Coincidence Analysis: A Novel Approach to Modeling Nurses' Workplace Experience

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Abstract

Objectives The purpose of this study is to identify combinations of workplace conditions that uniquely differentiate high, medium, and low registered nurse (RN) ratings of appropriateness of patient assignment during daytime intensive care unit (ICU) work shifts.

Methods A collective case study design and coincidence analysis were employed to identify combinations of workplace conditions that link directly to high, medium, and low RN perception of appropriateness of patient assignment at a mid-shift time point. RN members of the study team hypothesized a set of 55 workplace conditions as potential difference makers through the application of theoretical and empirical knowledge. Conditions were derived from data exported from electronic systems commonly used in nursing care.

Results Analysis of 64 cases (25 high, 24 medium, and 15 low) produced three models, one for each level of the outcome. Each model contained multiple pathways to the same outcome. The model for "high" appropriateness was the simplest model with two paths to the outcome and a shared condition across pathways. The first path comprised of the absence of overtime and a before-noon patient discharge or transfer, and the second path comprised of the absence of overtime and RN assignment to a single ICU patient.

Conclusion Specific combinations of workplace conditions uniquely distinguish RN perception of appropriateness of patient assignment at a mid-shift time point, and these difference-making conditions provide a foundation for enhanced observability of nurses' work experience during hospital work shifts. This study illuminates the complexity of assessing nursing work system status by revealing that multiple paths, comprised of multiple conditions, can lead to the same outcome. Operational decision support tools may best reflect the complex adaptive nature of the work systems they intend to support by utilizing methods that accommodate both causal complexity and equifinality.

Keywords

- work shifts
- intensive care unit
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- data analysis
- information systems

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Background and Significance

Maintaining a balance between patient demand for nursing care and work system capacity to satisfy that demand is a precondition for safe, effective, and efficient nursing care. Excess patient demand contributes to registered nurse (RN) overload and degraded service delivery, and excess staff capacity contributes to inefficient utilization of scarce health care resources.[1] Effective allocation of nursing resources has been an area focus of research for several decades. Patient outcomes associated with staffing insufficiency include adverse patient events[2,3] as well as inadequate patient surveillance, skin care, oral hygiene, pain management, therapeutic interaction, and discharge preparation.[4–8] RN outcomes associated with staffing insufficiency include work-related strain,[9–11] fatigue,[12] job dissatisfaction,[13] moral distress,[14] burnout,[15,16] and intention to leave the profession.[17]

Maintaining supply–demand balance, defined for the purposes of this study as the process of making products or services available at the right place and time for a customer, is a common challenge across many industries. In health care, the real-time nature of service delivery constrains the strategies that can be used to level load demand. For example, it is not possible to "stockpile" nurse capacity in advance of anticipated demand because nursing care is created and delivered simultaneously. Nursing work systems experience dynamic, nonlinear interactions between system components[18,19] that shape an ever-changing balance between capacity and demand. Inevitably, nursing work systems experience periods of supply–demand imbalance as patient volume and individual demand for nursing care vary across the hours of a work shift.[20] During periods of strain, graceful degradation and rapid service recovery[21] are dependent upon a work system's ability to sense the change in workplace characteristics and activity that provide early warning that a "coping zone" is being approached.[22]

Although electronic information systems are available and commonly used to support forecasting, scheduling, and assignment of RNs to individual patients at the outset of a work shift, hospitals primarily rely upon human surveillance to detect the emergence of demand–capacity imbalance during a work shift. Charge nurses integrate information from multiple sources and employ heuristic knowledge and clinical judgment to assess and respond to changes in the patient care unit environment.[23] As a step toward enhanced, dynamic monitoring of nursing work environments at mid-shift timeframes, there is a pressing need for the transformation of real-world data streams into real-time markers of sufficiency and wellbeing, and signs of strain.

Objectives

The purpose of this study is to identify combinations of conditions that uniquely differentiate high, medium, and low RN perceptions of appropriateness of patient assignment during daytime intensive care unit (ICU) work shifts.

