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Patient Turnover and Nursing Staff Adequacy

Lynn Y. Unruh and Myron D. Fottler

Objective. To assess the relative validity of patient turnover adjustments and the difference in nurse staffing using measures that adjust for patient turnover and severity versus those that do not.

Data Sources. Numbers of registered nurses (RNs), adjusted patient days of care (APDC), length of stay, and patient severity information from acute care general hospitals in Pennsylvania 1994–2001, obtained from the Pennsylvania Department of Health, the American Hospital Association, and the Atlas MediQual system.

Study Design. After examining the trends in patient turnover and severity and their relationship to RN staffing, we apply two-patient turnover indices, with and without patient severity adjustments, to RN staffing measures, and test the difference between the original and adjusted measures using paired sample *t*-tests.

Data Extraction Methods. Data sets were match merged by hospital ID, and patient turnover and severity indices were created, using 1994 as the base year. RN staffing measures were developed using unadjusted APDC, and APDC adjusted for patient turnover and both patient turnover and severity.

Principal Findings. Patient turnover increased significantly from 1994 to 2001. The difference between RN staffing measures adjusted for patient turnover and severity and those not adjusted was increasingly significant from 1995 onward. Unadjusted RN staffing showed a 1 percent decline over the 8-year-period compared with decreases of from 9 to 26 percent after adjustments.

Conclusions. These results indicate that the assessment of unadjusted RN staffing by RN to patient ratios alone underestimates nursing workload and overstates RN staffing levels. Patient turnover, as well as severity, should be taken into account in staffing assessment and decision making.

Key Words. RN staffing, nurse staffing, patient turnover, patient throughput, length of stay, healthcare workforce, nursing workforce, nursing care intensity

National and statewide assessments of hospital nurse staffing frequently utilize a measure that averages counts of the number of nurses or hours of nursing care given the number of patients or patient days of care per hospital (Aiken, Sochalski, and Anderson 1996; Anderson and Kohn 1996; Spetz 1998;

Buerhaus and Staiger 1999; Kovner, Jones, and Gergen 2000; Unruh 2002). These calculations provide a rough measure of nursing staff resources given patient volume, but they do not consider the *intensity* of nursing care that must be provided for that patient volume.

Intensity of nursing care, or the intensive effort spent at work (Green 2001), is important to consider because staffing needs vary not only with the number of patients being cared for, but also with the type of care provided for each of those patients. As nursing care intensity increases, the amount of nursing staff required to properly care for patients will increase (Moores 1970).

Factors that contribute to the level of intensity include: (1) other human resources, such as support staff; (2) physical resources, such as unit layout; (3) the work design and technology, such as the level of computerization and model of nursing care; (4) administrative practices; (5) the severity of the patients being cared for; and (6) the turnaround time to produce the product (patient turnover or throughput) (Cooper and Zaske 1987; Nichols 1991; Shamian et al. 1994; O'Brien-Pallas et al. 1997; Allan 1998; Cavouras 2002; Seago 2002).

Ideally, a measure of nursing staff adequacy indicates the volume of nurses of a certain skill level that is necessary for the given volume of patients *given the intensity of nursing care required for those patients.* Measuring intensity directly has been difficult as it involves assessment of mental and physical exertion on a variety of tasks and decision-making processes (O'Brien-Pallas et al. 1997). Indirectly, one could approximate it by using one or more of the factors listed above.

Patient severity is an important factor influencing nursing care intensity that is measurable and has been used to adjust nurse staffing measures (Aiken, Sochalski, and Anderson 1996; Lichtig, Knauf, and Milholland 1999; Spetz 2000; Unruh 2002, 2003a, b). Patient turnover (the inverse of length of stay) is another important measurable factor affecting the intensity of nursing care. As patient turnover increases, a similar amount of nursing care must be delivered in a shorter period of time during each patient stay (Moores 1970; Dellit et al. 2001). Also, as turnover increases, admission, transfer, and discharge

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Address correspondence to Lynn Y. Unruh, Ph.D., RN, LHRM Associate Professor of Health Services Administration, Department of Health Professions College of Health and Public Affairs 210L HPA2, University of Central Florida, Orlando, FL 32816. Myron D. Fottler, Ph.D., is Professor and Director of Health Services Administration Program, Department of Health Professions College of Health and Public Affairs, University of Central Florida, Orlando, FL.

procedures, thought to be the most intensive periods of the patient's stay, take up an increasing proportion of the stay (Moores 1970; Jacobson, Seltzer, and Darn 1999; Cavouras 2002; Steinbrook 2002). In general, reduced length of stay is hypothesized to eliminate the lower resource use patient care days, while retaining the higher resource use days (Shamian et al. 1994).

