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Using Cognitive Work Analysis to fit decision support tools to nurse managers' work flow

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ABSTRACT

Purpose: To better understand the environmental constraints on nurse managers that impact their need for and use of decision support tools, we conducted a Cognitive Work Analysis (CWA). A complete CWA includes system analyses at five levels: work domain, decision-making procedures, decision-making strategies, social organization/collaboration, and worker skill level. Here we describe the results of the Work Domain Analysis (WDA) portion in detail then integrate the WDA with other portions of the CWA, reported previously, to generate a more complete picture of the nurse manager's work domain.

Methods: Data for the WDA were obtained from semi-structured interviews with nurse managers, division directors, CNOs, and other managers ($n=20$) on 10 patient care units in three Arizona hospitals. The WDA described the nurse manager's environment in terms of the constraints it imposes on the nurse manager's ability to achieve targeted outcomes through organizational goals and priorities, functions, processes, as well as work objects and resources (e.g., people, equipment, technology, and data). Constraints were identified and summarized through qualitative thematic analysis.

Results: The results highlight the competing priorities, and external and internal constraints that today's nurse managers must satisfy as they try to improve quality and safety outcomes on their units. Nurse managers receive a great deal of data, much in electronic format. Although dashboards were perceived as helpful because they integrated some data elements, no decision support tools were available to help nurse managers with planning or answering "what if" questions. The results suggest both the need for additional decision support to manage the growing complexity of the environment, and the constraints the environment places on the design of that technology if it is to be effective. Limitations of the study include the small homogeneous sample and the reliance on interview data targeting safety and quality.

1. Introduction

The quality and safety of healthcare in the US continues to be troubling [1]. In acute care hospitals, nurse managers are expected to improve the safety and quality of care on patient units while cutting costs, increasing productivity and meeting external regulations and standards. Implementing unit innovations can be challenging because innovating is not only expensive in terms of time, labor and change-induced stress, but is context sensitive. That is, the fact that an innovation worked well elsewhere is no guarantee of local success.

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We are developing a dynamic network analysis decision support tool (DyNADS) that will enable nurse managers to test the likelihood of success of various innovations in virtual units functionally similar to their own before implementing the innovations on their actual units. DyNADS integrates the computational modeling capability of OrgAhead with the network analysis functionality of *ORA. (OrgAhead and *ORA are described in detail and available at http://www.casos.cs.cmu.edu/computational_tools/tools.html.) If DyNADS—or any decision support tool—is to be well utilized, it must fit with nurse managers' work flow and cognitive processes [2,3].

As part of the primary study, we conducted a Cognitive Work Analysis (CWA) to describe the nurse managers' workplace environment and degree to which data needed by DyNADS can be collected from existing sources, as well as how DyNADS might best be incorporated into the existing workflow. A CWA examines the dynamic interactions between the environment, organizational infrastructure, and humans [4–6]. In this paper, we describe our application of CWA, as well as the results and implications for the design of useable and useful decision support for nurse managers.

CWA is a framework and set of tools developed to guide the design of technology for the workplace [6]. CWA is unique in that it allows the analyst to study complex sociotechnical systems without abstracting away the complexity of the system [7]. A complete CWA includes system analyses at five levels: work domain, decision-making procedures, decision-making strategies, social organization/collaboration, and worker skill level. Cognitive Work Analysis has become increasingly popular, although frequently just the Work Domain Analysis (WDA) is done.

Partial or full CWAs have been used in a number of domains, including engineering, military, airline industry, and business [8]. In health care, partial or complete CWAs have been used to evaluate how anesthetists interact with anesthesia alarm systems [9], to model anesthesia domains [10] and intensive care unit patients [11], to design CPOE systems [12], to study patient falls [13], and to clarify the patient's role in preventing and recovering from medical errors [14]. CWA has also been used to facilitate the design of CPOE systems [12] and to understand nurses work processes related to documentation [15] and patient falls [13].

Our CWA was intended to inform, not only our DyNADS design and implementation, but also the efforts of others who are developing and implementing health information technology for nursing units and/or nurse managers. Examples of the types of questions we wanted to answer through our CWA are shown in Table 1.

To conduct a full CWA required using several data collection and analysis methods as described below. The WDA relied on structured interviews of nurse managers, Chief Nursing Officers (CNOs), division directors, and other managers. The decision procedures and strategies portions of the CWA used a portion of the data collected from nurse managers in the WDA interviews, as described below, but utilized "decision ladders" for analyses. The methods for the procedure and strategy analyses have been reported elsewhere in detail [16]. For the socio-organizational analysis, we collected information from staff about the unit communication network (which staff they interacted with, discussed patient care with, got information from, or gave information to on the last shift they worked). Those data were then entered into *ORA, a dynamic network analysis software application. *ORA allowed us to visualize the networks in various ways for comparison purposes. *ORA also produced a number of network metrics (e.g., network density, hierarchy, or the speed of information diffusion). For our analysis, we used only 14 of the metrics, selected to cover the spectrum of measures without redundancy (many of the *ORA metrics are similar, differing only in their mathematical computation). We then used correlation statistics to determine which network metrics might be associated with patient safety and quality outcomes (patient falls, adverse drug events (ADEs), patient satisfaction, self care ability, and symptom management). Those results have been described elsewhere [17]. Workers' skill levels were derived from the WDA and unit data collected via nursing staff survey as part of the primary study. In the remainder of this paper, we will focus primarily on the specific methods used for the WDA and the results of that analysis. After describing the WDA in detail, we will summarize the results of the other CWA component studies then integrate the findings to provide a more complete description of the nurse manager's environment.

