Final Progress Report

Title: Nurse Staffing Policy, Hospital Occupancy, Market Structure, and Patient Outcomes

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Abstract

Purpose

The goal of this award was to prepare the candidate for an independent health services research career. The study aim was to determine the effects of California's patient-to-nurse ratio mandate on outcomes.

Scope

California was the first state to mandate hospital patient-to-nurse ratios. Policymakers in other states are interested in the effect of the policy.

Methods

This observational study implemented difference-in-differences based approaches to determine whether 1) staffing and skill mix (registered nurses as a proportion of all licensed nurses) changed under California's staffing mandate, 2) whether these changes varied by safety net hospital status, and 3) whether staffing changes resulted in better patient outcomes. Hospital and patient administrative data for California and comparison hospitals were used. I estimated the effects of the nurse staffing mandate with fixed-effects regression models.

Results

Staffing increased significantly before and after the mandate in California hospitals compared to similarly situated hospitals without a mandate. Skill mix did not decline as feared. Safety net hospitals benefited significantly from the mandate with the greatest gains coming for the most understaffed hospitals. Compared to Pennsylvania, where there is no mandate, California's staffing improvements were significantly associated with lower surgical mortality and failure to rescue.

Key Words: nursing, staffing, ratios, California, policy, law

Purpose

The primary goal of this Career Development Award was to prepare the candidate for a career as a successful independent investigator devoted to health policy outcomes research. Specifically, the Award provided the candidate an opportunity to 1) engage in intensive study and research training focused on the statistical methods and analytic techniques required to empirically evaluate the effect of health policies and regulations on quality of care-sensitive patient outcomes and 2) conduct an independent research project under guided mentorship.

The specific aims of the research was to determine whether 1) staffing and skill mix (registered nurses as a proportion of all licensed nurses) changed under California's staffing mandate, 2) whether these changes varied by safety net hospital status, and 3) whether staffing changes resulted in better patient outcomes.

Scope

In 1999, then California Governor Gray Davis signed Assembly Bill 394 (AB 394) into law requiring the California Department of Health Services to adopt regulations establishing minimum nurse-to-patient staffing ratios for hospitals. The intent underlying California's minimum nurse staffing ratios was to improve quality of care, patient safety, and nurse retention. Since the passage of AB 394, there has been a significant, though not entirely consistent, body of evidence demonstrating the link between lower nurse staffing levels and unfavorable quality of care outcomes. Higher ratios of patients per nurse, particularly of registered nurses, have been associated with a number of unfavorable patient outcomes, such as higher surgical mortality and higher complication rates due to errors. Higher patient workloads for nurses have also been linked to unfavorable nurse outcomes (e.g., job dissatisfaction and burnout) that are associated with retention problems.

Following the passage of AB 394, the California Department of Health Services held hearings and invited stakeholders to make recommendations regarding which nurse-to-patient ratio minimums should be mandated. In 2002, California announced the final ratios, which were initially to be implemented in July 2003 but did not go into effect until January 1, 2004. The regulations specified staffing ratios for different specialties. For example, minimum staffing in general medical and surgical units were set at one licensed nurse for six patients for an 18-month phase-in period, and then further reduced to one nurse for five patients. Hospitals could staff above these ratios but not below.

One feature of AB 394 is that, with few exceptions, hospitals comply with the mandate by staffing up to 50% of their required staff with licensed vocational nurses (sometimes called licensed practical nurses). Licensed vocational nurses have less training and a more restricted scope of practice than registered nurses and generally are paid less. Hospitals with higher proportions of licensed vocational nurse staffing (referred to as lower skill mix) have been shown to have poorer patient health outcomes. Although the mechanism allowing for staffing with up to 50% licensed vocational nurses provides a means for hospitals in markets where registered nurses are in short supply to meet the mandate's requirements, it may undermine the legislative intent of improving patient safety by increasing nurse staffing. One concern expressed in the debate before implementation was that the mandate created an incentive to

shift employment to lower skilled nurse labor and hospitals would potentially meet the mandate's requirements by hiring predominately licensed vocational nurses as opposed to registered nurses. The resulting effect of California's staffing mandate on skill mix is an important consideration for policymakers in other states as they plan how best to design similar staffing legislation. I set out to address this gap by conducting a longitudinal study with multiple comparison groups of U.S. hospitals to assess the effect of AB 394 on staffing and skill mix from 1997 to 2008.