It is not known exactly to what extent increased patient turnover (a shorter length of stay) increases nursing intensity. Improvements in some surgical techniques can lead to patients recovering more quickly from surgery, which may result in less needed nursing care per patient stay. Also, when patients are discharged sooner, they may have nursing care "left over" to be completed postdischarge. However, other types of medical care improvements that reduce the length of stay may result in even greater amounts of needed nursing care, while having nursing care to be performed postdischarge also necessitates a more intensive discharge teaching process. In the absence of direct observation of the nursing process, measures indicating nursing care intensity through a patient turnover indicator such as length of stay can only be preliminary and approximate.

Previous Research

Research over a number of years indicates that the inverse of length of stay is an indicator of nursing care intensity. An early paper by Moores (1970) reviews a 1948 British study by Cohen that found a significant inverse relationship between length of stay and the number of trained nurses. Cooper and Zaske (1987) find a strong inverse relationship between pharmacy workload intensity and length of stay. In a 1983 study, length of stay is the most significant predictor of nursing resource use (Caterinicchio and Davies 1983). Shorter (longer) length of stay is related to increased (decreased) nursing hours in several recent studies (Kumarich, Biordi, and Milazzo-Chornick 1990; Shamian et al. 1994; ANA 1997; O'Brian-Pallas et al. 1997).

In a case study using data from a hospital Medicus patient classification system, Graf and associates (2003) find that while average patient length of stay (ALOS) fell around 22 percent from 1993 to 2000, daily nursing workload per patient increased 19 percent. Several studies call for including length of stay in physician or nursing workload measurement systems (Jacobson, Seltzer, and Darn 1999; Lichtig, Knauf and Milholland 1999; Dellit et al. 2001).

It is important to look at the issue of patient length of stay as an indicator of nursing care intensity because recent research on registered nurse (RN)

staffing shows unchanged or improved hospital staffing (Aiken, Sochalski, and Anderson 1996; Spetz 1998, 2000; Buerhaus and Staiger 1999; Kovner, Jones, and Gergen 2000) while RNs claim staffing has become worse (Aiken et al. 2001; Wakefield 2001). Only a few studies that adjust for patient severity report a decline in RN staffing (Unruh 2002, 2003a, b). From 2000 to 2002, the ratio of hospital RNs to patient days of care *increased* by around 6 percent (Buerhaus, Staiger, and Auerbach 2003; CDC 2004), yet an RN *shortage* existed, with RN vacancies between 15 and 20 percent (Thompson 2003).

To date, nurse staffing research at the aggregate level does not adjust staffing measures for patient length of stay. Yet theory and research suggest that there is some degree of an inverse relationship between patient length of stay and nursing care intensity. As ALOS in U.S. nonfederal, short-stay hospitals fell from 7.5 days in 1980 to 4.9 days in 2001, a drop of 35 percent (CDC 2004), the validity of unadjusted staffing measures is called into question.

If nurse staffing included a length of stay adjustment, the assessment of nurse staffing and the validity of studies utilizing nurse staffing measures would improve, and analyses of changes in staffing over time might produce different results. The challenge is to determine a valid adjustment which neither over- nor under-adjusts for patient turnover. Ultimately, the only way to accurately assess the impact of patient turnover on nurse staffing is to conduct time-motion studies. However, as a preliminary step, ad hoc indicators utilizing length of stay could be used to adjust nurse staffing.

This study explores the use of two ad hoc measures for adjusting staffing for patient turnover. One assumes a full one-to-one inverse relationship between length of stay and nursing intensity. The other, the square root of the inverse of length of stay, assumes that as length of stay falls, efficiencies in the delivery of care are found, so that the impact on nursing intensity is never fully one-to-one. The study then examines whether these ad hoc adjustments of nurse staffing, with and without adjustment for patient severity, significantly alter the measurement of staffing over time. We compare our results to a case study relating length of stay to nursing workload (Graf et al. 2003).