A WDA focuses on the worker's environment, assuming that if the environment (i.e., context) can be well understood, the degrees of freedom left to be explained by the worker's cognitive activities, which are more difficult to observe, will be fewer [18]. Although nurse managers have been shown to affect the work climate and staff satisfaction on their units through their leadership behaviors [19,20], their own work environment had not been clearly described. A more systematic investigation of their environment was needed if we were to provide nurse managers with useful, usable decision support.

A WDA characterizes the work environment as a hierarchy with two dimensions (*decomposition* and *abstraction*). The decomposition dimension describes the system under study in terms of part–whole relationships. In our study, the decomposition dimension included three levels: hospital, division, and nursing unit. The abstraction dimension describes the system in terms of several conceptual levels that range from abstract to physical. Each level provides a unique perspective of the same system. In our analysis, we used five abstraction categories: Functional Purpose (why the system exists and environmental constraints); Priorities or Values (criteria used to assess whether purposes are being achieved); Purpose-Related Functions (those functions needed to achieve the purpose); Object-Related Processes (capabilities and limitations of physical work objects and resources); and Work Objects and Resources (the physical components in the nurse manager's work environment).

Means–ends relationships are defined by moving up and down the abstraction hierarchy. For example, if we were to focus initially on a Purpose-Related Function of the nurse manager as *what* the manager does, the level above (Priorities or Values) should provide information as to *why* the nurse manager carries out the function, and the level below (Object-Related Processes) information on *how* the function is carried out (i.e., the processes needed to carry out the function). A WDA is time and event-independent, which makes the results

Table 1 – Examples of Cognitive Work Analysis questions by domain.

Domain	Questions
Environment evaluation	• What constraints outside the organization might constrain or facilitate the manager's ability to improve safety and quality outcomes (e.g., regulations, laws)?
Organizational analysis	• What organizational constraints might constrain or facilitate the manager's ability to improve unit safety and quality outcomes? • What organizational data are currently available? In what format?
Work Domain Analysis	• What are the goals, priorities and values of the unit in terms of safety and quality improvement? • What tools and technology are available to facilitate safety and quality improvement?
Task analysis	• How are decisions related to safety and quality improvement initiatives made? • What information is used? • What tools are available? What tools are used?
Strategies analysis	• What strategies are possible for managers who want to improve safety and quality outcomes? • What information is needed?
Actor's resources	What is the nurse manager's educational background? • How experienced is he/she in using IT? In management? • What support staff are available? • What technology and technology support is available?

even more valuable as a basis for designing technology that can be used widely. Typically, the most relevant goals and priorities are found at higher levels of decomposition (e.g., the organization), while object-related processes and the objects themselves are found at lower levels (e.g., the nursing unit).

The WDA was designed to answer three main research questions:

1. What constraints does the nurse manager's work domain impose on their need for decision support to improve safety and quality outcomes on their units?
2. In what ways is the nurse manager's work domain similar or different across units and hospitals?
3. What constraints might the nurse manager's work domain exert on the design and implementation of a decision support tool?

2. Methodology

2.1. *Setting and sample*

After obtaining human subjects protection approval from the University of Arizona Institutional Review Board and each hospital, we interviewed 10 nurse managers, 2 nursing directors, 2 nurse executives, 3 information technology (IT) managers, and 3 quality managers employed by three acute care hospitals in Arizona that had achieved Magnet status. All 10 nurse managers had considerable managerial experience, but differed in whether that experience was obtained in the same hospital or at the same job level. The nurse managers' education varied from baccalaureate to master's degree.

2.2. *Design and procedures*

A descriptive design was used for the WDA. Two researchers with management expertise conducted 1-h interviews with informants. Potential informants were contacted via email to schedule the interviews and inform them about the types of questions they would be asked. Participants were interviewed individually in their offices. Prior to each interview, participants were asked to read and sign a consent form. During the audio-recorded, semi-structured interviews, we asked nurse manager participants to describe a typical day, using their calendars as memory aids. We then asked each participant to describe the quality and safety initiatives they were currently working on at the hospital and unit levels. In addition, we asked nurse manager participants to describe a safety or quality issue they had recently identified, how they learned about it, their information sources, and what interventions they had taken to correct the problem. Interviewers asked additional questions as needed to clarify responses. IT managers were asked to describe the information and communication technology currently in place, and quality managers were asked to provide examples of quality and safety report formats.