Another concern was that California's mandate would burden safety-net hospitals (those serving large proportions of uninsured patients) while not leading to improved staffing or inducing them to reduce their skill mix. Safety-net hospitals are increasingly susceptible to challenging economic environments. This has raised concerns about the extent to which safety-net hospitals could respond to economic and policy challenges like a staffing mandate even though the initiative was aimed at improving the quality and safety of care. Another part of my analysis examined the differential effect of California's staffing mandate on safety-net and non-safety-net hospitals.

The final issue is the affect of California's mandate on patient outcomes. Although cross-sectional work has shown that better nurse staffing is associated with better outcomes, debate has continued about whether and to what extent better patient outcomes in California hospitals resulted from the staffing legislation — a key issue for policymakers going forward. I set out to compare the effects of staffing changes before and after implementation of California's patient-to-nurse ratio mandate on changes in inpatient surgical mortality and failure to rescue (i.e., death following a complication for surgical patients) in California hospitals versus hospitals in states without a similar patient-to-nurse ratio mandate.

Methods

I used California's nurse staffing mandate as a 'natural experiment' to examine the effect of the law on hospital outcomes (staffing and skill mix) and patient outcomes.

Staffing and skill mix analysis.

For the analysis of the effect of the mandate on staffing, I analyzed hospital registered nurse staffing, nursing skill mix, and a number of control variables in all adult, non-federal, acute care hospitals in the United States in 1997-2008. The primary data source was the American Hospital Association Annual Survey for the years 1997 through 2008.

Outcomes. Two dependent variables were constructed to evaluate the effect of the law: a staffing measure reflecting the ratio of registered nurses to patients and a skill mix measure reflecting the mix of registered nurses and licensed practical nurses. The staffing variable was constructed as a workload ratio of the productive nursing hours per patient day based on the full-time equivalent registered nurse positions per adjusted patient day and using a standard conversion. Skill mix — the ratio of registered nurses to total licensed nurse staffing — was evaluated as an outcome to determine whether California hospitals reduced their skill mix in response to AB 394. Skill mix was calculated as the number of registered nurses divided by total nursing staff (registered nurses and licensed vocational nurses).

Covariates. In models testing the specific effects of the mandate, I included multiple controls to account for the variance in staffing and skill mix. Hospital structural characteristics drawn from the 1997-2008 American Hospital Association data were chosen as controls based on their previous use in staffing research and their potential to affect nurse staffing. Variables included hospital bedsize, ratio of resident/fellow physicians to beds, occupancy rate, ownership status, Medicare case-mix index, percent of admissions with Medicare as the primary payer, the percent of admissions with Medicaid as the primary payer, state registered nurse supply, and the Herfindahl-Hirschman index as a proxy for market competition.

Analytic approach. I constructed a longitudinal panel data set of hospitals accounting for hospital consolidations and mergers for the time period 1997-2008 for analysis. Variables contrasting California hospitals with hospitals from all other states excluding California were constructed for comparison over time.

I used propensity score matching to match California hospitals with comparable hospitals from all other states excluding California. The propensity score, based on the baseline year of 2001 (the year prior to the announcement of the ratios faced by hospitals), was the probability of an individual hospital being a California hospital conditional on observed covariates. I assessed standard balance diagnostics to find the set of comparison hospitals that provided the best comparison group for the California hospitals. I also compared California hospitals to comparison groups of hospitals including all U.S. hospitals as well as (separately) the state hospital populations of 1) Florida, 2) New York, 3) Pennsylvania, and 4) Texas.