METHODS

Initial Measures and Sources of Data

Initial data are the ALOS, average patient severity, the number of adjusted patient days of care (APDC), and the number of full-time equivalent (FTE) RN

positions per Pennsylvania hospital per year 1994 through 2001. Functional forms of ALOS and patient severity are used as proxies for nursing care intensity, APDC represents patient volume, and FTE RNs are the volume of RNs. As used by Unruh (2002, 2003a, b) in prior studies, we used MediQual severity scores for patient severity. These scores range from 0 to 4, and are based on the patients' clinical status upon admission, patient history, and other factors. (Iezzoni et al. 1996). The MediQual system is appropriate as an independent proxy for nursing intensity because it measures patient severity upon admission. APDC is composed of hospital inpatient days of care plus estimated outpatient days of care (AHA 2002). RN FTEs are the number of yearly filled positions in each hospital on June 30th. FTEs are one full-time position or two part-time positions (AHA 2002).

We acquired the ALOS and nursing staff data for each general, acute care Pennsylvania hospital (from 1994 to 2001) from the Pennsylvania Department of Health, patient severity from the Atlas MediQual system, and APDC from the American Hospital Association, annual survey of hospitals. Because of hospital openings, mergers, closings, missing data, and outliers, the number of hospitals in the analyses varied from year to year, ranging from 162 to 205.

Data Preparation and Analyses

Using statistical analysis software (*SAS*), we ran descriptive statistics for the measures as reported in Table 1. To roughly test whether an inverse relationship exists between length of stay and nursing intensity, we plotted existing RN staffing against existing ALOS, using the 8 years of data. The relationship is generally inverse (the plot is not presented here).

As the *specific* inverse relationship is not known, we developed two functional forms of the inverse to test as indicators. The first form is the full inverse (1/LOS). The second form, the square root of the inverse, is designed to moderate the full effect of the inverse as discussed previously.

We explored two methods of transforming the indicators into indices. The first was to divide the hospital's yearly mean by the 1994 aggregate average. The second was to divide the hospital's yearly mean by the hospital's own 1994 value. As this study examines the impact of patient turnover on staffing measures over time, we chose the latter method. To ascertain differences across hospitals, cross-sectional comparisons could easily employ the first method.

Table 1: Average Patient Length of Stay, Patient Turnover, Turnover Indices, Severity, and Severity Index in Pennsylvania Hospitals 1994–2001

	1994	1995	1996	1997	1998	1999	2000	2001	% Δ 1994–2001
Average patient length of stay									
Mean	6.32	5.96	5.67	5.50	5.26	5.13	4.90	4.87	—
Standard deviation	1.67	2.23	2.21	1.95	2.00	2.03	1.04	0.97	—
% Δ from prior year	—	−4.46	−5.04	−2.41	−4.16	−2.47	−1.88	−1.73	−20.84
Patient turnover									
Mean	0.17	0.18	0.19	0.19	0.20	0.20	0.21	0.22	—
Standard deviation	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	—
% Δ from prior year	—	6.97	6.05	2.98	4.73	1.45	2.65	2.42	29.43
Turnover index 1*									
Mean	1.00	1.07	1.14	1.18	1.23	1.24	1.28	1.29	—
Standard deviation	0	0.10	0.13	0.17	0.16	0.17	0.16	0.19	—
% Δ from prior year	—	6.97	6.27	2.98	4.70	1.34	3.24	1.20	29.43
Turnover index 2†									
Mean	1.00	1.04	1.07	1.08	1.11	1.11	1.13	1.13	—
Standard deviation	0	0.04	0.05	0.07	0.06	0.07	0.07	0.08	—
% Δ from prior year	—	3.56	2.96	1.37	2.33	0.69	1.40	0.23	13.26
Patient severity score									
Mean	1.12	1.15	1.11	1.17	1.39	1.40	1.32	1.23	—
Standard deviation	0.22	0.25	0.25	0.27	0.21	0.23	0.22	0.19	—
% Δ from prior year	—	2.82	−1.86	8.75	23.56	1.04	−5.49	−6.11	9.8
Severity index									
Mean	1.00	1.03	1.00	1.07	1.31	1.31	1.25	1.16	—
Standard deviation	0	0.13	0.16	0.32	0.56	0.57	0.51	0.49	—
% Δ from prior year	—	2.78	−1.77	8.61	23.70	0.99	−5.56	−6.16	15.66

*Turnover index 1 uses 1/LOS.