2.3. *Data analysis*

Interviews were transcribed verbatim for further analysis. The analysis involved four steps: 1. Three of the investigators individually identified thematic units (generally phrases) and entered them into an excel spreadsheet, together with unit and participant identifiers, as well as an item number. 2. Similar thematic units were clustered as themes, and tentative decomposition and abstraction levels were assigned (e.g., patient safety was coded as at the *hospital* decomposition level and at the *priority* abstraction level). 3. Similar themes were grouped and synthesized into higher level concepts. 4. Concepts were then entered into the abstraction–decomposition grid. An audit trail was maintained to document the analysis process. Internal consistency among the raters was increased by sessions in which we examined the evidence leading to conclusions and reached consensus through discussion. We also deconstructed our analyses by working backwards to verify our findings. We created a glossary that defined each concept through the thematic units from which it was derived. The glossary enabled anyone to go back to the actual interview content to validate the results. We shared the results with nurse managers, which helped assure their validity.

3. Results

3.1. The Work Domain Analysis

Separate WDAs were conducted for each hospital and then summarized across hospitals, retaining only concepts identified in at least two of the hospitals (Table 2). All functional purposes and most priorities were identified at the hospital level. Most purpose-related functions were identified at the unit level. The fourth level of abstraction (Object-Related Processes) describes the capabilities and limitations of work objects and resources; some had both. For example, numerous reports conveyed important information, but contributed to nurse managers' data overload.

In our analysis, the fifth level of abstraction lists work objects and resources in five categories (departments, people, committees, equipment, information technology, and data reports). We deemphasized the physical structure of the unit, instead focusing on objects, people and data used by nurse managers to solve problems. We were particularly interested in data available to nurse managers that might be imported directly into DyNADs. Because all three hospitals were Magnet hospitals, they collected similar nursing data, and the data were usually available in Excel or Access format. Levels 4 and 5 are *not* shown in Table 2 because of the number of items.

A small portion of the overall WDA analysis using data aggregated from all informants is shown in Fig. 1, which highlights some of the means–ends linkages between themes at different levels. That is, if a given theme is the *what*, links at higher levels describe *why*, and lower links describe *how*. Only a few priorities are shown without distinguishing whether they were identified at hospital, division, or unit level. The major theme that surfaced was communication, which appeared at all scales and at several levels of abstraction.

3.1.1. Values or Priorities

Improving quality and safety was a hospital-level priority. However, the hospital priority exerted strong constraints on nurse managers' activities at the unit level. External environmental constraints that nurse managers cited included regulatory requirements from the Center for Medicare Services (CMS), Joint Commission, Health Insurance Portability and Accountability Act (HIPAA), American Nurses Credentialing Center (ANCC), National Database of Nursing Quality Indicators (NDNQI), and the American Hospital Association. Nurse managers' work was also constrained by specific hospital initiatives. For example, a 6-month initiative aimed at improving patient satisfaction through daily rounding by nurse managers on all patients consumed most of nurse managers' time in one hospital. Everyone turned to nurse managers when an initiative had to be implemented—even if nursing was not the primary focus of the initiative and nurse managers were no more knowledgeable about the initiative than other managers. When nurse managers took on these initiatives, achieving their own goals was likely to be delayed.

Nurse managers' priorities, goals, functions, and processes were consistent across hospitals in some areas but varied in others. All nurse managers were challenged to solve problems related to patient safety, quality, patient satisfaction, financial viability and staffing. Patient safety priorities included compliance with external regulators' quality performance indicators. Specific safety goals focused on reducing falls, hospital acquired infections and medication errors, together with eliminating pressure ulcers. Quality managers told us that the number of CMS priorities had increased dramatically and would increase even faster in the coming year. In one hospital, nurse managers emphasized a different quality or safety priority to their staff each day. Managers spent much time daily checking in with patients and assuring their positive experience in the hospital because improving patient satisfaction was paramount.

3.1.2. Goal-Related Functions

Across hospitals, the functions in which nurse managers were engaged included multiple meetings at the unit, division, and hospital levels to assure their participation in achieving defined patient quality, safety and satisfaction goals. All nurse managers were concerned with staffing and meeting financial targets. Nurse managers often led committees to meet quality and safety targets, which required significant time away from their units. All nurse managers were very concerned with optimizing patient throughput, including managing length of stay and ensuring the availability of beds to meet demand. Throughput-related functions could consume up to three meetings a day for multiple levels of management when the patient census was high.

3.1.3. Object-Related Processes

Processes that nurse managers had in common included initiating and monitoring hourly patient rounds by staff, conducting their own daily patient rounds to assure that patients' needs and expectations were being met, coordinating patient bed assignment (related to throughput), staffing, scheduling, monitoring their unit's performance against quality benchmarks, and ensuring that their staff maintained required competencies and adhered to annual education requirements.

3.1.4. Work Objects/Resources

The availability of resource staff varied substantially across units and hospitals. Only one nurse manager reported having a dedicated clinical pharmacist on the unit. Two units had discharge nurses to facilitate patient throughput. One nurse manager reported that the lack of a unit-based educator limited her ability to meet quality goals.

Unit size varied from 28 to 42 beds, with one hospital having larger units (two 36 bed and one 42 bed) than the others. Managers' span of control ranged from 52 to 136 staff members. All but one of the nurse managers in the study managed a single unit. The nurse manager who supervised two units was responsible for 58 beds and 136 staff.

Patient care, information and communication technologies differed by hospital. In this sample, more technology was associated with higher fall rates. The lack of information system integration was a common challenge across units and hospitals. Nurse managers spent a great deal of time accessing and/or reviewing reports residing in multiple information systems. Given the amount of data they had to integrate, nurse managers found it cumbersome to have to access varied

Table 2 – Themes by decomposition and abstraction level (Object-Related Processes and Work Objects and Resources are not shown).