Setting

The study setting is a 16-bed adult medical ICU within a west coast academic medical center. The study unit utilizes a primary care nursing model in which on-duty RNs are assigned to one or two patients who reside in private rooms. A typical work shift comprises 9 to 11 RNs, including a charge nurse who manages unit operations and a resource nurse who addresses urgent situations. The unit utilizes health aides for restocking supplies but does not utilize nursing assistants. Between care activities, nurses work at a computer station behind glass windows to maximize RN line of sight to assigned patients.

Methods

A collective case study design and coincidence analysis (CNA)[24,25] were employed to identify combinations of workplace conditions that link directly to high, medium, and low RN ratings of perceived appropriateness of patient assignment midway through 12-hour daytime work shifts. A case study design was selected because this design is particularly useful in studies that seek to explain the "how" and "why" of a circumstance or phenomenon.[26]

CNA is a formal mathematical approach to cross-case analysis and is relatively new to health-related research. CNA draws upon Boolean algebra and set theory to identify a "minimal theory," defined as a set of difference-making combinations of categorical conditions that uniquely distinguish one group of cases from another.[27,28] The analytic objective of CNA, a configurational comparative method, is to identify *necessary and sufficient conditions* for an outcome, which is a different aim compared with more traditional correlation-based methods (e.g., regression). Strengths of CNA include the ability to assess complex causality (when the joint presence of multiple conditions account for an outcome), a capacity to handle equifinality (different sets of conditions lead to the same outcome), and versatility with small-n studies.[29] These strengths are particularly useful in the study of a complex work system, where different combinations of conditions may contribute to RN perception of appropriateness of patient assignment. Key steps in CNA include data collection for included cases with and without the outcome, transformation of raw data into categorical variables whose levels provide the basis for sets of conditions of interest, data reduction, and solution path identification.[29]

Case Description

In this study, a case reflects a single RN patient assignment on a 12-hour daytime ICU work shift. The case is composed of an RN-reported rating of appropriateness of patient assignment collected between 11:00 AM and noon and quantified variables that summarize assignment-related activity between 7:00 AM and noon on the same shift. The study dataset consisted of 64 cases and 55 variables whose categorical levels represent potential explanatory workplace conditions.

Case Outcomes

RN-reported ratings of appropriateness of patient assignment, collected at a midshift time point serve as case outcomes in this study. RN ratings of appropriateness were originally collected to assess RN perceptions of appropriateness of patient assignment during pilot deployment of an electronic health record-based work intensity tool[30] using a question from the National Database of Nursing Quality Indicators (NDNQI) Survey.[31] The original validated NDNQI question is "My patient care assignment was appropriate, considering both the number of patients and the care they required." The modified question for data collection at a midshift time point is: "During the *first four hours of my work shift*, my patient care assignment was appropriate, considering both the number of patients and the care they required." RN-reported ratings were converted into three outcome levels: high, medium, and low. "Strongly agree" and "agree" indicate a clearly positive perception (or "high"), and "disagree" and "strongly disagree" indicate a clearly negative perception (or "low"). While "tend to agree" and "tend to disagree" (the middle two values of the 6-point scale) can be viewed as qualitatively different, practicing RNs on the study team affirmed that both ratings reflect perceived appropriateness of patient assignment that is neither "high" nor "low." For the purposes of this analysis, "medium" is defined as "neither high nor low."

Case Sampling

Case outcomes were drawn from a pool of 683 RN-reported appropriateness ratings in a separately reported study[30] conducted at the same academic medical center. Of 683 previously reported RN ratings, 364 were collected in the ICU study unit. The majority of assignments were perceived to be appropriate, with 303 of 364 (82%) ratings of "agree" or "strongly agree." To construct a balanced sample representing the full range of responses, we included all (35) cases in which an RN rated their work shift "tend to agree" or lower. We subsequently excluded three cases because the RN patient assignment included patients whose charts were restricted, leaving 32 RN shift ratings of "tend to agree or lower." We randomly sampled an additional 32 RN ratings, which produced 25 cases of high, 24 cases of medium, and 15 cases of low perception (►Table 1). Included 64 cases reflect the work of 32 distinct bedside RNs who delivered care to 107 distinct patients on one or more daytime work shifts between August and October 2018. Of 32 distinct nurses, 15 (23%) contributed two or more ratings to the analytic sample, and 10 of 15 (67%) contributed ratings to both the "tend to agree or lower" set and the paired set of "tend to agree or higher" ratings. The sampling strategy resulted in the inclusion of a single case per calendar day in a majority (53 of 64) of cases. All cases of "strongly disagree" occurred on separate calendar days, indicating that study data represent low ratings across multiple shifts, rather than multiple low ratings from the same work shift.

