The Institute of Medicine’s infamous 2004 report highlighted the importance of nurses’ work environments for patient safety.\(^1\) Since then, a number of researchers have begun to investigate how workplace characteristics (for example, organizational climate, distractions, safety climate, leadership, and technology) affect quality and safety outcomes. However, few of these studies have explored the complex interplay of organization, nursing unit, and individual staff member, in large part because they lacked the methods needed to do so.\(^2\)
In any case, our understanding of what innovations are most likely to improve patient care safety and quality outcomes on a given nursing unit remains marginal. As a result, nurse managers are all too often unpleasantly surprised to find that an innovation recommended by colleagues or a review of literature fails miserably on some of their units.

Computational modeling offers nurse managers a potential solution. Computational modeling is best understood as a “set of loosely interrelated research tools” that have been developed to investigate how complex systems, including the individuals who populate those systems, function. Using these tools, computer models can be created that represent core characteristics of the complex systems, or organizations, being modeled. The virtual models then can be used to simulate actual organizational processes and predict the likely outcomes of those processes under various conditions.

Computational modeling lets managers ask complex, multilevel “what if” questions that can’t be answered easily using traditional methods. Because simulations can be specific to a particular organization or even a nursing unit, the predictions generated are also organization- or unit-specific. Nurse managers can use the modeling tools to answer questions such as, “Which is more likely to decrease medication errors on my unit, increasing RN staffing or implementing barcoding technology?” Finding the likely answer in a virtual world before doing a full-scale (or even a pilot) implementation in the actual world can save considerable cost and effort.

**Usage history**

Computational modeling was first applied in organizations to describe how shoppers’ behaviors determined what stock to order and how much to charge for it. Computational modeling was later used to model project teams for designing hospitals and other buildings, to study organizational response to crisis, and to estimate the impact of turnover. Today, computational modeling is widely used by both military and civilian organizations for organizational design and assessment.

In healthcare, computational modeling has been used to optimize wait times, throughput and costs; to predict staffing needs, facility size, and financial and patient outcomes of program modifications; and to analyze workflow. In nursing, computational modeling was initially used to develop cost reimbursement models and reduce clinical waiting times. Generally this took the form of mathematical “what if” techniques, such as those available in spreadsheet or statistical programs.

Although certainly useful, this type of mathematical modeling isn’t powerful enough to handle the complexity of today’s nursing organizations. However, modeling tools do exist that have sufficient power to simulate multiple levels of organizations and many interrelated variables. My colleagues and I used one application, with a structure and underlying assumptions based on broadly accepted socio-organizational theories, to create virtual nursing units that corresponded functionally to 32 actual units, then used the simulated virtual units to predict the likely impact of various unit-level innovations on the actual units’ safety and quality outcomes.

We used data collected from the actual nursing units to create the virtual units then validated that the performance of the virtual units corresponded to that of the actual units (in terms of quality and safety outcomes).

We then began to look at how we could improve outcomes in the virtual units, focusing mainly on the kinds of changes in structure, processes, or staffing that nurse managers could make on their own. To identify the changes that would improve patient safety and quality outcomes most, we systematically increased or decreased specific work environment factors and observed the impact of doing so on safety and quality. Next we drilled down to see how changes in the various components of task
complexity (percentage of elderly patients, number of comorbidities, percentage of self-pay patients, RN workload, and turbulence) contributed to task complexity.

We then drilled even further into the components of turbulence represented in our model (specifically, environmental uncertainty, distance nurses traveled to give care, accessibility to supplies and medications, and responsiveness of support staff) to study their relative impact. We followed a similar procedure to evaluate the impact of nursing culture and staff education/experience on safety and quality outcomes.

**Heeding predictions**

Overall, task complexity and its staffing and environmental turbulence components had the greatest impact on quality and safety outcomes; although the innovations that improved quality and safety outcomes most differed significantly across units. Improving RNs’ control over nursing practice was also frequently effective. Hiring more highly educated nurses or providing on-the-job training improved unit performance, but not as much.

When we reported the predictions generated by the model for each unit to the managers and selected staff on that unit, their responses were overwhelmingly positive. Managers told us that the information was extremely useful for suggesting what they might change, as well as what they shouldn’t change, to improve outcomes. Although we didn’t compare costs, one of our programmers demonstrated that this would be relatively easy to add to the program.

Other computational modeling tools can be used to study communication patterns. Some of the most promising are based on social network analysis. For example, one researcher used a dynamic social network analysis program to analyze information use in a public health organization. Her analysis produced graphical representations of the organization’s communication structure, as well as statistical reports on the quality of the information network, employees in key positions, status of experienced staff, and strengths and weaknesses of the organization.

Significantly, this researcher was able to project the impact of an impending organizational merger on communication quality and patterns. Organizational leaders used these results to help plan for restructuring after the merger. The potential uses for these tools are many. For example, one of our former nursing doctoral students used social network analysis to study communication patterns in patient handoffs, an area often implicated in patient safety problems.

The computational modeling I’ve described here was carried out by researchers and was both time and labor intensive. In each case, surveys were used to collect the data needed to construct the models. However, we expect that nurse managers or their assistants soon will be able to do computational modeling with minimal support because the tools themselves rapidly are becoming more accessible and user friendly. In addition, hospital information systems should soon be able to provide the bulk of data needed for modeling without additional surveys of staff or patients.

In sum, computational modeling offers nurse managers a valuable set of tools for evaluating the likely impact of innovations on safety or quality outcomes before undergoing the pain, expense, and risk of implementing them. To use the tools today would likely require that managers collaborate with researchers and others in their organizations to collect the data needed for modeling and conduct the analyses. However, in the very near future these tools are likely to reside on managers’ desktops and will be as easy to use as a spreadsheet.

**REFERENCES**


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