Decomposition level	*Abstraction level*: themes
Hospital	*Functional purposes*: safety, quality, solvency, competition, workforce competency and stability; *Environmental constraints*: nursing shortage, organizational culture, regulations, census fluctuations *Priorities*: optimizing safety and quality care, improving throughput, increasing reimbursements, improving patients' experience, complying with external standards, maintaining a competitive edge, creating a great place for employees to work, increasing shared leadership, developing a blame-free culture, improving environmental safety *Purpose-related functions*: communication
Division	*Purpose-related functions*: communication
Unit	*Environmental constraints*: unit appearance, microculture *Purpose-related functions*: communication, documentation, human resource management and development, leadership, operations management, quality improvement, research, supervision, and surveillance

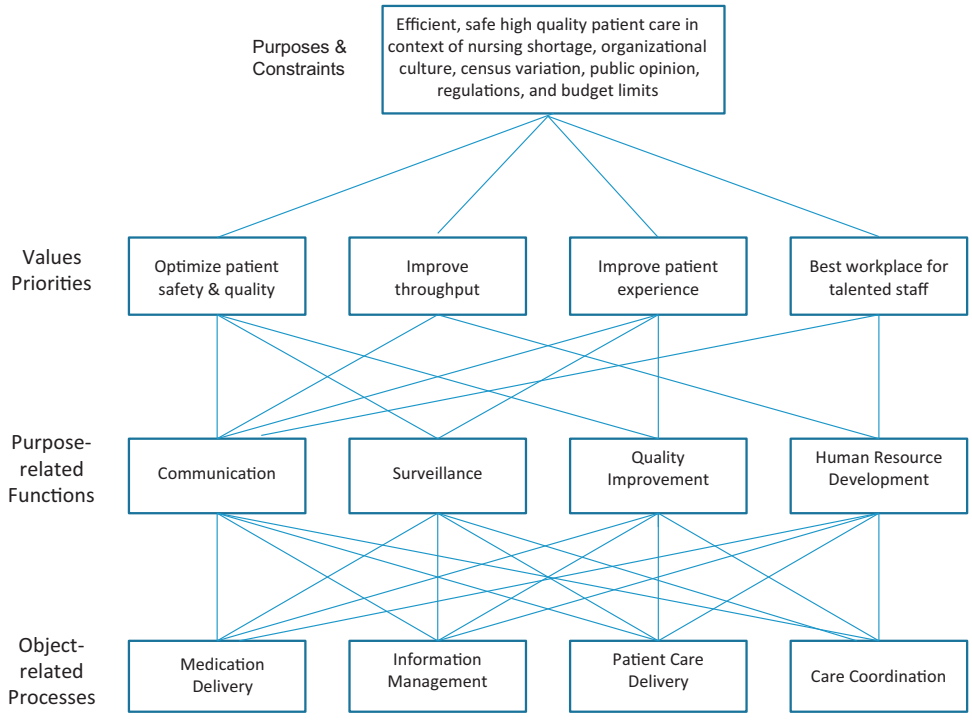

Fig. 1 – Portion of the overall Work Domain Analysis, showing links between levels (level 5, work objects and resources, is not included).

software programs to get the information needed to do their work. One nurse manager commented:

> *We have a gazillion different software programs of which only about 1/3 of them share information, which makes it contrary to what you are trying to do. . .we rework that. . .it's a band-aid. And it can be done, it's just that when you get multiple, multiple processes that are band-aided like that then the process becomes burdensome.*

In one hospital, managers reported that data on fall rates were difficult to obtain and were not readily available to staff; moreover some reports lacked unit level data, which made it more difficult to apply.

All nurse managers reported having either clinical leaders or charge nurses. Charge nurses in two hospitals did not take patient care assignments but were available as a clinical resource; charge nurses in the third hospital did take a patient assignment. The third hospital also used clinical leaders. Nurse managers reported that the presence or absence of these roles made a big difference in their own responsibilities and what functions or processes (e.g., scheduling, patient rounds, quality improvement initiatives, or staff evaluations) could be delegated.

All nurse managers worked long hours; few had administrative staff support. Given nurse managers' busy schedules and the lack of staff support, it is likely that additional administrative or IT staff would be needed to enter or upload data into DyNADS, run the simulations, and generate the reports, but this individual could potentially support multiple units. The quality and safety data needed by DyNADS were available (usually as Excel spreadsheets). Staff satisfaction data were already being collected, but using a different survey than we were using. Whether the instruments that hospitals were using would produce equivalent

Table 3 – Abstraction–decomposition hierarchy for a single hospital (2 nursing units).

