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Registered Nurse Staffing Mix and Quality of Care in Nursing Homes: A Longitudinal Analysis

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Purpose: To examine the relationship between registered nurse (RN) staffing mix and quality of nursing home care measured by regulatory violations. ***Design and Methods:*** A retrospective panel data study (1999–2003) of 2 groups of California freestanding nursing homes. One group was 201 nursing homes that consistently met the state's minimum standard for total nurse staffing level over the 5-year period. The other was 210 nursing homes that consistently failed to meet the standard over the period. All facility and market variables were drawn from California's cost report data and state licensing and certification data, as well as 3 other databases. ***Results:*** The RN to total nurse staffing ratio was negatively related to serious deficiencies in nursing homes that consistently met the staffing standard, whereas the ratio was negatively associated with total deficiencies in nursing homes that consistently failed to meet the standard over the 5-year period. As the RN to licensed vocational nurse ratios increased, total deficiencies and serious deficiencies decreased in both groups of nursing homes. ***Implications:*** A higher RN mix is positively related to quality of care, but the relationship is affected by overall nurse staffing levels in nursing homes. Further studies are necessary for a better understanding of RNs' unique contributions to the quality of care in nursing homes.

Key Words: Nurse skill mix, Nurse staffing level, Nursing home quality, Deficiencies, Panel data analysis

Nursing homes are a major sector of the U.S. health care delivery system. Approximately 1.4 million residents are in 16,000 Medicare- or Medicaid-certified nursing homes (Harrington, Carrillo, & Mercado-Scott, 2005). The quality of care in nursing homes has long been one of the most critical concerns of the public. Despite various efforts to improve quality, the average number of care deficiencies per facility increased from 4.9 in 1997 to 9.2 in 2003; only 9.9% of the 15,138 nursing homes surveyed in 2003 displayed no quality of care deficiencies (Harrington et al., 2005). Total nurse staffing levels have been almost at the same level over time, whereas registered nurse (RN) staffing levels have dropped by 25%, from 0.8 to 0.6 hr per resident day (HPRD), since the Balanced Budget Act was implemented in 1998.

With a consensus on the importance of nurse staffing to quality, several recommendations on minimum nursing home staffing levels have been proposed. The Institute of Medicine (IOM, 1996) recommended one RN for 24 HPRD, whereas the current federal standard requires one RN only for 8 consecutive hours. A geriatric expert panel recommended a total of 4.55 HPRD (Harrington et al., 2000). A study for the U.S. Centers for Medicare and Medicaid Services (CMS, 2001) reported that a total of 4.1 HPRD was a threshold to prevent harm for long-stay residents, and this was also confirmed by a direct observation study with a sample of 21 California nursing homes

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(Schnelle et al., 2004). In fact, 97% of U.S. nursing homes provide below the 4.1 total HPRD recommended by the study for CMS (Harrington et al., 2005). About 33 states specify a minimum staffing level, but no state requires 4.1 total HPRD. Florida requires the highest level, 3.60 HPRD, followed by Washington, DC (3.50), Delaware (3.28), and California (3.20); and Oregon has the lowest level requirement at 1.76 HPRD (Mueller et al., 2006).

Staff mix, often interchangeable with *skill mix* of nursing staff (Buchan & Dal Poz, 2002), is the "composition of the nursing staff by licensure or educational status" (Van den Heed, Clarke, Sermeus, Vleugels, & Aiken, 2007, p. 291). It also often refers to the combination of three categories of nursing personnel: registered nurses (RNs), licensed vocational/practical nurses (LVNs/LPNs), and nursing assistants (NAs; Rantz et al., 2004). Studies have reported that as nurse staffing level increases, nursing homes receive fewer survey deficiencies and complaints and have lower prevalence of pressure ulcers, weight loss, mortality, hospitalization, and infections (Bostick, Rantz, Flesner, & Riggs, 2006; Konetzka, Norton, Sloane, Kilpatrick, & Stearns, 2006; Scott-Cawiezell & Vogelsmeier, 2006; Simmons, 2007; Wan, Zhang, & Unruh, 2006). Yet, few studies have given attention to nurse staffing mix (Lang, Hodge, Olson, Romano, & Kravitz, 2004; Newbold, 2007).

