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Analysis of Nurse Staffing and Patient Outcomes Using Comprehensive Nurse Staffing Characteristics in Acute Care Nursing Units

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Associations between comprehensive nurse staffing characteristics and patient falls and pressure ulcers were examined using negative binomial regression modeling with hospital- and time-fixed effects. A convenience sample was collected from 35 nursing units in 3 hospitals. Rates of patient falls and injury falls were found to be greater with higher temporary registered nurse staffing levels but decreased with greater levels of licensed practical nursing care hours per patient day. Pressure ulcers were not related to any staffing characteristics. **Key words:** *nurse staffing*, *patient falls*, *pressure ulcers*, *temporary nursing staff*, *turnover*

IT has been predicted that in the United States, 300 000 to 1 million new registered nurses (RNs) will be needed in 2020.[1] Although the current economic recession has seen an increase in RN employment and some easing of the nursing shortage, researchers still project renewed post-recession demand and large shortages for the future.[2] These shortages are expected to have severe effects on the quality of patient care. Nursing shortages often lead to suboptimal staffing characteristics such as low staffing levels, high turnover, high use of temporary (agency) staff, low RN professional staff mix, and greater use of nurse overtime.[3-5] Previous studies have shown that nurse staffing levels and RN skill mix are related to lower quality of patient care.[6-9] However, limited empirical research has been conducted to examine the impact of nurse turnover and the use of temporary nursing staff on quality of care in combination with staffing levels and RN skill mix in acute care hospital settings. Therefore, the purpose of this study was to examine the relationship of nurse staffing to quality of patient care outcomes, by including not only nursing turnover and temporary nursing staff but also nurse staffing levels and RN skill mix.

A major consequence of turnover is the loss and disruption of organizational processes,

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which can be detrimental to both the effectiveness and productivity of care delivery.[10,11] High turnover creates an unstable workforce and has a negative impact on workgroup dynamics. As turnover increases, the remaining staff must constantly adjust to new staff; turnover can then affect the interactions and integration within the workgroup,[12] resulting in poor workgroup cohesiveness, demoralization, communication breakdowns, and fragmented coordination.[12-14] Researchers have found that high levels of staff turnover were associated with poor quality of care.[15-18] Conversely, however, other researchers have suggested that some turnover might be beneficial, improving the quality of patient outcomes as new people and ideas enter the workgroup and keeping the organization from becoming stagnant.[19] Employee mobility is also important for innovation because it enables organizations to become more flexible and adaptable to change.[20] Innovation can enable a workgroup to learn from errors.[15,21]

Research findings about the use of temporary staff are also mixed. The main reasons for employing temporary nursing staff include staff absences, recruitment, retention, and vacancies.[22] Hiring temporary nursing staff can help to increase staffing levels; however, it can also affect other staff as well as facility operations, thus leading to poorer patient care.[23,24] Higher use of temporary staff can increase administrative burdens, disrupt routines and teamwork, and require additional supervision by permanent staff.[23] It may also interfere with continuity of care. The use of temporary nurses has been related, for example, to the spread of nosocomial infections among patients,[25] needlestick injuries among temporary nurses,[26] and medication errors.[27] However, Aiken and colleagues have argued that using temporary nurses may not hinder quality of care because current working schedules do not permit continuity of care (ie, prevalent use of 12-hour shifts for 3 days per week) and found that temporary nursing staff were not less qualified than permanent staff.[28,29] Using temporary nursing staff was not related to the quality of patient care, but other work environment characteristics were related to that.[29,30]

As stated earlier, there is strong, though mixed, evidence regarding the impact of nursing turnover and the use of temporary nursing staff on the quality of patient care, and there is evidence regarding staffing levels and RN skill mix. However, previous studies on nurse staffing and quality of care have not considered nursing turnover and temporary nurse staffing characteristics together with nurse staffing levels and professional skill mix in acute care hospital settings.

METHODS

Design and sample

The data used in the study were collected by the Western New York Center for Workforce and Quality. These data consist of nursing-sensitive quality indicators and nurse staffing data obtained in 75 nursing units at 6 hospitals. Among those 6 hospitals, only 3 hospitals provided data for all variables required for this study. As a result, we only used the subset of 3 hospitals' data. The subset of the data was collected retrospectively from October 2010 to March 2012 in 35 nursing units at the 3 hospitals.