Abstraction level	Decomposition level		
	Hospital	Nursing unit	
Functional purposes	High quality patient care Safe environment Safe patient care Satisfied patients	Stable, competent staff	
External constraints	Ethics Financial Laws Nursing shortage Public opinion Regulations Standards		
Priorities or values	Improve patient satisfaction Maximize efficiency; optimize through-put Maximize reimbursement Minimize expenses Meet or exceed external benchmarks and standards Minimize errors Minimize nosocomial infections Minimize pressure ulcers Zero falls	Develop leaders among staff Improve staff satisfaction/reduce turnover Staff meet or exceed competency requirements Minimize blood infections Minimize urinary tract infections Minimize overtime Optimize workflow and efficiency Timely callbacks to physicians	
Purpose-related functions		Action plan development Clinical resource Committee leadership Committee participation Communication Compliance assurance Decision making Disciplinary actions Goal setting Leadership development Managing patient expectations	Monitor workflow Nursing care delivery Planning Problem solving Recruiting Rounding Routinization Staff education Staffing Supervision Surveillance Teaching
Object-related processes	Benchmarking Documentation Medical care Nursing care Patient progression Recruitment facilitation	1-h rounding by staff Data collection Data management Error monitoring Handoffs	"Huddles" Operation management Staffing/scheduling Orientation
Work objects and resources (examples)	Bed board Meeting templates Protocols Safety fairs Benchmarking data Human resources department Quality improvement department	Nursing staff Medical staff Unit resources (pharmacist, etc.) Patients Checklists HIT applications Committees (unit and hospital)	Educational materials Pyxis IV Pumps Quality book Specialized equipment Reports

results to ours would have to be evaluated. Patient satisfaction data were being collected by all three hospitals in a similar format, but one that differed from that used for our study.

Abstracting across hospitals loses some of the detail, as shown in Table 3, which outlines the abstraction-decomposition hierarchy for one hospital having two nursing units. As expected, purposes were described primarily at the hospital level, as were Goal-Related Functions. However, priorities were almost equally divided between unit and hospital levels; work objects and resources were described at both levels, although more were defined at the unit level.

3.2. *Task and decision-making strategy analyses*

The results of these two portions of the analysis have been reported elsewhere [16] so will simply be summarized briefly here. The nurse managers we interviewed described a variety of safety and quality issues (e.g., high fall rate, or medication errors due to improper use of infusion devices). We observed that nurse managers were very comfortable doing a quick investigation into the causes of errors, but sometimes jumped quickly to a solution that was typically remedial staff education. The most frequent strategy used was what Rasmussen [21] terms "decision tables" (i.e., if problem A occurred, then the solution was XYZ).

3.3. Socio-organizational analysis

Communication network patterns differed by shift, by unit, and by hospital. *ORA produced visualizations that allowed us to identify patterns, and *ORA's metrics helped us understand which characteristics were important and examine which metric patterns correlated with specific safety and quality outcomes. Network metrics included information diffusion, network density, the strength of connections between individuals, the number of cliques, the number of groups of three, hierarchical (one-way) communication and intensity of influence. Specific patterns of correlations with network metrics were observed for each type of patient outcome (falls, ADEs, symptom management, self care, and satisfaction).

Key performers differed by role, as well as by unit and shift. On some units, RNs were more frequently key information hubs, authorities, or those with the best group knowledge. On other units, it was more likely that unit clerks (UCs) or patient care technicians (PCTs) took these roles. See [17] for a more detailed description of this portion of the CWA.

3.4. Skill level

All nurse managers worked diligently to secure and retain a competent workforce. Lack of experienced and educationally prepared nurses was a problem that some nurse managers tried to solve by providing strong mentorship for new graduate nurses. One nurse manager reconfigured existing positions such as PCTs to meet demands and budget constraints.

Six variables (skill mix, percent of RN staff with a BSN, orientation time, mean continuing education time, mean hospital tenure, and mean unit tenure) were analysed to evaluate nursing unit staff skill. Skill mix ranged from 58 to 70% RNs; the percent of staff with a BSN ranged from 26.7 to 56.5%. Continuing education time ranged from a mean of 18.2–48.8 h. Unit and hospital tenure ranged from 19.6 to 72.4 months and 24.5 to 101.9 months respectively. Units with a higher percentage of RNs were also high in mean continuing education time. Nursing units with fewer RNs were also low in continuing education time. Although communication network data showed that PCTs and UCs were likely to be informal leaders and very influential, on some units they received little to no continuing education. Units with a high proportion of nurses with baccalaureate degrees spent fewer hours orienting staff. Staff who had long unit tenure also had long hospital tenure. One hospital contained the two units with the longest staff tenure, while a second hospital contained the two units with the shortest staff tenure.

4. Discussion

We conducted a CWA on seven nursing units in three Arizona hospitals to better understand the work environment of nurse managers and the constraints imposed on nurse managers by that work environment. As a basis for the analysis, we conducted semi-structured interviews with managers at three levels of the organizations (hospital, division, and nursing unit), as well as with IT and quality managers. Most priorities were generated at the hospital level and were consistent across hospitals. Nurse managers' functions were described at all levels, but object-related processes were generally described at the unit level. The division level yielded little new information in terms of priorities, functions, or processes, probably due to the nature of their coordinative roles.

Our results emphasize the multiple demands and goals that today's nurse managers are asked to satisfy and highlight the massive amount of data they must synthesize to make decisions about how to improve the care on their units. Much of their time was spent on facilitating efficient patient flow through the system and ensuring patient satisfaction. The managers spent considerable time on implementing and monitoring a variety of patient safety and quality initiatives. Often, there were multiple initiatives in place simultaneously, and staff were given reminders of what to emphasize each day. A decision support tool that could help managers integrate the many priorities into a few higher level priorities and allow them to test the likelihood of various innovations to improve outcomes in these areas could be extremely helpful in helping nurse managers think more proactively about issues and solutions.