Hospital quality studies have reported that a high RN staffing mix is related to positive patient outcomes, such as lower rates of infection, mortality, and pressure sores (Aiken, Smith, & Lake, 1994; Blegen, Goode, & Reed, 1998; Tourangeau, Giovannetti, Tu, & Wood, 2002); but across nursing home studies, only a relatively small number of empirical studies have examined RN staffing mix and quality of care. In a recent systematic review of a total of 87 studies on nursing home staffing, Bostick and colleagues (2006) found that only 5 studies examined the relationship of nurse staffing mix to quality of care in nursing homes. The findings are inconsistent across the studies. Some found that a high RN staffing mix (higher RN to total staffing ratio or higher RN to LPN staffing ratio) was related to fewer deficiencies and better pressure ulcer and cognitive outcomes (Anderson, Hsieh, & Su, 1998; Moseley & Jones, 2003; Munroe, 1990; Weech-Maldonado, Meret-Hanke, Neff, & Mor, 2004), but others documented no such significant relationships (Dellefield, 1999; Pearson, Hocking, Mott, & Rigges, 1992; Rantz et al., 2004).

Several factors, such as limitations in quality measures (QMs), data, risk adjustment, and analytic approach, have been identified as contributors to the inconsistencies in direction and extent of the relationships (Schnelle, 2004; Unruh & Wan, 2004). Another possible explanation could be interactions between RN staff mix and total staffing level: The impact of RN staffing mix on quality of care may have been influenced by the total staffing level, but few studies have examined the relationships of RN staffing mix to quality of care with consideration to the total staffing level.

The purpose of this study was to examine the relationship of RN staff mix to quality of nursing home care using recent 5-year panel data from California nursing homes. California has the largest number of nursing homes and has established a standard of 3.2 total nursing HPRD (Harrington & O'Meara, 2004), which is considerably below the 4.1 total HPRD level recommend by a study for CMS (2001). Existing nursing home staff mix studies were mainly cross-sectional studies (Rantz et al., 2004; Weech-Maldonado et al., 2004). To fill the gap in the literature, this study examined the relationship of nursing staff mix to regulatory deficiencies with consideration to whether nursing homes met the state staffing standard level over a 5-year period, 1999–2003.

Methods

Research Design

We examined the relationship of RN staffing mix to quality of care in nursing homes using two subgroups of 1,099 Medicare- and Medicaid-certified freestanding nursing homes in California that received one or more state surveys between 1999 and 2003. One group consisted of a total of 201 nursing homes that consistently met the California state staffing standard, 3.2 or more total HPRD, over the 5 years; the other group was 210 nursing homes that consistently failed to meet the standard in all state inspections over the 5-year period. The high number of facilities not in compliance with the state standard was related to the decision of California officials not to enforce the minimum standard after it was adopted (Harrington & O'Meara, 2004). The rest of the state's nursing homes met the standard in some observed years and failed to meet it

in other years. They were excluded from the sample of this study.

Registered nurse staffing mix was measured by the RN to total nurse staffing ratio and the RN to LVN staffing ratio. Quality of nursing care was measured by the number of total deficiencies and the number of serious deficiencies that nursing homes received in state inspections. We also calculated the marginal effects of the staffing mix ratios on deficiencies.

Data Sources

This was a secondary panel data analysis study. The study data were drawn mainly from two electronic databases: California's long-term care annual cost report (hereafter, the annual cost report) and the Automated Certification and Licensing Administrative Information and Management Systems (ACLAIMS). The annual cost report is a document that all California nursing homes licensed by the Department of Health Services (DHS) must submit annually to the California Office of Statewide Health Planning and Development (COSHPD; 2004). It includes detailed information on staffing and facility characteristics of nursing homes. The annual cost report data are audited by COSHPD's own professional staff and also by the California (CA) DHS, which reviews the accounting systems of selected facilities on-site to validate the reported data (COSHPD, 2004). The data from the annual cost report are more reliable than those from the federal Online Survey Certification and Reporting (OSCAR) system (Kash, Hawes, & Phillips, 2007).

