predictors: room size, room shape, OR table orientation, clinical nurse workstation location, team size, number of doors in the OR, and procedure type. A total of 192 simulated scenarios were used and 50 replications per scenario were conducted. Room size, procedure type, and team size collectively play an important role related to total number of contacts. The model was statistically significant, $F(8,11,323) = 2,834.68$, $p < 0.0001$, and explained 66.7% of variance in TNC. All predictors were statistically significant except for number of doors in the OR. Thus, a second multiple linear regression was conducted with all predictors but excluded number of doors in the OR. The overall model was statistically significant, $F(7,11,324) = 3,239.92$, $p < 0.0001$, and explained 66.7% of variance in the dependent variable. All predictors were statistically significant at the 0.0001 level.

Focusing on the main effects model, when holding the other predictors constant, increasing the team size from five to seven increased TNC by 16. Compared to the medium room, the small room resulted in an average increase on TNC by 13. Compared to the circulating nurse workstation located at the foot of the OR table, the circulating nurse workstation beside the wall resulted in an average decrease on TNC by 7. Although the remaining predictors were statistically significant, the predicted average change in TNC was not as large. For example, compared to an angled OR table orientation, a horizontal OR table orientation resulted in an average increase on TNC by 1. The largest semi-partial correlation, or the single largest unique predictor of TNC, came from team size ($sr = 0.52$), followed by room size ($sr = -0.41$), procedure type ($sr = 0.41$) and circulating nurse workstation location ($sr = -0.22$).

Limitations

Process-related factors were not included to further contextualize findings, such as patient flow related to on-time starts, task handoffs, team coordination and cooperation, and task assignments. The model has only been applied to this set of cases, which may impact generalizability of findings.

Design Implications

Situating the circulating nurse workstation at the foot of the operating table may influence total number of contacts. Further consideration should be given into the design and orientation of the operating table, as horizontal placement is significantly better than other orientations (angled or at foot of bed) for some procedures (e.g., pediatric OTO, which are high foot traffic type of procedures), but worse for others (e.g., adult G-LAP procedures).