Data for 4 nurse-staffing characteristics (nurse staffing, skill mix, nursing turnover, and temporary nursing staff) and for 1 patient outcome (patient falls) were collected monthly. Injury falls were collected monthly. However, incidents of injury falls were rare with small variation in monthly data, so we aggregated monthly data of injury falls into quarterly data, which were used for the current study. For total pressure ulcers and unit-acquired ulcers, only quarterly data were available for the analysis. Thus, quarterly data for these 2 patient outcomes (patient falls with injuries; pressure ulcers, including both total pressure ulcers and unit-acquired pressure ulcers) were used (see Supplemental Digital Content, Table, available at http://links.lww.com/JNCQ/A73). A total of 511 unit-month data points and 171 unit-quarter

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data points were used for the analytic sample. This study was approved by the institutional review boards of the authors' universities and the 3 participating hospitals.

Measures

Patient outcome variables

Nursing unit patient falls, patient falls with injuries, and pressure ulcers (both total pressure ulcers and unit-acquired pressure ulcers) were used as measures of patient outcomes. These patient outcomes are recognized nursing-sensitive quality indicators.[31,32] For this study, the operational definitions of each patient outcome variable are the same as those used for the National Database of Nursing Quality Indicators.[33] Monthly patient falls and quarterly patient falls with injuries were defined as the number of incident adjusted per 1000 patient days. Quarterly pressure ulcers (total pressure ulcers and unit-acquired pressure ulcers) were defined as prevalence rates. The Supplemental Digital Content Table (available at http://links.lww.com/JNCQ/A73) presents definitions for each patient outcome variable.

Nurse staffing variables

To capture the effects of different types of nurse staffing, we used nursing hours per patient day for RNs, licensed practical nurses (LPNs), and unlicensed assistive personnel (UAP). Skill mix indicated the proportion of RNs to LPNs and UAPs. For nursing turnover and temporary nursing staff, we used RN turnover rate and temporary RN care hours per patient day, because RNs make up the majority of nursing staff and provide the most critical components of nursing care. After assessing the distribution of RN temporary nursing care hours, we categorized RN temporary nursing care hours into 3 groups by using zero and 0.3 care hour as cutoff points (low, moderate, and high). There are 2 reasons for that. First, more than 60% of the sample had zero care hours, so we created this as a group (low levels). Second, among those units using temporary nursing staff, we created 2 other groups to distinguish those units with higher levels of the use of temporary RNs ($\geq$0.3 care hour) from those units with moderate levels (>0 and <0.3 care hour). Detailed information of definitions of the nurse staffing variables is presented in Supplemental Digital Content Table (available at http://links.lww.com/JNCQ/A73).

Unit covariates

To control for other nursing unit characteristics that might affect both nurse staffing and patient outcomes, several nursing unit characteristics were included as covariates: unit size, unit type (critical care units, step down units, medical/surgical units, and other units), and quality improvement initiatives (transforming care at the bedside units and dedicated education units). In addition, statistical methods such as hospital- and time-fixed effects were used to control for other potentially confounding factors.

Analytic model and data analysis

To isolate the effect of nurse staffing on patient falls, we used a negative binomial model to investigate whether comprehensive nurse staffing characteristics affected the likelihood of patient falls. The following equation (1) presents the details as

$$Y_{ubym} = F(\text{Nurse Staffing}_{ubym}, \text{Unit Covariates}_{ubym}, H_b, \text{Year}_y, \text{Month}_m, \varepsilon_{ubym}),$$

where the subscripts u, b, y, and m represent nursing unit, hospital, year, and month. Y represents monthly patient falls. After assessing the distribution of monthly patient falls, we used a count model. So, $F(\cdot)$ represents a negative binomial distribution function.

Nurse staffing characteristics included the key predictor variables: RN, LPN, and UAP care hours per patient day; skill mix; RN turnover; and temporary RN care hours per patient day. With the exception of temporary RN care hours per patient day, all other nurse staffing variables were continuous. For temporary RN care hours per patient day, 2 dummy variables (moderate, high) were created; units

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without any temporary RN use (low) served as a reference group. *Unit covariates* were those mentioned earlier. *Hospital*-fixed effects (*H*) were also included to eliminate bias from unobserved hospital-level confounding factors that do not change over time, such as general hospital characteristics. We also included 2 *time*-fixed effects, *year* and *month*, and thereby controlled for fixed time effects that do not vary across units, such as the promotion of nationwide awareness of quality of care that are not observed empirically.