†Turnover index 2 uses square root (1/LOS).

Descriptive statistics for the indices are reported in Table 1. Turnover indices 1 and 2 show a 29 and 13 percent increase, respectively, over the 8-year period. The most significant increases in patient turnover were in the 1995–1998 period. The severity index increased 16 percent overall. Its growth peaked in 1998 and 1999.

Following data preparation, we ran simple fixed effects regression analyses on the turnover indicators to examine their fit to RN staffing. The model was $\text{RN/APDC} = \beta_0 + \beta_1^*$ turnover indicator$+\delta_i\text{FE}+\varepsilon$. Turnover indicator 1 was significantly related to RN staffing at $p<.0001$ (coefficient = .00302), and turnover indicator 2 was significant at $p<.01$ (coefficient = .001823).

Next, we assessed the effect of the indicators on nursing staff measures by constructing a baseline measure composed of the ratio of RNs to standard APDC, and new measures of the ratio of RN to adjusted APDC (APDC multiplied times the patient turnover indices, and times both patient severity and the turnover indices). Finally, we assessed the significance of the difference between the original and new measures of RN staffing by conducting a paired sample *t*-test of the mean difference in the measures, and in the percent change in measures, in each hospital in each year 1994–2001.

RESULTS

Table 2 presents Pennsylvania hospital RN staffing ratios from 1994 to 2001 before and after patient turnover and severity adjustments, the mean differences between the unadjusted and adjusted measures, and the statistical significance of the differences (*t*-values). Unadjusted ratios increased until 1996, then decreased slowly thereafter, ending slightly lower in 2001 compared with 1994. Adjusted ratios fell sharply from the beginning. The adjusted staffing ratios were significantly lower than the comparable unadjusted staffing ratios starting in 1995, and the difference became increasingly larger and more significant over time. By the year 2001, the *t*-values of the mean differences were large and significant at the .0001 level. In real terms, the unadjusted RN staffing ratio of 2.81 in 2001 would be reduced to between 2.09 and 2.56 depending on which of the four patient turnover adjustments is used. This means that the unadjusted 2001 measure overstates the actual RN staffing ratio anywhere from 9 to 26 percent.

Table 3 shows the percentage change in staffing ratios from 1994 to 2001 before and after adjustments, the mean differences between the measures, and the *t*-values of these differences. The percentage change in unadjusted staffing ratios barely changed year-to-year, whereas the turnover-adjusted measures fell 1–4 percent per year, and those adjusted for both turnover and severity fell up to 18 percent in some years. Instead of a continual improvement in RN staffing through 1996, as indicated by the unadjusted measure, all adjusted measures show declines starting in 1994. Then, between 1996 and 2000, measures adjusted for turnover show much deeper decreases in RN staffing than the unadjusted measures. Because patient severity peaked in 1999, measures adjusted for both turnover and severity decrease deeply until 1999, then show increases in percent change. Overall, unadjusted RN/APDC fell only 1 percent, whereas adjusted RN/APDC fell from 10 to 26 percent.

Table 2: RN/1,000 APDC in Pennsylvania Hospitals 1994–2001, before and after Adjustment for Patient Turnover and Severity