The deficiency data were obtained from the ACLAIMS database, the computerized California state nursing home licensing and certification database maintained by the CA DHS. The ACLAIMS includes data related to the quality of care in nursing homes, such as deficiencies, complaints, citations, and penalties (O'Meara, Collier, & Harrington, 2005). On average, every 12 months nursing homes receive an inspection to maintain federal certification. Through these on-site inspections, state surveyors verify whether a nursing home complies with all state and federal regulatory requirements and then enter the survey findings into the ACLAIMS database (Harrington, Mullan, & Carrillo, 2004). California uses both federal and state deficiencies for nursing home enforcement (Harrington et al., 2004). The federal deficiencies serve as minimum requirements, and additional state deficiencies may be issued for violations of state requirements. Although state and federal surveys are conducted at the same time, the same deficiency cannot be simultaneously cited under both federal and state regulations (Tsoukalas et al., 2006).

Operationalization of Variables

Quality of care was measured by two deficiency variables: total and serious deficiencies. Deficiencies are one of the QMs recommended by the IOM (1996) and have been widely used in nursing home quality studies (Grabowski, 2004; Harrington, Zimmerman, Karon, Robinson, & Beutel, 2000; Konetzka, Yi, Norton, & Kilpatrick, 2004; Smith, Feng, Fennell, Zinn, & Mor, 2007). Deficiencies are the only available source for determining nursing homes' compliance with regulatory requirements for quality care (Harrington et al., 2005), although there are concerns about the variability of the state survey process in issuing deficiencies. Resident outcomes from the Minimum Data Sets, such as pressure ulcers or functional change, could be alternative measures; but the lack of reporting accuracy and inadequate risk adjustments are recognized challenges to the use of those measures (Arling, Kane, Lewis, & Mueller, 2005; Bates-Jensen, Simmons, Schnelle, & Alessi, 2005).

When only federal deficiencies are counted, deficiencies are actually underreported (Tsoukalas et al., 2006), so we counted both types of deficiencies. The number of total deficiencies in this study was the sum of all federal and state deficiencies in the areas of quality of care, mistreatment, resident assessment, administration, environment, life safety, nutrition, pharmacy, and resident rights (Harrington et al., 2000; Mullan & Harrington, 2001). When surveyors find federal and state deficiencies that pose imminent and severe danger to the residents, they classify federal deficiencies as level G or higher and state deficiencies as level A or higher. *Serious deficiencies* in this study refers to the sum of the number of level G or higher federal deficiencies and the number of level A or higher state deficiencies that nursing homes received (O'Meara et al., 2005). The numbers of state deficiencies were too small to be modeled separately with adequate statistical power in this study.

The two RN staffing mix variables were RN to total nurse staffing ratio and RN to LVN ratio. The RN to total nurse staffing ratio was calculated by dividing RN HPRD by total nursing HPRD,

which was the sum of RN, LVN, and NA HPRD. The RN to LVN ratio was calculated by dividing RN HPRD by LVN HPRD. If a nursing home consistently provided 3.2 or more total nursing HPRD between 1999 and 2003, it was coded among *nursing homes meeting the state standard*. If a home consistently failed to meet the standard over the 5-year period, we coded it among *nursing homes not meeting the state standard*. Nursing hours included the hours of full-time, part-time, and temporary employees, and only productive hours. Time for vacation, sick time, disability, and other paid time off were excluded (COSHPD, 2004).

We controlled for several facility and market characteristics based on a literature review in examining the relationships between RN staffing mix and regulatory deficiencies (Table 1). Nursing home size was categorized into three groups—small (fewer than 60 beds), medium (60–119 beds), and large (120 or more beds)—based on the number of certified beds (Harrington et al., 2000). A dichotomous variable coded nonprofit and government nursing homes as 0 and for-profit homes as 1. Another dichotomous variable from the OSCAR database was used for chain affiliation. If a nursing home was a member of a nursing home system (two or more facilities), it was coded as 1.

Payer mix was measured by the proportion of Medicare, Medicaid (called Medi-Cal in California), and self-paid resident days to the total resident days as defined in the cost report (COSHPD, 2004). Occupancy rate was operationalized by the percentage of licensed beds occupied during the reporting period. Resident care needs were measured by average case mix score, an aggregate resource use groups score (Fries et al., 1994). Per capita income and population aged 85 and older in a county, obtained from the U.S. Bureau of Economic Analysis (BEA, 2003), were added into the analytic model, divided by 1,000 for scaling purposes. Competition was measured by the Herfindahl index, the sum of the squared market shares of the facilities in each county (Grabowski, 2004; Grabowski & Angelelli, 2004). The index ranges from 0 to 1. A lower index score refers to higher competition. Two dichotomous variables were used to indicate whether a nursing home was located in the Bay area or the Los Angeles area, where the Medi-Cal reimbursement rate for nursing homes is higher than in other areas of the state (O'Neill, Harrington, Kitchener, & Saliba, 2003). Lastly, time-fixed effects, underlying time trends in deficiencies, were also adjusted for in the model by using four dichotomous variables with the year 1999 as a reference.