Similarly, to isolate the effect of comprehensive nurse staffing characteristics on quarterly falls with injuries, total pressure ulcers, and unit-acquired pressure ulcers, the same model in the equation (1) was estimated for quarterly falls with injuries, quarterly total pressure ulcers, and quarterly unit-acquired pressure ulcers. On the basis of assessment of the distribution of these patient outcome variables, for injury falls and unit-acquired pressure ulcers, Y represents binary outcomes, and $F(\cdot)$ thus represents a cumulative logit distribution function. For the total pressure ulcers, $F(\cdot)$ represents a negative binomial distribution function. To make correct statistical inferences, standard errors were adjusted for unit clustering.

To summarize, we used 2 analytic models (negative binomial and logit models) depending on the distribution of the outcome variables. Using these analytic models, we can estimate the relationship between comprehensive nurse staffing characteristics and the likelihood of patient outcomes. In addition to controlling for unit characteristics using unit covariates, we also controlled for unobserved hospital characteristics and the time trend, which might affect patient outcomes by the analytic methods to reduce omitted-variable bias and to draw rigorous study findings. All the analyses were performed in STATA, version 10.0 (Stata Corp, College Station, Texas).

RESULTS

The Supplemental Digital Content Table (available at http://links.lww.com/JNCQ/A73) presents descriptive statistics for the study variables. The average monthly staffing levels were 8.23, 0.42, and 1.41 care hours per patient day for RNs, LPNs, and UAPs, respectively. The average quarterly staffing levels were similar. In the case of LPN care hours per patient day, we found that about 45% of the sample units used zero LPN care hours. The average professional staff mix (ie, RNs/[RNs + LPNs + UAPs] $\times$ 100) both monthly and quarterly was around 79.50%. The RN monthly turnover rate was 1.82%, whereas the RN quarterly turnover rate was 5.00%. Average temporary RN care hours per patient day were 0.08 both monthly and quarterly. About 74% of nursing units did not use temporary RN staff in any month. The other 17% used more than zero and less than 0.3 care hour per patient day provided by temporary RN staff. Temporary RN staff provided equal to or greater than 0.3 care hour per patient day in another 9% of nursing units. When calculated per quarter, 64% of nursing units did not use any temporary RN staff, 26% used more than zero and less than 0.3 care hour per patient day, and 10% used equal to or greater than 0.3 care hour per patient day.

Table 1 presents the associations between (1) monthly patient falls and quarterly falls with injuries and (2) comprehensive nurse staffing characteristics. The first panel of Table 1 presents the impact of comprehensive nurse staffing characteristics on monthly patient falls. Two staffing characteristics were significantly related to the occurrence of patient falls. With all other variables held constant, an hour increase in LPN care hours per patient day led to a decrease in patient falls by a factor of 0.540. In other words, when all other conditions are same, an increase of LPN care hours was related to a decrease in patient falls. Compared with nursing units without any temporary RN staff, units that used temporary RN staff to provide equal to or more than 0.3 care hour per patient day had a rate 1.552 times greater for patient falls, which means that nursing units using the higher levels of care hours of temporary RNs experienced greater occurrence of patient falls.

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Table 1. Associations of Patient Falls and Injury Falls With Nurse Staffing Characteristics

	Monthly Patient Falls	Quarterly Injury Falls
	Negative Binomial Regression	Logit Regression
Nurse Staffing Characteristics	**IRR (SE)**	**OR (SE)**
Staffing levels		
RN nursing hours per patient day	1.060 (0.079)	1.330 (0.322)
LPN nursing hours per patient day	0.540 (0.150)[a]	0.058 (0.115)
UAP nursing hours per patient day	0.720 (0.156)	0.178 (0.200)
Professional staff mix		
Skill mix	0.956 (0.023)	0.820 (0.118)
Turnover		
RN turnover rate	1.015 (0.008)	0.996 (0.034)
Temporary nursing staff		
RN contract nursing care hours per patient day		
No RN contract care hours (reference group)		
0 < RN contract care hours < 0.3	1.099 (0.162)	4.169 (2.684)[a]
RN contract care hours ≥ 0.3	1.552 (0.260)[b]	4.679 (4.907)
N	470	158

Abbreviations: IRR, incident rate ratio; LPN, licensed practical nurse; OR, odds ratio; RN, registered nurse; UAP, unlicensed assistive personnel.
All models controlled for unit size, unit type, dedicated education units and transforming care at the bedside units status and included hospital fixed-effects and time (year and either month or quarter) fixed-effects. Standard errors (SE) are reported in parentheses, and are adjusted for clustering at the nursing unit level.
[a] $P < .05$.
[b] $P < .01$.