Workplace Conditions

RN members of the study team hypothesized explanatory workplace conditions to be potential difference makers through the application of theoretical and empirical knowledge. To facilitate future application of study findings in real-time workplace monitoring systems, quantified metrics reflecting potential explanatory conditions were derived from data generated by electronic systems commonly present in nurses' workplace (►Table 2).

A lack of electronic linkages between RN identifiers and assigned patients at the study site made data collection a laborious process. For example, to calculate a count of nurse call lights associated with an individual RN patient assignment, we first identified patients assigned to an RN using handwritten shift assignment notes. We then identified room and bed numbers associated with assigned patients to summarize data from the nurse call system at the RN level. Because case conditions were derived from data that are routinely generated during patient care, we did not encounter known instances of missing data. Some factors, such as the presence or absence of a health unit clerk, meal break, and RN float status were collected as categorical data. Other factors, such as work intensity scores, were converted into into categorical variables by setting category boundaries at natural cut points observed in the data.

Table 1 RN-reported appropriateness ratings by the outcome level

RN-reported rating on a 6-point scale	Trichotomized RN ratings
Strongly agree (14)	Perceived appropriateness as "high" (25)
Agree (11)	
Tend to agree (7)	Perceived appropriateness as "medium" (neither high nor low) (24)
Tend to disagree (17)	
Disagree (10)	Perceived appropriateness as "low" (15)
Strongly disagree (5)	
Total 64	Total 64

Abbreviation: RN, registered nurse.

Data Analysis

Analyses were conducted using the software applications R, the CNA R package "cna" and R Studio.[32] Categorical candidate conditions were identified through the application of a configurational data reduction method described in detail in other studies.[27,28,33,34] The minimally sufficient condition (msc) routine within the R package "cna" was applied using multi-value CNA to look across all 64 cases and 55 conditions at once to identify configurations (sets) of conditions with the strongest connection to high, medium, and low perceptions of patient assignment appropriateness. A key model parameter in configurational analysis is consistency, defined as the number of cases identified by the model that also have the RN-reported outcome divided by all cases identified by the model. A second key parameter is coverage, defined as the number of cases identified by the model that also have the RN-reported outcome divided by all cases with the outcome (►Table 3).

Table 2 Data sources and case conditions

Data source	Case conditions—potential difference makers
Daily patient assignment sheet (scanned hand-written artifact)	Unit census, RN–patient ratio, on-duty RN count, presence or absence of resource RN, health unit clerk, and health aide
Business Objects (SAP, Paris, France)	Patient movement events (admit, discharge, and transfer), total electronic health record-based work intensity total score and subscores at the nurse and unit levels; mean, min, max RN-level work intensity scores, and minutes of elapsed time between the time patient assessments were taken and documented
Communication logs (Vocera Communications, San Jose, CA)	Count of electronic communication events
Medication cabinet transaction records (Omnicell, Mountain View, CA),	Count of medications dispensed by the RN providing a rating, proportion of medications dispensed by a nonassigned RN as an RN–RN helping behavior
Nurse Call logs (Rauland, Mount Prospect, IL)	Count of nurse call events, with subcounts for regular, bed exit and staff emergency events; mean call light duration in minutes across patient rooms assigned to the RN providing a rating
Time and attendance (Kronos, Lowell, MA)	RN FTE, float status, overtime, missed meals or breaks, ratio of RN overtime hours to regular hours
RN-specific employment data	Nursing degree, years of experience at facility, critical care certification status, and step placement of RN providing the rating
Contextual information	Day of week

Abbreviation: FTE, full time equivalent; RN, registered nurse.