Sample and Data Preparation

The study sample included a total of 850 yearly observations (1999–2003) from the 201 nursing homes meeting the state standard and 910 yearly observations from the 210 nursing homes not meeting the state standard in California. They were Medicare- and Medicaid-certified freestanding skilled homes that consistently met or failed the state nursing home staffing standard over the 5-year period. Approximately 98% of observed nursing homes in both groups had three or more valid inspection data during the 5 years. The results were consistent whether or not we excluded nursing homes with only one or two valid inspections during the period, so we present the findings based on all valid observations.

Nurse staffing data were cleaned by the rules developed by the CMS report to Congress on staffing (CMS, 2001): Excluded were nursing homes with less than 0.5 or more than 12 total nursing HPRD, zero RN hours in a nursing home with more than 60 beds, or nursing homes with a more than 100% occupancy rate. In addition, nursing homes with missing values in staffing, case mix, or chain affiliation in all 5 years were also dropped.

Analytic Approach

The Poisson random effects model was used to estimate the relationships between RN staffing mix and the number of deficiencies. Because the dependent variables of the study were nonnegative integer variables, we adopted the Poisson regression, a widely used nonlinear function form for count-dependent data (Wooldridge, 2002), and added the random effects component to the Poisson regression to adjust for the unobserved heterogeneity that may cause the omitted variable bias (Greene, 2007a).

Large administrative data sets, such as those analyzed in this study, are often limited in terms of their depth and breadth of information because they are not collected for the specific purpose of the research. For example, each nursing home may have its own unique culture or communication style that would rarely change and may affect the quality of care. Omitting such unobserved, individual nursing home–specific, time-invariant variables may cause bias, the so-called omitted variable bias, in the estimation of the relationships of nurse staffing mix to deficiencies.

The Poisson random effects model we adopted assumes that heterogeneity in the model comes

Table 1. Descriptive Statistics of California Nursing Homes, 1999–2003

Variable	Nursing homes meeting the state standard (n = 850)		Nursing homes not meeting the state standard (n = 910)	
	M/%	*SD*	*M*/%	*SD*
Deficiencies				
Total deficiencies (*n*)	13.20	9.81	15.23	11.30
Serious deficiencies (*n*)	0.54	1.43	0.52	1.42
Nurse staffing				
Total staffing hours	4.01	1.05	2.79	0.34
RN hours	0.57	0.46	0.26	0.13
RN to total staff ratio	0.14	0.07	0.09	0.05
RN to LVN ratio	0.94	1.29	0.64	0.74
Facility characteristics				
Small homes (%)	0.44		0.13	
Medium homes (%)	0.31		0.59	
Large homes (%)	0.25		0.28	
Nonprofit (yes = 1)	0.43		0.03	
Medicare-paid days (%)	8.76		5.59	
Medi-Cal-paid days (%)	37.95		73.14	
Self-paid days (%)	42.67		10.50	
Occupancy rate (%)	85.91		88.69	
Chain affiliation (yes = 1)	0.50		0.64	
Resident care needs	1.21	0.39	0.93	0.24
Market characteristics				
Per capita income ($)	33,703.0	9,448.4	31,386.4	7,226.2
Population aged 85+ (*n*)	41,391.0	42,580.0	60,350.7	50,158.0
Competition (HI)	0.05	0.11	0.04	0.09
Bay region (yes = 1)	0.25		0.17	
Los Angeles region (yes = 1)	0.23		0.44	

Note: RN = registered nurse; LVN = licensed vocational nurse; HI = Herfindahl index.

from time-invariant, individual nursing home–specific traits. It controls for the heterogeneity through a random-effects parameter. Many of the variables in our analytic model are time invariant, so the Poisson fixed-effects model cannot be carried out (Greene, 2007a). We did not adopt the negative binomial random effects model because that model induces overdispersion in the data (Greene, 2007b). The standard dynamic panel model (Greene, 2007b) was not applicable to our data, which had discrete dependent variables. The generalized methods of moments using instrumental variables could have been used, but the model is not well developed (Blundell, Griffith, & Windmeijer, 2002).

