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Explanations for Persistent Nursing Shortages

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Explanations for Persistent Nursing Shortages*

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Abstract

This paper contributes to the economics literature on nursing market shortages by putting forward two new models that suggest three new explanations for perceived nursing shortages. The first model focuses on hospitals hiring both permanent staff nurses and temporary contract nurses. It shows that hiring both classes of nurses can represent optimizing behavior, and that an interesting kind of perceived nursing shortage results from this dual hiring. The second model posits two classes of hospitals, "premier" and "funds-constrained," and generates two distinct kinds of nursing shortages: economic shortages, involving unfilled, budgeted positions, and "noneconomic" professional standards shortages. We believe that the perceived existence of professional standards shortages may be a significant explanation for the widespread impression of persistent shortages.

KEYWORDS: nursing shortage, nurse labor supply, hospital models, monopsony, vacancies, occupational wage distributions, efficiency wages, contract nurses

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I. INTRODUCTION

A long history of concern about shortages of nurses goes back at least to the 1950s (McKibbin, 1990). We present empirical evidence apparently supporting these concerns, and argue that existing explanations in the economics literature do not satisfactorily explain these persistent shortages.

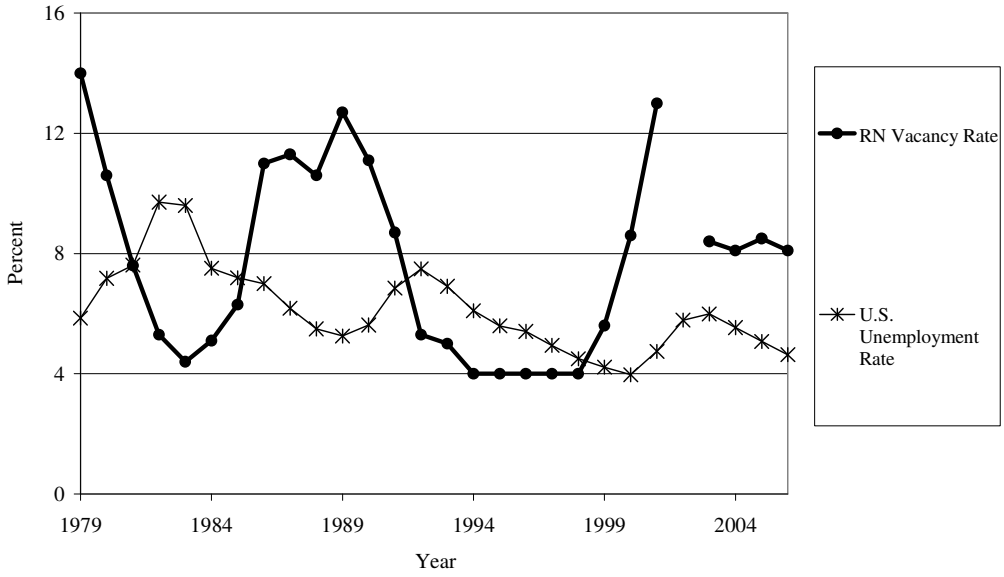
This paper sets out three additional explanations for shortages of registered nurses (RNs) embodied in two models we develop. First, the use of temporary contract nurses can explain hospitals having persistent, budgeted vacancies for *permanent staff* nurses. While most economists would not describe these vacancies as true economic shortages, they give the appearance of shortages. Second, under special assumptions (limited budgets for a set of "funds constrained hospitals", efficiency wages paid by "premier" hospitals, and limitations in the supply of trained nurses in a local labor market), true economic shortages can result at the funds constrained hospitals. However, these shortages are likely to be temporary. Thus, this phenomenon cannot explain persistent shortages, but provides more fine-grained microeconomic foundations for the dynamic shortages highlighted in Feldstein (2003) and discussed below. Finally, we argue that the existence of what we call "professional standards" shortages is likely to be a large contributor to the perception of widespread, persistent shortages. We present some partial empirical support for these three explanations, describe further potential empirical tests, and discuss policy implications.

II. EVIDENCE FOR PERSISTENT NURSING SHORTAGES

The empirical evidence for persistent nurse shortages is somewhat inadequate, despite the claims of some hospital spokespersons and efforts to use public funds to recruit and train nurses. The U.S. Bureau of Labor Statistics (BLS) does not collect vacancy data by occupation. Thus, the only national source for such vacancy data is a survey conducted by the American Hospital Association (AHA). The Secretary's Commission on Nursing (U.S. Department of Health and Human Services. 1988. Vol.II, p.IV-6) notes that "the American Hospital Association's data on hospital R.N. vacancies,… are the most extensive of their kind…" However, these existing data for nurses are not part of larger data sets with comparable vacancy rates for a large range of occupations.[1]

[1] Moreover, there are strong reasons to question the validity of the vacancy rates calculated by the AHA. For example, the response rate for the 2007 AHA Survey of Hospital Leaders (AHA 2007b) was only 17%. The hospital leaders who complete these surveys may be more concerned with vacancy rates at their institutions than the administrators who do not complete the surveys, thus introducing bias in the estimated vacancy rate. In response to a Congressional request to

Figure 1: Registered Nurse Vacancy Rates and Tightness in the Labor Market



Sources for RN vacancy rates: 1979-2001: Feldstein (2003, p. 264); 2003-06: American Hospital Association (2004, 2005, 2006, 2007b).
Source for civilian labor force unemployment rate data: Bureau of Labor Statistics, with monthly rates averaged by year by the authors.