In general, the environment of nurse managers was similar across units in terms of goals, priorities, functions, and processes, which is not surprising given that all were working in Magnet hospitals. Nurse managers' priorities were largely externally driven (e.g., by the Joint Commission, CMS, HIPAA, etc.) and therefore were similar; although specific safety and quality initiatives differed across hospitals and nursing units. Even though the hospitals were remarkably similar in their safety, quality, satisfaction, fiscal, and market share goals, they differed in the number of initiatives underway, the strategies used for improvement, and the level of staff involvement in the initiatives. The growing national focus on safety and quality suggests that nurse managers will encounter even more initiatives in the future. The results of the communication network study [17] suggest that different initiatives may be needed to improve specific safety and quality outcomes. If this proves to be the case in other settings, then nurse managers will find improving outcomes even more challenging—and the need for decision support to optimize a solution for their particular unit will become even more critical.

Nurse managers were generally systematic in collecting data about the cause of safety and quality problems. However, the managers often jumped quickly to a solution—and the solution was likely biased toward remedial education for staff. Decision support tools that suggest alternative solutions could be helpful in preventing premature action.

The availability and level of integration of IT differed across hospitals. More technology was associated with higher fall rates [17]. As the number of technologies on a nursing unit grows, it can add to the combinatorial complexity to the point where the multiple technologies detract staff from the direct patient observation required to prevent falls [22]. The hospital with the longest list of IT applications had the least integration, and the lack of integration was viewed by nurse managers as problematic.

Although a great deal of data was available to nurse managers, these data had to be accessed from multiple sources and

information systems. Hospital and nursing dashboards were generally available and were reported to be useful because they combined data from different sources into one easy-to-read display. To be most effective, decision support tools might need to summarize results in a similar dashboard format.

Managers received numerous reports about quality, safety, human resources, and finances, frequently via the hospital's Intranet. Some reports were *pushed* to managers; others had to be intentionally accessed. Nurse managers reported that most of the reports were useful; however, acuity or financial reports were sometimes exceptions, either because they were not provided at the unit level or because some data were missing, misclassified, erroneous, or late. Decision support tools such as DyNADS are likely to depend on data collected from several sources, perhaps at different times. Ensuring that the data used are accurate and current will be a challenge.

The nurse managers in our study were experienced, although their educational preparation varied from baccalaureate to master's degree. Only one manager was responsible for more than one unit. Each worked long hours and reported little time for planning other than when they were driving to work. Although they received many discrete reports on their unit's performance, none of the nurse managers reported the availability of decision support tools to facilitate planning.

Staff skill levels varied among the units. Tenure varied—and there was some correlation with hospitals. How staff were utilized differed (for example, charge nurses functioned in various ways—either to support staff or to carry out specific projects). More orientation and continuing education were observed in units with more baccalaureate-prepared RNs. Because this was also associated with hospital, this difference may well be due simply to hospital continuing education policies. It will be useful to have, as part of decision support, staff education variables.

The frequency with which informal leaders (communication hub, authority, etc.) varied among staff, and particularly among roles, was surprising. On some units, PCTs and UCs were as likely to have central communication roles as RNs. Clancy refers to these informal leaders as "positive deviants" [23]. These "diamonds in the rough" [23] have many informal connections with other staff and quickly learn from their contacts (both inside and outside the unit) how to work around unfriendly rules or technology to get the job done. Others then follow their leadership. Further research will be needed to explore more fully the impact of these informal leadership roles on safety and quality outcomes. For the present, we can only encourage others to include communication network measures within administrative decision support tools.

Some nurse managers hired experienced emergency medical technicians (EMTs) into PCT positions because of their additional skills and ability to manage stress. Nursing units where PCTs reported greater control over their practice also had lower patient fall rates. The same was not true for RNs. This discrepancy is likely due to the fact that PCTs are more often at the bedside observing patients. The infrequent continuing education provided for non-licensed staff on some units should be explored further in other settings in light of their centrality to unit communication patterns and safety outcomes in this study. These findings highlight the importance of including, but differentiating, licensed and non-licensed staff in decision support tools for nurse managers.

4.1. *Limitations*

Our sample of nursing units was small and more homogeneous than would be ideal. All three hospitals had achieved Magnet status, which further contributed to similarities in the data they collected and reported. Non-Magnet hospitals may be less similar. Arizona hospitals typically experience seasonal census variations because of the many winter visitors, but one of the hospitals was experiencing an unusually large drop in census at the time of data collection, which may have affected their results.

Our interview questions did not ask explicitly about the purpose of the hospital (or unit); therefore, functional purposes were inferred from informant responses, as well as from information on the hospital's website. Our questions focused largely on quality and safety, so most respondents described goals, strategies, and issues related to those areas. This may have resulted in a less complete picture of the unit, but the focus was appropriate for our purposes because DyNADS targets unit safety and quality outcomes. Even with the focused questions, some of the data we collected was beyond the scope of our project so considerable pruning and condensing of the preliminary thematic units was necessary.