The second panel in Table 1 presents the impact of the comprehensive nurse staffing characteristics on quarterly falls with injuries. Only temporary RN staff use was significantly related to the occurrence of falls with injuries. Compared with nursing units without any use of temporary RN staff, units that used greater than zero but less than 0.3 care hour per patient day provided by temporary RN staff had a rate 4.169 times greater for injury-related falls. Table 2 presents the associations between (1) comprehensive nurse staffing characteristics and (2) quarterly pressure ulcers and quarterly unit-acquired pressure ulcers. None of the staffing characteristics were significantly related to the occurrences of pressure ulcers.

DISCUSSION

In this study, with all other conditions held constant, greater use of LPNs was related to a decrease in patient falls, and increased use of temporary RN staff was related to increased patient falls and falls with injuries. Given the Centers for Medicare and Medicaid Services' decision not to reimburse for certain preventable adverse outcomes such as patient falls,[34] the present findings provide valuable evidence regarding the linkages between nurse staffing and patient outcomes. Using comprehensive characteristics of nurse staffing and a longitudinal methodology provide a more definitive test of the relationships between staffing and outcomes than that

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Table 2. Associations of Pressure Ulcer and Unit-Acquired Pressure Ulcer With Nurse Staffing Characteristics

	Quarterly Pressure Ulcer	Quarterly Unit Acquired Pressure Ulcer
	Negative Binomial Regression	Logit Regression
Nurse Staffing Characteristics	**IRR (SE)**	**OR (SE)**
Staffing levels		
RN nursing hours per patient day	0.946 (0.090)	0.837 (0.127)
LPN nursing hours per patient day	1.287 (0.608)	1.900 (1.290)
UAP nursing hours per patient day	0.792 (0.244)	0.665 (0.392)
Professional staff mix		
Skill mix	1.016 (0.036)	1.003 (0.047)
Turnover		
RN turnover rate	0.998 (0.011)	1.038 (0.028)
Temporary nursing staff		
RN contract nursing care hours per patient day		
No RN contract care hours (reference group)		
0 < RN contract care hours <0.3	0.847 (0.126)	0.564 (0.286)
RN contract care hours ≥0.3	0.928 (0.304)	0.623 (0.378)
N	161	160

Abbreviations: IRR, incident rate ratio; LPN, licensed practical nurse; OR, odds ratio; RN, registered nurse; UAP, unlicensed assistive personnel.

All models controlled for unit size, unit type, dedicated education units and transforming care at the bedside units status and included hospital fixed-effects and time (year and quarter) fixed effects. Standard errors (SE) are reported in parentheses, and are adjusted for clustering at the nursing unit level.

offered by earlier studies and may account for the robust associations identified between the comprehensive staffing characteristics and patient quality indicators found here.

The US Department of Health and Human services found a strong association between nurse staffing levels and quality of patient care by using data from more than 4000 hospitals.[35] Those nursing-sensitive outcomes included urinary tract infections, pressure ulcers, hospital-acquired pneumonia, and deep vein thrombosis. The present findings add to the evidence of this relationship between nurse staffing and quality of patient care.

Our most important finding is that increased levels of temporary RN staffing resulted in greater patient falls—both non–injury-related and injury-related falls. This is consistent with findings of previous studies,[23,36] and it suggests that the use of temporary RN staff may be detrimental to the quality of patient care. Given the present study's limitations, one should be cautious in interpreting its results. As mentioned earlier, 74% of unit-month data points and 64% of unit-quarter data points were zero temporary RN care hours per patient day. About 9% to 10% of sample reported equal to or greater than 0.3 temporary RN hours. That means in this study sample, relatively fewer nursing units used temporary RN staff. Although we found the statistically significant findings of

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relationships between use of temporary RN staff and patient falls, this may not have enough power to have clinical significance given small variations of temporary RN staffing variables with the study sample. However, using the small sample, we found statistically significant findings so that the relationship between temporary RN staff and patient falls may also be seen in a larger sample. Future research needs to investigate the levels of temporary RN staffing, which might be harmful to patient falls, with larger samples.