For all comparisons, time-period variables were created to indicate the three key time intervals: 1) prior to 2002, the period before the final ratios were released, 2) 2002-2004, the post-announcement period but prior to when the California Department of Health Services regulations went into effect, and 3) 2004 and beyond, when the California Department of Health Services regulations implementing the ratios pursuant to AB 394 went into effect. These intervals are referred to as the 'Pre-announcement', 'Announcement,' and 'Implementation' periods, respectively. I was primarily interested in determining if there was an Announcement effect (i.e., if upon knowing the ratios they would face, hospitals changed their staffing and skill mix) and if there was an Implementation effect (i.e., the effect due to the ratios actually being implemented). The Implementation effect was assessed by contrasting it with the Pre-announcement period for an overall effect and, alternatively, by contrasting it with the Announcement period to determine the effect that was over and above any Announcement effect.

Separate hospital-level regression models were used to estimate the effect of the California mandate compared to each comparison group. To determine the effect of the mandate on registered nurse staffing and skill mix, I estimated models that included interactions between the variable indicating whether the hospital was a California hospital or not and the three time period variables (Pre-announcement, Announcement, and Implementation) and evaluated the sign, size, and significance of the coefficients for these interaction terms.

Safety net hospital analysis.

Once staffing and skill mix had been examined using comparison states as a contrast to California, I then focused on comparing the effect of the mandate on safety-net and non-safety net hospitals in California. For this analysis, I used data from the Annual Hospital Disclosure data files from the California Office of Statewide Health Planning and Development (OSHPD) for the years 1998 to 2007. The OSHPD data provide information on all California hospitals, including detailed staffing information and hospital characteristics.

Outcomes. The primary outcomes were nurse staffing and skill mix. The measure of nurse staffing was the number of inpatient medical-surgical patients per licensed nurse. This measure was obtained from the OSHPD hospital files, which supply detailed information on licensed nurses' (both registered nurses and licensed vocational nurses) hours and patient days across revenue centers, including medical-surgical units. I then converted nurse hours per patient day to patients per nurse using a standard formula to make the staffing measure consistent with the legislation of interest. Skill mix in each hospital was measured as registered nurses' hours divided by total licensed nursing staff hours (the sum of registered nurse plus licensed vocational nurse hours).

Safety-net status. Safety-net hospitals were defined based on each hospital's average burden of uncompensated care in the years before the mandate was implemented in 2004. To calculate a hospital's total uncompensated care, I added bad debt and charity care, adjusting this sum by the hospital's cost-to-charge ratio. Those hospitals in the top decile, based on the ratio of uncompensated care to total expenses, were considered to be "high-burden" hospitals, or safety-net hospitals. Public city and county hospitals—significant providers of care to the vulnerable poor—were also counted as safety-net hospitals. Under Section 17000 of California's Welfare and Institutions Code, counties are responsible for the care of low-income uninsured residents who have no other source of care.

Covariates. Although the fixed-effects modeling approach controlled for all time-invariant characteristics of the hospitals in the panel data, I included factors that could be jointly related to staffing and to being a safety-net hospital that are not stable over time. These included number of beds, level of technology, net patient revenue per patient day, cash on hand as a percentage of total revenue, the Herfindahl-Hirschman index (HHI) as a proxy measure for market competition, the Medicare area wage index, county-level annual unemployment rate, annual hospital-level Medicare case-mix index, and the share of Medicare and Medicaid inpatient days out of all inpatient days.

Analytic approach. I constructed a balanced longitudinal data set for the time period 1998 to 2007 for analyses, accounting for hospital consolidations and mergers by combining data before the mergers and dropping those hospitals that closed during the observation interval.

I created a series of dummy variables and interactions to evaluate the effect of the mandate on staffing and skill mix and the difference in this effect by safety-net status. I also labeled those hospitals with patient-to-nurse ratios at or below that required by the mandate (less than or equal to 5:1) before the ratios were released in 2002 as compliant and those hospitals with patient-to-nurse ratios exceeding 5:1 as noncompliant. Because some hospitals —as many as half, by some estimates—were already in compliance with the mandated staffing

levels, I expected that the legislation would have less of an effect on those hospitals and would result in little or no change in staffing. Hospitals with patient-to-nurse ratios that exceeded the mandated level before the release of the final ratios would be expected to change and to change the most for those hospitals furthest from the mandated level initially.