Most CWAs focus on a single site and often a single activity. Our focus was considerably broader. We would have liked to have spent more time observing nurse managers directly as they worked; but this was not feasible, given the scope of the study. Nonetheless, the 1-h interviews provided us with a good understanding of the environment into which DyNADS or any decision support tool must fit, the questions it must answer, and how it might fit into the nurse manager's workflow.

There continues to be disagreement in the field on the best terminology for a WDA. Some proponents of CWA (e.g., [4]) argue that only nouns must be used because the goal is to describe the environment. Others (e.g., [8] encourage verb forms as well, especially for functions. We attempted to use nouns throughout, but found it extremely difficult—and, in the end, not as useful. It may be that nurse managers' environments are much less constrained by their physical environments than by conceptual and interpersonal factors—at least at the purpose, priority and function levels. In any case, because DyNADS is a planning and decision support tool for evaluating and improving organizational performance, this approach was a better fit.

4.2. *Conclusion and recommendations*

The CWA proved to be very useful. We collected critical information about the environment in which nurse managers try to improve quality and safety outcomes on their units and the many constraints imposed by that environment on their ability to improve outcomes. The semi-structured interviews enabled us to collect the needed information efficiently. Generalization of the results is limited because of the small sample

and the homogeneity of the sample (all medical-surgical units in Magnet hospitals). Although direct observation might have added detail, our needs for efficiency, as well as the nursing and nursing management backgrounds of our interviewers, made this a better approach for our purposes. We did not evaluate the physical layout of the unit, but plan to do that in future studies because the physical layout may constrain communication patterns among staff.

As organizations evolve, they become more complex and therefore more challenging to manage [24,25]. Optimizing patient quality and safety while staying within a budget and maintaining a qualified staff is an exceedingly difficult problem that cannot be solved with an Excel spreadsheet. Nurse managers need decision support tools that are equal to the complexity of the problems they face, that can deal with multifactorial problems in ways that synthesize the disparate issues nurse managers encounter into higher level concepts and allow them to test hypotheses about the kinds of solutions they might implement in a safe, virtual environment. By stimulating higher level thinking, managers might be less likely to engage in "fire stomping" or jump to quick solutions without considering the larger picture. New computational modeling tools are available that could help nurse managers cope with the increasing complexity, at least in terms of the personnel optimization problems they face [26]. More sophisticated decision support tools, such as DyNADS, will be needed to provide decision support for improving quality and safety outcomes. To fit into nurse managers' workflow, these tools must be easy-to-use and accept as input current, electronically available hospital data. Some of the data needed by DyNADS are available in hospitals in electronic format. However, the surveys we used for our study to collect data from staff and patients differed from those currently used in the hospitals. Further research will be needed to evaluate the degree to which the different instruments produce comparable results. Our results suggest that, with few exceptions, the actual end users of these tools are likely to be administrative staff that will, under the direction of the manager, input the data, run the simulation, and generate the reports. Still, the primary beneficiary of the decision support provided will be the nurse manager.

Based on the results of the CWA, it is clear that if DyNADS, or any other decision support tool, is to be maximally useful to nurse managers, it must incorporate data that are already collected by the hospital for other purposes to minimize the need for additional data entry, synthesize data from these multiple sources, and provide effective, timely decision support. The degree to which existing data map onto existing DyNADS variables and can be imported directly into DyNADS has yet to be fully determined. However, finding that hospitals are collecting some data using the same questionnaires and that those data are available in common formats (Excel or Access) is encouraging. Ultimately, the decision support offered by DyNADS should focus on decisions related to the quality, safety, timeliness, and cost of care, utilize available data to the extent possible, and efficiently provide nurse managers with easy-to-understand reports that evaluate the relative impact of changes in the unit's physical structure, communication structure, culture, staffing levels, and staff expertise and experience—factors over which they have direct control.

Summary points

What is already known about the topic?

- The quality of patient care in the US continues to be an issue.
- Nurse managers are challenged to improve patient safety and quality on their units and have few decision support tools available.
- Partial or complete Cognitive Work Analysis has been used successfully to describe a variety of environments.

What this study added to our knowledge?

- Described the environmental constraints on nurse managers' ability to improve safety and quality outcomes
- Clarified nurse managers' need for decision support tools that can help them plan innovations to improve outcomes in an increasingly complex environment
- Identified design constraints that must be considered in developing decision support tools for nurse managers

Authors' contributions

Dr. Effken was involved in the design, data collection and analysis of the Cognitive Work Analysis and socio-organizational analyses, as well as serving as primary author for this paper. All authors were involved in data analysis, as well as assisting with writing the paper. Drs. Verran and Logue were also involved in data collection (interviews and/or surveys). All authors read and approved the final manuscript.

Conflicts of interest

No conflicts of interest are identified for any of the authors.

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City, NY; the American Academy of Nursing 37th Annual Meeting and Conference, November 11–13, 2010, Washington, DC; and the American Organization of Nurse Executives Conference and Exhibition in San Diego, CA, April 13–16, 2011. The authors thank Dr. Ya-Chuan Hsu for her assistance with data analysis for an earlier version of this manuscript. Finally, we are grateful for the advice on conducting a CWA provided by Dr. John Lee.