Table 3 Definitions of configurational consistency and coverage

Consistency	# cases identified by model and have the outcome
	All cases identified by the model
Coverage	# cases identified by the model and have the outcome
	All cases with the outcome

The consistency threshold was initially set to 80% and the coverage threshold to 15% to identify candidate configurations that were both reliable and had explanatory power. We considered all one-, two-, and three-condition configurations in our dataset that met this dual threshold. If no configurations met these criteria during the data reduction phase, we iteratively dropped the consistency threshold by increments of 5 percentage points (i.e., from 80 to 75%) and repeated the process of creating a new condition table until configurations emerged that satisfied all criteria.

Next, we sorted the condition table by complexity (number of conditions in a candidate solution path) and identified configurations with the highest coverage scores. We began with one-condition configurations to see if they met the consistency and coverage thresholds and were uniquely distinguished from all other one-condition configurations. We then proceeded to examine two- and three-condition configurations, working upward to minimize possible redundancy. Using this approach, we reduced the dataset to a smaller subset of candidate conditions to use when iteratively developing solution pathway models.[27,28,33] When developing models, we looked for overall solutions that could explain RN perceptions with >70% consistency and >66% coverage with no model ambiguity.[35,36]

Results

Our analysis produced three models, one for each level of the outcome.

Outcome Level 1: High Perceived Appropriateness of Patient Assignment

For work shifts with "high" ratings of perceived appropriateness, the msc routine identified a subset of four factors to consider in the modeling phase; the model ultimately involved three conditions across two solution pathways (►Fig. 1). Path 1 consisted of a combination of two conditions: limited (up to 30 minutes) overtime by the RN providing the rating *together with* one before-noon transfer or discharge at the unit level. This pathway accounted for 11 of 25 "high" cases, representing 44% coverage (11 out of 25). It was also moderately consistent, as this combination of conditions appeared only 15 times across all cases, and 11 of these 15 cases were associated with "high" ratings, translating into 73% consistency (11 out of 15).

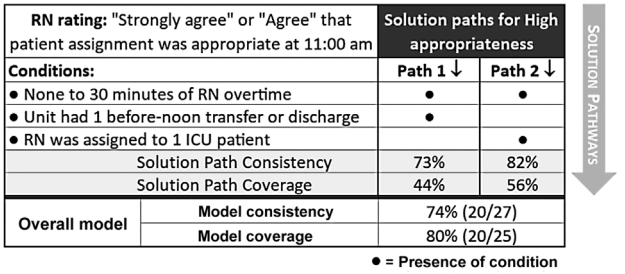

Fig. 1 Configurational model for high perception of appropriateness of patient assignment.

Path 2 consisted of limited (up to 30 minutes) overtime by the RN providing the rating together with an RN assignment of a single ICU patient. This pathway accounted for 14 of 25 "high" cases, representing 56% coverage (14 out of 25). This pathway was also highly consistent, as this combination of conditions appeared only 17 times in the dataset and 14 of 17 occurrences represented "high" ratings, translating to 82% consistency (14 out of 17). The overall model, which jointly represents Solution Paths 1 and 2, explained 20 of the 25 "high" shifts (coverage = 80%) with a high degree of consistency (74%, or 20 out of 27). This model demonstrated the concept of equifinality in configurational analysis, as there were two separate pathways to the same outcome of a "high" RN perception of appropriateness of patient assignment.

Outcome Level 2: Medium Perception of Appropriateness of Patient Assignment

For work shifts with "medium" (i.e., neither high nor low) ratings of perceived appropriateness, the msc routine identified seven factors to consider in the modeling phase. The model for "medium" patient assignment appropriateness ratings involved three conditions over two pathways (►Fig. 2). The two pathways that uniquely differentiated "medium" shifts from "high" or "low" rated shifts were (1) an RN with low tenure (2–5 years) at the facility working with a midrange (7–8) number of on-duty RNs for the unit, OR (2) more than half of the unit's nurses not taking a 30-minute meal break before shift end. Together, these two pathways to the outcome explained 2/3 of the shifts rated "medium" with a high degree of consistency (80%) at the overall model level.