In short, the relationships between RN staffing mix and deficiencies were estimated in two groups of nursing homes, one that consistently met the state staffing standard between 1999 and 2003 and another that consistently failed to meet the standard, while adjusting for all the observed facility and market covariates and time-fixed effects as well as unobserved, nursing home–specific heterogeneity. All data analysis was conducted with SAS 9.1 and NLOGIT 4.0.

Results

Table 1 presents descriptive statistics of the variables used in the analysis. One thing to note is there were relatively small differences in the average numbers of serious deficiencies in nursing homes that consistently met the state staffing standard (M = 54, SD = 1.43) and nursing homes that consistently failed to meet the standard (M = 0.52, SD = 1.42), whereas differences between the two groups of nursing homes in total staffing levels and RN staffing levels were much larger.

In the nursing homes that consistently met the state staffing standard (Table 2), RN to total staffing ratios were not related to total deficiencies, but they were negatively related to serious deficiencies (β = –2.180, p = .043). Unlike RN to total staffing ratio, as RN to LVN staffing ratios increased, both total deficiencies (β = –.029, p = .017) and serious deficiencies (β = –.273, p = .017)

Table 2. Estimation Results of the Relationship Between RN Staffing Mix and Deficiencies in Nursing Homes Meeting the State Standard, 1999–2003 (n = 850)

	Total deficiencies		Serious deficiencies	
	Coefficient (*SE*)	Coefficient (*SE*)	Coefficient (*SE*)	Coefficient (*SE*)
Constant	2.070 (.188)***	2.140 (.190)***	–4.417 (1.086)***	–4.773 (1.119)***
RN to total staff ratio	–0.201 (.198)		–2.180 (1.075)*	
RN to LVN ratio		–0.029 (.012)*		–0.273 (.114)*
Bed <60[a]	–0.395 (.070)***	–0.395 (.071)***	–0.439 (.245)	–0.459 (.244)
Bed 120+[a]	0.119 (.052)*	0.110 (.053)*	0.373 (.348)	0.353 (.346)
Nonprofit (yes = 1)	–0.129 (.049)**	–0.131 (.049)**	0.001 (.251)	–0.003 (.246)
% Medicare days	0.013 (.002)***	0.013 (.002)***	0.028 (.010) **	0.029 (.010)**
% Medi-Cal days	0.001 (.001)	0.001 (.001)	0.008 (.006)	0.009 (.006)
% Self-pay days	–0.001 (.001)	–0.002 (.001)	0.007 (.005)	0.008 (.006)
Occupancy rate	0.003 (.001)***	0.004 (.001)***	0.025 (.006)***	0.029 (.007)***
Chain (yes = 1)	0.174 (.030)***	0.177 (.030)***	0.320 (.169)	0.354 (.170)*
Resident care needs	0.049 (.051)	0.041 (.051)	0.579 (.360)	0.507 (.363)
Per capita income/1,000	0.006 (.004)	0.004 (.003)	0.030 (.020)	0.029 (.020)
Population 85+/1,000	–0.005 (.002)*	–0.005 (.002)*	–0.009 (.013)	–0.009 (.014)
Competition (HI)[b]	–0.024 (.324)	–0.043 (.328)	2.102 (1.876)	2.167 (1.791)
Region Bay (yes = 1)	0.076 (.098)	0.105 (.099)	–0.156 (.450)	–0.121 (.439)
Region Los Angeles (yes = 1)	0.393 (.230)	0.375 (.222)	–0.547 (1.331)	–0.563 (1.434)
Year 2000	–0.014 (.021)	–0.014 (.021)	–0.524 (.143)***	–0.524 (.141)***
Year 2001	0.105 (.022)***	0.103 (.020)***	–0.616 (.126)***	–0.623 (.121)***
Year 2002	0.046 (.022)*	0.047 (.021)*	–0.929 (.150)***	–0.944 (.145)***
Year 2003	–0.007 (.029)	–0.006 (.024)	–0.738 (.176)***	–0.810 (.172)***
Alpha	.171 (.019)***	.175 (.020)***	1.319 (.279)***	1.278 (.272)***
Log likelihood	–3,321.182	–3,276.374	–852.6194	–828.3703