	1994	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
Before adjustment								
RN/1,000 APDC	2.84	2.88	2.94	2.92	2.89	2.88	2.86	2.81
After adjustment for patient turnover[†]								
RN/1,000 APDC (adj)	2.84	2.75	2.65	2.54	2.43	2.37	2.29	2.26
Mean difference	0	−0.14	−0.29	−0.37	−0.47	−0.51	−0.60	−0.62
t-Value	—	−3.00*	−5.82***	−8.11***	−8.64***	−11.14***	−20.17***	−23.21***
After adjustment for patient turnover[‡]								
RN/1,000 APDC (adj)	2.84	2.80	2.78	2.71	2.63	2.61	2.58	2.56
Mean difference	0	−0.10	−0.18	−0.22	−0.28	−0.29	−0.32	−0.33
t-Value	—	−12.45***	−14.66***	−17.18***	−19.47***	−18.75***	−20.18***	−22.60***
After adjustment for patient turnover[†] and severity								
RN/1,000 APDC (adj)	2.86	2.71	2.71	2.51	1.96	1.93	1.20	2.09
Mean difference	0	−0.19	−0.23	−0.41	−0.95	−0.98	−0.92	−0.80
t-Value	—	−3.43***	−4.18***	−6.92***	−23.68***	−24.46***	−21.61***	−20.44***
After adjustment for patient turnover[‡] and severity								
RN/1,000 APDC (adj)	2.86	2.75	2.81	2.68	2.16	2.23	2.28	2.43
Mean difference	0	−0.14	−0.11	−0.25	−0.75	−0.81	−0.68	−0.56
t-Value	—	−5.31***	−3.42***	−5.39***	−20.86***	−16.60***	−18.33***	−12.40***

*$p<.01$;
**$p<.001$;
***$p<.0001$.
[†]Turnover adjustment 1 uses 1/LOS.
[‡]Turnover adjustment 2 uses square root(1/LOS).

Table 3: Percentage Change in RN/1,000 APDC in Pennsylvania Hospitals 1994–2001, before and after Adjustment for Patient Turnover and Severity

	1994–5	*1995–6*	*1996–7*	*1997–8*	*1998–9*	*1999–00*	*2000–01*	*1994–01*
Before adjustment								
RN/1,000 APDC	2.25	1.61	−0.27	−0.58	−0.17	−1.86	−2.09	−1.26
After adjustment for patient turnover[†]								
RN/1,000 APDC (adj)	−3.98	−3.77	−1.78	−3.56	−1.47	−3.58	−1.31	−20.23
Mean difference	−6.54	−5.48	−1.47	−3.26	−1.10	−2.24	0.66	−19.51
t-Value	−13.13***	−10.65***	−4.69***	−8.57***	−2.20*	−4.53***	1.34	−23.84***
After adjustment for patient turnover[‡]								
RN/1,000 APDC (adj)	−0.97	−0.68	−1.23	−1.58	−0.23	−2.30	−0.73	−10.41
Mean difference	−3.33	−2.86	−1.25	−1.23	−0.65	−1.11	1.31	−9.51
t-Value	−13.19***	−10.95***	−4.79***	−8.82***	−2.78**	−4.61***	1.32	−23.07***
After adjustment for patient turnover[†] and severity								
RN/1,000 APDC (adj)	−6.02	0.04	−7.07	−17.69	−1.30	2.13	5.95	−26.49
Mean difference	−8.57	−1.25	−7.04	−17.71	−1.09	3.59	6.14	−25.97
t-Value	−9.43***	−1.04	−6.21**	−14.36***	−3.11**	5.17***	7.84***	−20.35***
After adjustment for patient turnover[‡] and severity								
RN/1,000 APDC (adj)	−2.24	3.35	−4.87	−15.95	−0.51	2.98	6.30	−16.50
Mean difference	−4.77	1.58	−5.16	−15.77	−0.42	4.82	6.52	−15.55
t-Value	−4.58***	1.33	−5.35***	−13.68***	−2.57	8.99***	11.03***	−14.13***

*$p<.01$;
**$p<.001$;
***$p<.0001$.
[†]Turnover adjustment 1 uses 1/LOS.
[‡]Turnover adjustment 2 uses square root(1/LOS).

Although there were varying degrees of difference between the adjusted and unadjusted measures, there was a highly significant statistical difference between unadjusted and all four adjusted measures for most of the 8 years. The maximum year-to-year difference between measures occurred between 1997 and 1998, with t-values from 8 to 14 at $p < .0001$. The difference between the unadjusted and adjusted ratios was reduced from 2000 to 2001, and was even positive between the unadjusted and dually adjusted measures (because patient severity peaked in 1999). For the period overall, t-values of the mean difference in measures were 14–24 with $p < .0001$.