Outcome Level 3: Low Perceived Appropriateness of Patient Assignment

For work shifts with "low" ratings of perceived appropriateness, the msc routine identified 11 factors to consider in the modeling phase. The configurational model for "low" perceived appropriateness of patient assignment was the most complex, with three different solution pathways (►Fig. 3). The pathways that uniquely differentiated "low" shifts from "high" or "medium" perceptions were (1) the RN providing the rating dispensed a large volume medications (average of every 12 to 20 minutes) and having a high proportion of medication-related work intensity points OR (2) initiating a staff emergency call on the unit on a weekend day, OR (3) experiencing no before-noon transfers or discharges by the unit, having a known heavy patient assignment by one or more on-duty

RN rating: "Tend to agree" or "Tend to disagree" that patient assignment was appropriate at 11:00 am		Solution paths for medium appropriateness	
Conditions:		Path 1 ↓	Path 2 ↓
• 7–8 RNs present during the shift (mid-range for Unit)		•	
• RN experience of 2–5 years (low for Unit)		•	
• > 50% of on-duty RNs did not take a meal break			•
	Solution Path Consistency	80%	86%
	Solution Path Coverage	50%	25%
Overall model	Model consistency	80% (16/20)	
	Model coverage	67% (16/24)	

Solution Pathways

• = Presence of condition

Fig. 2 Configurational model for medium perception of appropriateness of patient assignment.

RN rating: "Disagree" or "Strongly disagree" that patient assignment was appropriate at 11:00 am		Soluion Paths for Low appropriateness		
Conditions:		Path 1 ↓	Path 2 ↓	Path 3 ↓
• RN dispensed 15–26 medications before noon		•		
• 25–50% RN work intensity attributable to medications		•		
• >=1 Staff emergency call on unit, via nurse call system			•	
• Case occurred on a weekend day			•	
• No before-noon transfers or discharges on Unit				•
• High work intensity score for 1 or more RNs on Unit				•
• Mean patient age in RN assignment > 48 years				•
	Solution Path Consistency	100%	75%	80%
	Solution Path Coverage	27%	20%	27%
Overall Model	Model Consistency	83% (10/12)		
	Model Coverage	67% (10/15)		

Solution Pathways

• = Presence of Condition

Fig. 3 Configurational model for low perception of appropriateness of patient assignment.

RNs at the highest of three possible work intensity score categories, and assigned patients having the mean age of >48 years, the middle or highest of three possible categories. Together, these pathways explained 67% of the shifts with "low" ratings with a high degree of consistency (83%).

Discussion

In this first known application of CNA in the field of informatics, this study identified specific combinations of nurse- and unit-level conditions that consistently and uniquely distinguished high versus medium versus low RN perception of appropriateness of patient assignment during an ICU work shift. Moreover, in addition to determining how the interplay of specific conditions explains a complex phenomenon like RN perception of the appropriateness of their patient assignment, the analysis—at each of three outcome levels—identified multiple paths leading to the same outcome. Operating under a fundamentally different framework than traditional statistical or qualitative methods, CNA is well suited for explaining variation in complex, real-world nursing work systems, the dynamics of which can be influenced by many factors in combination. CNA findings provide insight into mutable nurse- and unit-level factors that link directly to the perceived appropriateness of patient assignment.

It is unsurprising that both paths leading to the perception of a highly appropriate patient assignment involve minimal (up to 30 minutes) overtime, as overtime is associated with work-related strain.[9] The first path pairs minimal (up to 30 minutes) overtime with single-patient assignment at the nurse level, which is consistent with a previous finding that nurses who report appropriate patient assignments also report positive working conditions including fewer assigned patients.[10] Assignment to a single patient combined with limited overtime may reflect time sufficiency and the absence of the need to make efficiency-thoroughness trade-off decisions[37] between competing needs across patient rooms. The second path pairs minimal overtime with a single before-noon discharge. This finding suggests that the unit had sufficient capacity to accommodate the added work of a patient discharge and the absence of rapid turnover which is associated with unit turbulence.[38,39]