Notes: RN = registered nurse; LVN = licensed vocational nurse; HI = Herfindahl index.
[a]Nursing homes with 60–119 beds are the reference.
[b]Higher HI score refers to lower competition.
*p < .05. **p < .01. ***p < .001.

decreased. Small nursing homes received fewer total deficiencies, but large nursing homes received more total deficiencies than middle-size (60–199 beds) nursing homes. Profit status, proportion of Medicare residents, occupancy rates, and chain affiliation were all positively related to the number of total deficiencies in nursing homes meeting the state staffing standard. As for serious deficiencies, nursing homes that were chain affiliated with a higher occupancy rate and those that had a higher number of Medicare residents requiring post-acute care received more serious deficiencies.

In the nursing homes that consistently failed to meet the state staffing level standard between 1999 and 2003 (Table 3), RN to total staffing ratios were related to only the number of total deficiencies (β = –2.130, p = .000), which is the opposite of findings in the nursing homes that met the standard (Table 2). RN to LVN staffing ratios were negatively related to total deficiencies (β = –.117, p = .000) and also to serious deficiencies (β = –.456, p = .001), which was consistent with what we found in the nursing homes that met the standard. Among these nursing homes that failed to meet the state standard, occupancy rate and Medicare-paid days were negatively associated with total deficiencies; self-pay days were negatively associated with serious deficiencies; and as Medicaid-paid days and resident care needs increased, both total and serious deficiencies increased.

Table 4 summarizes the estimated marginal effects of RN staffing mix on deficiencies. A 1-unit increase of the RN to total staffing ratio did not change the number of total deficiencies in nursing homes meeting the standard, but it decreased by about 32.44 the number of total deficiencies in nursing homes that consistently failed to meet the standard over the 5 years. As for serious deficiencies, a 1-unit increase of the RN to total staffing ratio decreased by about 1.17 the number of serious deficiencies only in nursing homes that met the standards. Lastly, a 1-unit increase of the RN to LVN ratio slightly (range 0.15–1.79) but consistently decreased both deficiencies in both types of homes.

Table 3. Estimation Results of the Relationship Between RN Staffing Mix and Deficiencies in Nursing Homes Not Meeting the State Standard, 1999–2003 (n = 910)

	Total deficiencies		Serious deficiencies	
	Coefficient (*SE*)	Coefficient (*SE*)	Coefficient (*SE*)	Coefficient (*SE*)
Constant	3.008 (.142)***	2.863 (.149)***	3.607 (.683)***	3.652 (.701)***
RN to total staff ratio	–2.130 (.199)***		–1.550 (1.310)	
RN to LVN ratio		–0.117 (.017)***		–0.456 (.141)**
Bed <60[a]	–0.211 (.103)*	–0.252 (.109)*	0.063 (.289)	0.049 (.286)
Bed 120+[a]	0.112 (.044)*	0.076 (.044)	0.120 (.219)	0.125 (.222)
Nonprofit (yes = 1)	–0.323 (.162)*	–0.333 (.166)*	–0.541 (.801)	–0.502 (.791)
% Medicare days	–0.005 (.002)*	–0.005 (.002)*	–0.004 (.014)	–0.005 (.014)
% Medi-Cal days	0.002 (.001)*	0.003 (.001)**	0.004 (.004)	0.004 (.004)
% Self-pay days	–0.002 (.002)	–0.002 (.002)	–0.021 (.009)*	–0.021 (.008)*
Occupancy rate	–0.007 (.001)***	–0.006 (.001)***	–0.042 (.005)***	–0.042 (.004)***
Chain (yes = 1)	0.122 (.028)***	0.116 (.029)***	–0.175 (.143)	–0.169 (.145)
Resident care needs	0.460 (.068)***	0.418 (.069)***	0.970 (.362)**	0.996 (.344)**
Per capita income/1,000	0.003 (.003)	0.002 (.004)	–0.003 (.018)	0.001 (.020)
Population 85+/1,000	–0.010 (.002)***	–0.009 (.002)***	–0.017 (.012)	–0.019 (.013)
Competition (HI)[b]	–0.408 (.629)	–0.357 (.670)	–0.157 (2.496)	–0.178 (2.623)
Region Bay (yes = 1)	0.049 (.093)	0.050 (.094)	–0.264 (.483)	–0.223 (.511)
Region Los Angeles (yes = 1)	0.662 (.164)***	0.603 (.167)***	0.071 (1.065)	0.344 (1.130)
Year 2000	0.113 (.016)***	0.121 (.016)***	–0.456 (.112)***	–0.446 (.110)***
Year 2001	0.133 (.019)***	0.136 (.019)***	–0.770 (.119)***	–0.770 (.119)***
Year 2002	0.056 (.021)**	0.065 (.022)**	–0.471 (.118)***	–0.485 (.115)***
Year 2003	0.087 (.027)**	0.100 (.026)***	–0.500 (.141)***	–0.491 (.137)***
Alpha	0.156 (.017)***	0.159 (.016)***	0.865 (.187)***	0.861 (.188)***
Log likelihood	–3,953.599	–3,933.743	–926.6544	–918. 6062