DISCUSSION

Our study adjusts RN staffing ratios in Pennsylvania hospitals from 1994 to 2001 using two different ad hoc patient turnover adjustments and a severity adjustment. Our results indicate significant declines in average length of stay, increases in patient turnover, and declines in adjusted RN staffing ratios over this time period irrespective of which adjustment is used. RN staffing levels were significantly lower after adjustment for patient turnover, alone or together with patient severity adjustments. The significance of this finding is that unadjusted RN staffing measures overestimate RN staffing, although the use of ad hoc measures does not allow us to speculate as to what degree.

No previous research has adjusted RN staffing ratios for patient turnover or both patient turnover and patient severity. As both significantly impact RN workloads, the present study suggests that future research regarding nurse staffing or nurse workload should consider adjusting for patient turnover, or both turnover and severity.

Which of the adjustments should researchers use? In Table 4 we compare our findings to those of Graf et al. (2003). In the Graf et al. (2003) study, workload increased nearly 90 percent of the amount of the drop in length of stay in a 7-year-period. In the present study, the first turnover adjustment based on the full inverse of the length of stay increased staffing needs by nearly the same amount as the fall in length of stay in the 8-year period, thus slightly overestimating the impact compared with the Graf et al. (2003) study. The second turnover adjustment understated the impact by one-half. The first turnover adjustment along with patient severity overstated the amount of impact slightly. Finally, the second turnover adjustment along with severity slightly understated the staffing needs compared with the Graf findings (Graf et al. 2003).

Table 4: Comparison of Study Findings to Graf et al. (2003) Case Study

	Graf et al. (2003) (%)	*Turnover Adjustment 1 (1/LOS) (%)*	*Turnover Adjustment 2 Sqrt (1/LOS) (%)*	*Turnover Adjustment 1 and Severity (%)*	*Turnover Adjustment 2 and Severity (%)*
Percent change in LOS	22	21	21	21	21
Percent change RN staffing or workload	19	20	10	26	16
Increase in RN staffing as a proportion of increase in length of stay	90	95	48	124	76

Sqrt, square root.

Based on this comparison, we believe that the second turnover adjustment (square root of 1/LOS) is a conservative estimate of increases in nursing care intensity, and that it makes a reasonable indicator for changes in intensity in staffing. It could be used alone, or with an appropriate patient severity indicator. The first turnover adjustment (1/LOS) could also be used, but not with a patient severity adjustment.

The most significant limitation of our study is the lack of an empirically derived measure of nursing work intensity, such as that obtained through a time-motion study. Future research needs to better quantify the relationship of ALOS and patient severity to nursing care intensity and to nurse staffing. Consequently, research should focus on developing a more accurate measure of nurse intensity that includes patient severity, patient turnover, and other workplace factors which impact staffing (Seago 2002).

A second limitation of this study is the state-level sample. Future research should replicate this study on a national basis to allow for a stronger generalization. We should note that while the average length of stay in Pennsylvania hospitals declined from 5.96 to 4.87 days between 1995 and 2001 (see Table 1), the decline nationally was 5.4–4.9 days (see CDC 2004). This means that adjusted RN staffing adjustments would have decreased somewhat less nationally than in this study.

A third limitation is the focus on RN staffing ratios to the exclusion of other categories of nursing personnel. Future studies need to assess staffing patterns in all categories of nurses, as staffing patterns could be changing in

different directions for different categories of nurses as a result of work reorganization, substitution, and shortages.

The perceptions of nurses, the media, and others concerning increasing nurse workloads/declining staffing ratios are justified and supported by our study. Given the differences between adjusted and unadjusted staffing ratios, and the availability of length of stay and patient severity data necessary to make the adjustments, it is important to begin adjusting staffing measures for these factors. Furthermore, research that uses hospital-level RN staffing data as part of a larger study with other variables, should consider adjusting staffing for patient turnover or including it as an independent variable.

Future research needs to address the pros and cons of our recommended adjustment as well as other possible adjustments. Our study of one state over an 8-year period is suggestive but not definitive. The important point is that nurse staffing and nurse workload studies need to utilize adjusted data. The issue of nurse staffing is too important to continue to disseminate unadjusted results that significantly overstate the level of nurse staffing in hospitals.

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