Two separate paths uniquely differentiate "medium" from "high" or "low-rated" cases. The first path consists of a nurse

with low tenure (2–5 years) working with only seven to eight other RNs, a mid-range number of on-duty RNs for the study unit. This path is consistent with prior reports that low census shifts tend to be more difficult than high census shifts due to fewer on-duty nurses from which to recruit assistance and the possible absence of support staff such as a unit secretary.[40] Nurses with fewer (<5) years of experience may need more support than nurses with ≥5 years of experience, potentially causing the presence of fewer RNs to be especially impactful to this population. The second path consists of a single unit-level condition of >50% of on-duty RNs missing a meal break. A prior study found that reasons nurses do not take a meal break include prioritizing patient care over personal needs, a desire to avoid burdening other nurses, and lack of time to complete work before shift change.[41] Skipping a meal break may be an early sign of strain, as an example of how employees adapt their work to meet variable demand.[42] This finding is consistent with a previous finding that nurses who report appropriate patient assignments also report appropriate meal breaks.[10]

The solution path that uniquely differentiates "low" from "high" or "medium-rated" cases was the most complex, with three separate paths. In the first path, a work intensity score driven by medication burden and delivery of 15 to 26 medications in the first 5 hours of a shift reflects higher than typical medication activity, as a previous study found that RNs typically administer 19.7 medications across a full 12-hour shift.[43] Time pressure accompanies heavy medication burden as scheduled medications possess a defined time window, and pro re nata medications are driven by patient symptoms that must be addressed in a time-sensitive manner. The second path consists of a staff emergency on a weekend day, which may be explained by a weakened bench. Managers and ancillary support staff are typically off-duty on weekends, and cross-covering providers have decreased familiarity with patients, which may in turn require increased RN-provider communication. A recent systematic review found variable evidence for a "weekend effect" on patient mortality,[44] and among physicians, cross-coverage scenarios are associated with higher perceived workload versus regular coverage.[45] The third path to low appropriateness consists of the joint presence of three conditions: (1) no before-noon discharges on the unit, (2) one or more on-duty RNs having a work intensity score in the highest category, and (3) mean patient age >48 years in the patient assignment of the RN providing the rating. Delaying a patient discharge may reflect adaptive work, as nurses routinely reshuffle outstanding tasks to ensure that the most critical and time-sensitive tasks receive priority.[46] The second condition, comprised of one or more unit RNs with a work intensity score in the highest category, suggests that individual nurses may be influenced by high workload among RN peers, potentially through the diminished capacity to provide ad hoc assistance amidst competing demands. Nurse dependence upon mutual assistance is noted as a key finding in a previous ethnographic study of the nursing workplace.[47] Other studies suggest that nurses experience conflict between the need to recruit assistance from coworkers and a "supernurse" culture in which asking for help can be seen as a sign of weakness.[48] The third age-related condition is not surprising as 66% of patients over the age of 65 years experience delirium in the ICU setting,[49] and nurses' workload and responsibilities have been shown to increase when caring for patients with cognitive deficits.[50]

Implications: Hospitals possess multiple real-time operational data streams that can provide meaningful workplace insight at midshift time points. Consistent with recommendations of prior studies,[51,52] findings suggest that operational systems are candidate sources of automated sensing of emerging strain and that workload estimation methods may be enhanced through the inclusion of nurse- and unit-level factors, in addition to patient-level factors. Derivation of nurse- and unit-level conditions from operational systems, in addition to the electronic health record, can expand human and computer observability of nurse, unit, and contextual workplace factors that impact nurses' work experiences.

Recognizing that periods of capacity-demand balance will inevitably occur, hospitals may benefit from focusing on tools and methods to support graceful degradation and rapid recovery throughout a work shift, in addition to the time-honored focus on nurse staffing at the outset of a work shift. Hospitals can augment efforts to avoid RN overload and missed care by monitoring specific combinations of conditions that reflect appropriateness of patient assignment as an indicator of capacity–demand balance during a work shift. Combinations of conditions linked to high appropriateness have the potential to serve as candidate markers of balanced capacity and demand, conditions linked to medium appropriates are candidate markers of emerging imbalance, and conditions linked to low appropriateness are candidate markers of insufficient capacity and operational drift toward degraded performance. Monitoring conditions throughout a work shift can provide awareness that a unit is moving from an operational point of sufficiency to a point of coping and provide an opportunity for proactive intervention before negative patient and staff outcomes occur.