REFERENCES

[1] Institute of Medicine, in: L.T. Kohn, J.M. Corrigan, M.S. Donaldson (Eds.), To Err is Human: Building a Safer Health System, National Academic Press, Washington, DC, 1999.
[2] B. Kaplan, Evaluating informatics applications—some alternative approaches: theory, social interactionism, and call for methodological pluralism, Int. J. Med. Inform. 64 (2001) 39–56.
[3] B. Kaplan, N. Shaw, Future directions in evaluation research: people, organizational, and social issues, Methods Inf. Med. 43 (3–4) (2004) 215–231.
[4] K.J. Vicente, Cognitive Work Analysis, Lawrence Erlbaum, Inc., Mahwah, NJ, 1999.
[5] J.A. Effken, Different lenses, improved outcomes: a new approach to the analysis and design of healthcare information systems, Int. J. Med. Inform. 65 (1) (2002) 59–74.
[6] J. Rasmussen, A.M. Pejtersen, L.P. Goodstein, Cognitive Systems Engineering, Riso National Laboratory, Roskilde, Denmark, 1994.
[7] R. Fidel, A.M. Pejtersen, Cognitive work analysis, in: K.E. Fisher, S. Erdelez, E.F. McKechnie (Eds.), Theories of Information Behavior: A Researcher's Guide, Information Today, Medford, NJ, 2005.
[8] N. Naikar, R. Hopcroft, A. Moylan, Work domain analysis: theoretical concepts and methodology, Technical Report DSTO-TR-1665, Air Operations division, Defence Science and Technology Organisation, Australian, Government Department of Defence, 2005.
[9] M. Watson, P. Sanderson, Work domain analysis for the evaluation of human interaction with anaesthesia alarm systems, in: Proceedings of the Australian/New Zealand Conference on Computer–Human Interaction, AzCHI98, University of Wollongong, Wollongong, Australia, 1998, pp. 228–235.
[10] J.R. Hajdukiewicz, K.J. Vicente, D.J. Doyle, P. Milgram, C.M. Burns, Modeling a medical environment: an ontology for integrated medical informatics design, Int. J. Med. Inform. 62 (1) (2001) 79–99.
[11] A. Miller, A work domain analysis framework for modeling intensive care unit patients, Cogn. Technol. Work 6 (2004) 207–222.
[12] C.-P. Lin, J.H. Gennari, Designing CPOE systems using an ecological approach, in: AMIA 2007 Symposium Proceedings, 2007, p. 1033.
[13] K.D. Lopez, G.J. Gerling, M.P. Cary, M.F. Kanak, Cognitive work analysis to evaluate the problem of patient falls in an inpatient setting, J. Am. Med. Inform. Assoc. 17 (2010) 313–321.
[14] K.T. Unruh, W. Pratt, Patients as actors: the patient's role in detecting, preventing, and recovering from medical errors, Int. J. Med. Inform. 76S (2007) S236–S244.
[15] C. Robertson, E.N. Efthimiadis, K.W. Hammond, Nursing documentation usage analysis, in: AMIA 2008 Symposium Proceedings, 2008, p. 1112.
[16] J.A. Effken, J.A. Verran, M.D. Logue, Y-C. Hsu, Nurse managers' decisions: fast and favoring remediation, J. Nurs. Adm. 40 (4) (2010) 188–195.
[17] J. Effken, S. Gephart, D. Bianchi, J. Verran, Correlations of nursing communication network metrics with patient outcomes, in: Proceedings AMIA Fall Symposium 2010, 2010, Available at: http://proceedings.amia.org/127fas/1?highlightText=Effken.
[18] J.R. Hajdukiewicz, K.J. Vicente, A theoretical note on the relationship between work domain analysis and task analysis, Theor. Issues Ergon. Sci. 5 (2004) 527–538.
[19] A. Barrett, C. Piateck, S. Korber, C. Padula, Lessons learned from a lateral violence and team-building intervention, Nurs. Adm. Q. 33 (4) (2009) 342–351.
[20] S.F. Sellgren, G. Ekvall, G. Tomson, Leadership behavior of nurse managers in relation to job satisfaction and work climate, J. Nurs. Manag. 16 (5) (2008) 578–587.
[21] J. Rasmussen, Models of mental strategies in process plan diagnosis, in: J. Rasmussen, W.B. Rouse (Eds.), Human Detection and Diagnosis of System Failures, Plenum, New York, 1981, pp. 241–258.
[22] T.R. Clancy, Technology and complexity: trouble brewing? J. Nurs. Adm. 40 (6) (2010) 247–249.
[23] T.R. Clancy, Diamonds in the rough: positive deviance and complexity, J. Nurs. Adm. 40 (2) (2010) 53–56.
[24] T.R. Clancy, Organizing: New ways to harness complexity, J. Nurs. Adm. 37 (12) (2007) 534–536.
[25] T.R. Clancy, Planning: What we can learn from complex *systems* science, J. Nurs. Adm. 37 (1) (2007) 436–439.
[26] T.A. Fitzpatrick, B.A. Brooks, The nurse leader as logistician: Optimizing human capital, J. Nurs. Adm. 40 (2) (2010) 69–74.