I used hospital-level fixed-effects regression models to estimate the effect of nurse staffing mandate on California safety-net hospitals compared with non-safety-net hospitals. To evaluate the effect of the law on safety-net versus non-safety-net hospitals, I tested the interactions between the time period and safety-net status. I also examined models that included an interaction term that allowed me to determine whether the effect differed depending on the initial degree of noncompliance.

Patient outcomes analysis.

For the patient outcomes analysis, I examined the effect of changes in staffing on changes in patient outcomes in California hospitals compared to hospitals in Pennsylvania, a state without a similar mandate. Using a difference-in-differences framework with data from 1998-2006, I estimated the effect of the policy on staffing levels with the year 2002 (i.e., when the final ratios were released) as the implementation time-point. I then estimated the effect of staffing level changes on changes in risk-adjusted 30-day inpatient surgical mortality and failure-to-rescue rates.

Outcomes. The patient outcomes, 30-day inpatient surgical mortality and mortality after a complication (failure to rescue), had two forms in the analysis. At the hospital-level, I calculated continuous 30-day risk-adjusted inpatient mortality and failure to rescue rates. At the patient-level, 30-day inpatient mortality was a binary variable indicating inpatient death for a given individual; 30-day inpatient failure to rescue was a binary variable indicating inpatient death following a complication for a given individual.

Analytic approach. I used a differences-in-differences approach with longitudinal data to estimate the relationship between nurse staffing changes and changes in 30-day inpatient mortality and failure to rescue at the hospital-level. I first calculated the risk-adjusted mortality and failure to rescue rates for each hospital in each year. I used Elixhauser's risk-adjustment approach (excluding fluid and electrolyte problems and coagulopathy) for comorbidities, age, transfer status, and Diagnostic-Related Groups based on work by Silber and colleagues. I then took the change in adjusted mortality and failure to rescue rates from the pre-implementation to post-implementation periods and regressed these (independently) against the change in staffing over the same time interval. A difference model allowed me to quantify the effect of the staffing changes on outcomes for California hospitals compared to hospitals in Pennsylvania where there was no staffing mandate. This approach accounted for time-invariant unobserved characteristics, time trends affecting all hospitals, and measured patient risk factors as potential sources of confounding.

Results

Staffing and skill mix analysis

The comparison of staffing in California to a set of otherwise similar hospitals across the nation showed consistent evidence of an effect from the mandate.

The “Implementation” effect above and beyond the “Announcement” period suggests that the policy resulted in roughly an additional half-hour of productive nursing per adjusted patient day beyond what would have been expected in the absence of the policy (range 0.43 [compared to Florida] - 0.59 [compared to all hospitals in other states]). There was no evidence suggesting that the mandate resulted in any negative changes in skill mix. On the contrary, skill mix improved in California, keeping pace with the secular trend in similar hospitals across the nation.

Safety net hospital analysis

Despite concerns, patient-to-nurse ratios fell significantly in both safety-net and non-safety-net hospitals under the mandate. There were differences, however, in the effect on staffing based on safety-net status as well as the degree of initial noncompliance. For initially compliant non-safety-net hospitals, the mandate had the effect of reducing patient-to-nurse ratios by 0.72 patients per nurse. The effect was smaller for initially compliant safety-net hospitals (a reduction of 0.46 patients per nurse). Though the hospitals that began with the worst nurse staffing improved most as the mandate intended, there was a statistically significant difference in the magnitude of the change between safety-net and non-safety-net hospitals (0.27 patients per nurse, $p=0.02$).

Patient outcomes analysis

The results for this analysis are not finalized. Initial analysis suggests that, compared to Pennsylvania hospitals, a change of one fewer patient per nurse in California hospitals was associated with about five fewer surgical deaths per 10,000 surgical patients (0.48, SE=0.18, $p=0.008$) and 24 fewer deaths following a surgical complication (2.4 (0.6), $p<0.001$) per 10,000 surgical patients.

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