Study Limitations

This study was conducted in a single medical ICU in an academic medical center. Findings may not be generalizable to acute care settings with different patient populations or settings in which RN assignments contain more than two patients. Additional paths to medium and low RN perception of appropriateness of patient assignment exist, as evidenced by 67% coverage for these levels of the outcome. It is possible that work shift events after the study timeframe (after shift hour five) influenced overtime and missed meal breaks. This study does not reflect possible seasonal variation in workplace activity as all cases are drawn from a 12-week time period. RN travel distance data were not available at the study site but can be assessed via mobile activity-tracking technologies[53] and should be included in future studies. Interrater consistency, differences in workload perception across RNs,[11] and differences in perception by the same RN across time are beyond the scope of the current study but are

important to address in future studies. Despite limitations, this study is a step toward understanding observable conditions that reflect RN perception of high, medium, and low patient assignment appropriateness mid-way through the daytime work shift.

Future Study

As the health care environment faces an ongoing pandemic, health care worker shortages, and an aging population, additional studies are needed to translate observable midshift conditions reflecting high, medium, and low perceptions of workload appropriateness into dynamic workplace monitoring and decision support solutions to sustain supply–demand balance at the hospital bedside. Future applications of insights gleaned in this study will focus on real-time monitoring of workplace conditions and data-informed, dynamic allocation of flexible resources to address hot spots of strain as they emerge throughout a work shift. Studies of augmented human + computer workplace monitoring paired with flexible resource allocation are needed to assess the impact of new monitoring capabilities on patient safety outcomes including missed or delayed care and nurse outcomes including job satisfaction, peer-to-peer collaboration, fatigue, moral distress, turnover, and intention to leave the profession.

Conclusion

Specific combinations of workplace conditions uniquely distinguish RN perception of appropriateness of patient assignment at a mid-shift time point, and these difference-making conditions provide a foundation for enhanced observability of nurses' work experience throughout a work shift. This study illuminates the complexity of assessing nursing work system status by revealing that multiple paths, comprised of multiple conditions, can lead to the same outcome. Operational decision support tools may best reflect the complex adaptive nature of the work systems they intend to support by utilizing methods that accommodate both causal complexity and equifinality. Findings can inform future research regarding dynamic sensing of emergent strain during a work shift, which in turn can facilitate early warning and proactive intervention before the negative nurse or patient outcomes occur.

Clinical Relevance Statement

Future near-real-time monitoring of workplace conditions can provide early awareness that a unit is moving from a point of sufficiency to a point of coping, supporting proactive intervention before negative staff and patient outcomes occur.

Multiple Choice Questions

1. Which of the following from ►Fig. 1 is a "necessary but not sufficient" condition for high appropriateness of patient assignment?
   a. None to 30 minutes of RN overtime
   b. Unit had 1 before-noon transfer or discharge
   c. RN was assigned to 1 patient
   d. Both options a and c

   Correct Answer: The correct answer is option a. Both pathways in ►Fig. 1 feature the condition "None to 30 minutes of RN overtime" but in both pathways, it is not sufficient by itself for high appropriateness of patient assignment—it has to appear jointly with one other condition.

2. Which of the following is a "sufficient but not necessary" condition in ►Fig. 2?
   a. None to 30 minutes of RN overtime
   b. Unit had 1 before-noon transfer or discharge
   c. >50% of on-duty RNs did not take a meal break
   d. RN dispensed 16–25 medications before noon

   Correct Answer: The correct answer is option c In ►Fig. 2, the second pathway for "medium" appropriateness consists of a single condition— > 50% of on-duty RNs did not take a meal break—indicating this condition is sufficient for the outcome. It is not necessary, however, because a different pathway (Path 1) also leads to the same outcome.

Protection of Human and Animal Subjects

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Conflict of Interest

None declared.

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