Notes: RN = registered nurse; LVN = licensed vocational nurse; HI = Herfindahl index.
[a]Nursing homes with 60–119 beds are the reference.
[b]Higher HI score refers to lower competition.
*p < .05. **p < .01. ***p < .001.

Discussion

This study provides a new insight on the relationships of nurse staffing level and mix and their associations with quality of care in nursing homes. It demonstrates that a higher RN mix in total staff is important for providing quality care in nursing homes, as reported in the existing literature (Anderson et al., 1998; Weech-Maldonado, Neff, Mor, 2003; Weech-Maldonado et al., 2004); but the relationship between RN staffing mix and quality of care is not linear: It is affected by the overall staffing level. In other words, staffing mix and staffing level interact with each other, which influences quality of care. In nursing homes that did not meet the state staffing standard, a higher RN to total nurse staffing ratio had a significantly negative relationship only to total deficiencies; but in nursing homes that met the standard, a higher RN to total nurse staffing ratio had a significantly negative relationship only to serious deficiencies.

Few studies have reported such interaction effects, which limits discussion of the implications of the findings. A possible explanation could be that the RNs' role in a nursing team is critical for improving quality of care in nursing homes, but their contributions are limited by the overall capacity of the nursing team. A higher RN to total staffing mix in nursing homes that consistently fail to meet the state staffing standard is valuable for maintaining the day-to-day operations that may link to overall quality of care measured by total deficiencies, but because of the low capacity of the team, RNs may not be able to respond adequately to more serious problems, resulting in serious deficiencies that may need more time and the effort of the whole nursing team to assess, prevent, and manage. In contrast, a higher RN to total staffing mix in nursing homes with 3.2 or higher total nursing HPRD may not be very beneficial to overall quality of care, but because of the increased capacity of the team, RNs may be able to mobilize the nursing team to provide more surveillance and more focused care to decrease serious harms or deficiencies.

Another possible explanation for the inconsistent findings regarding the relationship of RN to

Table 4. Marginal Effects of RN Staffing Mix on Deficiencies

	Marginal effects (*SE*)			
	Nursing homes meeting the state standard (n = 850)		Nursing homes not meeting the state standard (n = 910)	
Staffing mix	Total deficiencies	Serious deficiencies	Total deficiencies	Serious deficiencies
RN to total	−2.652 (2.617)	−1.169* (.577)	−32.441*** (3.035)	−.814 (.688)
RN to LVN	−.380* (.159)	−.145* (.061)	−1.786*** (.260)	−.238** (.074)

Notes: RN = registered nurse; LVN = licensed vocational nurse.
*p < .05. **p < .01. ***p < .001.

total ratio to deficiencies could be related to the California state staffing standard, which is much lower than the standard (4.1 HPRD) recommended by the CMS study (CMS, 2001). In our sample, there were only a small number of nursing homes that consistently provided 4.1 or higher HPRD over the 5-year period, so we could not conduct a statistical analysis of these facilities. Even the nursing homes that consistently met the state standard had an average of 0.57 RN HPRD, which is 24% lower than the 0.75 RN HPRD recommended in the study for CMS. Still another reason for the inconsistent findings could be the wide variations in RN and total nurse staffing levels in the nursing homes that consistently met the state standard (median 3.7; range 3.20–11.93).