Another concern in interpreting the results is related to variables not accounted for in this study that might also affect the quality of patient care. Aiken and colleagues,[29] after accounting for nurse staffing, RN education, and work environment, found that the association between temporary RN staffing levels and quality of patient care was not significant. It is possible that unfavorable work environments for nurses can lead to both increased use of temporary RN staff and poor quality of care. Using temporary RN staff can aggravate unfavorable work conditions. Either way, this reciprocal relationship between the use of temporary RN staff and unfavorable work conditions can have a negative effect on quality of patient care.

Thus, one practical implication for quality of care in this study is that nursing units should be aware that the use of temporary RN staff may have an impact on quality of patient care, and thus they should try to reduce the use of temporary RN staff. If they have to use temporary RN staff, they should monitor their work environments to ensure the quality of patient care. Another implication for quality of care is related to the reason behind the use of temporary RN staff. As mentioned earlier, the main reasons for employing temporary RN staff are staff absences, recruitment, retention, and vacancies.[22] One way to reduce the use of temporary nursing staff is to make staffing levels stable. Providing favorable work conditions would help staffing levels remain stable, which ensures the quality of patient care.

The finding that adding more LPN care hours led to decreased levels of patient falls is in contrast with previous findings for patient outcomes. Glance and colleagues[37] found that an increased ratio of LPNs to total nursing staff was related to an increase in mortality and sepsis in hospital patients. These contradictory findings might be due to the types of patient outcomes considered. Mortality and sepsis can be more complicated and require more care from RNs, whereas adding an LPN can lead to a decreased level of patient falls because LPNs can conduct patient surveillance rounds and prevent such events. Another possible explanation could be omitted variable biases. Although this study controlled nursing unit covariates, patient characteristics and case mix were not controlled. Those omitted variables could relate to both levels of LPN staffing and patient outcomes. For future studies, it is important to understand the level at which we can use LPNs to provide patient care to ensure quality of care (eg, hours per patient day or proportion of nursing care hours). Similar to the findings for temporary RN staff care hours, we need to consider that about 45% of the sample reported zero LPN care hour. Although the study findings were statistically significant, readers need to be cautious to interpret this as clinical significance.

Another practical implication of this study is that organizations should not focus solely on nurse staffing levels. This study used comprehensive nurse staffing characteristics, including nurse staffing, skill mix, RN turnover, and temporary RN staff. Significant findings were identified for LPN staffing level and temporary nursing staff use. This suggests that staff nurses and nurse managers should pay attention to staff composition as well as staffing levels. To capture both staffing levels and staff composition, nurse managers can examine the care provided by RN and LPN staff and number of hours or proportion of nursing care hours. It is also important to understand that nursing staff other than RNs, including LPNs and temporary RN staff, influence the quality of patient care. In health care facilities, staffing standards should be established not

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only for RNs but for LPNs and temporary nursing staff as well. Currently, staffing strategies emphasize RN staffing due to State staffing policy (eg, mandating minimum nurse to patient ratios, public reporting, having staffing committees).[38] However, LPN staffing may help to prevent certain kinds of adverse patient outcomes, such as patient falls. For those units with higher risk of patient falls, hiring more LPNs may be a cost-effective way to prevent patient falls at the same time to reduce health care costs related to falls. According to the Bureau of Labor Statistics,[39] LPNs are $24 000 less expensive than RNs on average per year, and when used to supplement RNs rather than replace them, they may be effective in reducing falls. Thus, health care facilities need to develop the staffing strategies using such evidence to reduce cost and improve quality of patient care.

Regarding temporary RN staffing, researchers should investigate levels of temporary RN staffing in relation to quality. The present analyses did not suggest recommended levels because they are based on the sampling distribution of temporary nursing care hours. A replication with a larger sample is needed to establish staffing standards. Although the State of California has implemented mandatory nurse-to-patient ratios, these include no specific recommendation about temporary RN staff. Also, it is not yet known whether consistent use of temporary RN staff might be harmful to patient care in comparison with occasional use of temporary RN staff. The levels and fluctuation of temporary RN staff usage should be investigated.

This study has several limitations. The convenience sample used lacked population representativeness, and the findings are not applicable to hospitals in other regions. Another potential limitation is that other missing variables might affect patient quality of care. Although the study controlled for several time-invariant nursing unit characteristics, it did not control for time-variant characteristics such as leadership change. Also, the study did not control for the unit case mix and individual patient characteristics such as age or comorbidity related to risk of falls and pressure ulcers, because these data were not available for all units. Further research is needed to account for confounding variables that might affect the quality of patient care.

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