Unlike the RN to total staffing ratio, a higher RN to LVN ratio was consistently significant to quality of care, regardless of overall staffing level, although its marginal effect was relatively small. Munroe (1990) reported similar findings: A 25% increase in the RN to LVN ratio led to a decrease of 0.53 in the number of health-related deficiencies. No recent study examining the ratio was found. According to the OSCAR data report (Harrington et al., 2005), the variation among the states in the ratio of RN to LPN HPRD was 14-fold, from 0.1 in Georgia to 1.43 in Arkansas. The scopes of practice of RNs and LPNs often overlap and are not distinct in nursing homes. Registered nurses, with their higher education levels, however, may have better knowledge and skills to assess and monitor changes in patient condition and develop proper interventions in time, and also have better leadership and supervisory skills (Canadian Nurses Association [CNA], 2004; Ottem & Overton, 2000). Further investigations using other quality measures and other data sets are necessary to examine the impact of a rich RN mix in licensed nursing staff on quality of care in nursing homes. A large-scale direct observation study would also be beneficial to better understand the measurable contributions of RNs to the physical and psychosocial outcomes of residents.

Lastly, the organizational profiles of nursing homes meeting the standard (NHMS) differed from those of nursing homes not meeting the standard (NHNMS), which is consistent with the findings in the existing literature (Bostick et al., 2006; O'Neill et al., 2003). NHMS with a higher RN mix in total staff and also in licensed staff received fewer total deficiencies than NHNMS. NHMS were more likely than NHNMS to be small nonprofit homes taking care of Medicare and self-pay residents. In the multivariate analysis, the proportion of Medicare residents and the occupancy rates were positively related to both deficiencies in NHMS, but they were negatively related to the deficiencies in NHNMS. Finally, no market characteristics were significantly related to serious deficiencies across NHMS and NHNMS. Further studies are required to examine the factors affecting serious deficiencies.

There is a lack of consensus on effective nurse staffing mix in nursing homes (Spilsbury & Meyer, 2001). Currently, federal and state nursing home regulations on the overall staffing mainly focus level of nursing homes and have only minimal or no specified regulations on level or mix of RN staffing. Federal regulation requires a licensed nurse on hand 24 hours a day, but it does not differentiate RNs from LPNs and also disregards the number of residents (CMS, 2001). Most states' regulations on nurse staffing in nursing homes are based on total nursing hours, and they often do not specify the number of hours for each type of licensed nurse (RN or LPN; Mueller et al., 2006).

Given our findings of the significant relationships of RN staffing mix to quality of care in nursing homes, nurse staffing mix as well as level may need to be considered in developing requirements for the appropriate staffing of nursing homes. Simple

information about the relationship of RN mix to better quality, however, may not motivate nursing homes to change their behaviors in planning their nursing personnel. More cost-effectiveness studies and simulation studies are necessary to inform nursing homes of different options of staffing mix and level and their financial impacts. A follow-up, large-scale field-testing study may also help demonstrate the feasibility of translating evidence from the economic analysis into practice (Newbold, 2007; Schnelle, 2004; Zhang, Unruh, Liu, & Wan, 2006). Such studies may illustrate how higher nursing productivity can compensate for the labor cost increase due to a rich RN staffing mix, by saving costs from adverse events and improving patient outcomes (CNA, 2004).

This study has limitations. We analyzed data from California's freestanding nursing homes, so the findings may not be generalized. An inspector bias (Lee, Gajewski, & Thompson, 2006; U.S. General Accounting Office, 2004) may also exist due to variations in the training and experience of state surveyors as well as in the survey process across survey regions in the state. Quality of care was measured only by regulatory deficiencies. Properly risk-adjusted patient outcomes may be better measures for quality of care. Nurse staffing mix is a structural variable, and most of the variables in deficiency counts are also structural variables. Further studies are necessary on the relationships not only among structural variables but also among structural, process, and outcomes variables examining the quality of nursing home care. In addition, the relationships between nurse staffing mix and deficiency count in this observation study may not be causal. The experience and commitment of the nursing staff and the role of various other personnel may also affect the quality of nursing care. Although we adjusted for time-invariant institutional factors, time-variant factors such as turnover rate or agency nurse use (Castle & Engberg, 2007) may also affect quality of care.

To our best knowledge, however, this is the first study that demonstrates the interaction effects of nurse staffing mix and levels on quality of care in nursing homes over time using recent large panel data. Further studies are needed to test the evidence found in this study. Such studies can help policymakers and nursing home administrators make better informed decisions on nurse staffing and nursing work environment in nursing homes, thereby ultimately improving the safety and well-being of nursing home residents.

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