Figure 1 presents data on vacancy rates for registered nurses in hospitals between 1979 and 2006.[2] Over this 27-year period, the RN vacancy rate fluctuated between 4 and 14 percent. Although the surveyed hospital administrators are asked about unfilled vacancies for which the hospital is recruiting, we are skeptical whether their responses accurately reflect the state of

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investigate "whether there is… a current nursing shortage," the United States General Accounting Office concluded that "(n)ational data are not adequate to describe the nature and extent of these potential nurse workforce shortages, nor are data sufficiently sensitive or current to allow a comparison of the adequacy of the nurse workforce size across states, specialties, or provider types" (U.S. General Accounting Office, 2001, p. 1). Further, they note that, "(c)aution must be used when comparing vacancy rates from different studies," since "not all studies identify the method used to calculate rates" (p. 4). For a more detailed discussion of empirical problems with measuring various concepts of nursing shortages, see Goldfarb, Goldfarb, and Long (2008).

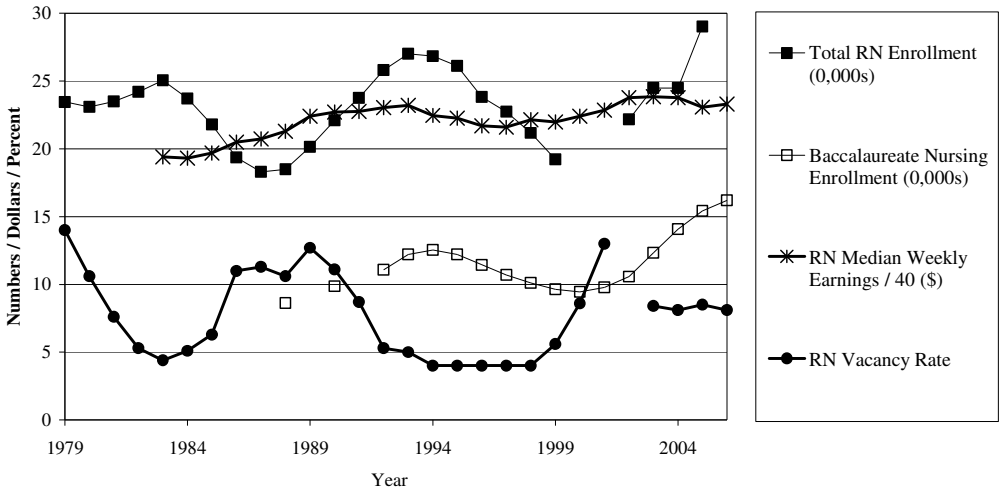
[2] The data for the years 1979-2001 are based on Feldstein (2003). The underlying sources for his data are American Hospital Association surveys of hospital administrators (see Feldstein 1994) along with additional data compiled by Peter I. Buerhaus and Douglas O. Staiger for more recent years. Feldstein's (2003) Figure 22.1 provides a time-series graph of nursing vacancy rates with each year's vacancy rate shown numerically. However, during the period 1994-1998, where his graph appears to shows a constant level of nursing shortages, only four of the five years are labeled as 4.0%. We assume, based on the graph, that the vacancy rate in the missing year is also 4.0%. Although the underlying source of the data compiled by Buerhaus and Staiger is not listed, it appears to mostly come from American Hospital Association surveys. The data for the years 2003 to 2007 were compiled by us using the same source: American Hospital Association surveys of hospital administrators.

their "unfilled" vacancies, given the use of contract nurses, which we discuss below. Nonetheless, these data do provide suggestive evidence of persistent high shortage rates occurring periodically. Moreover, there is a widespread perception that nursing vacancies are large; Buerhaus, Staiger, and Auerbach (2004) report that 82 percent of RNs and 81 percent of doctors "perceived shortages of RNs in the hospitals where they worked or admitted most of their patients." Comparing RN vacancy rates to unemployment rates suggests the relationship an economist would expect: RN vacancy rates are generally countercyclical, with higher vacancy rates occurring when overall labor market unemployment is low.

If the market for RNs were competitive, we would expect wages to rise in periods of more acute shortages. Additionally, we might expect an increase in the number of persons getting nursing training during periods of shortages in expectation of growth in wages. Figure 2 plots RN vacancy rates against RN weekly wages and nursing program enrollment during this period. There is a clear pattern reflected in these data, reflecting substantial lags between vacancies, wages, and RN enrollment. Following increases in vacancy rates, wages rise, but with a lag of two to three years. Following increases in wages, RN enrollment rises, but again with a lag of around two years. As a result, the raw correlation between vacancy rates and total RN enrollment is *-0.43* (i.e., enrollment is low when vacancies are high), while lagging the vacancy rates by 4 years yields a correlation of *+0.75*. These results imply that there is a substantial lag in information being transmitted to potential entrants to nursing about the shortages. However, the responsiveness of enrollment may also be limited by constraints on the ability or willingness of nurse training institutions to expand.[3]

[3] A significant portion of nursing education occurs in publicly-funded institutions of higher education, which are often budget-constrained in their ability to expand. In recent years, registered nurse training programs have turned away sizable percentages of apparently-qualified applicants, seemingly because of lack of places. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO), for example, notes that "(w)hile there are fewer nursing students than will be needed to meet the increasing demand for professional nurses, there are paradoxically, more than can be accommodated by the numbers of nursing faculty members…In all, nursing schools turned away 5,000 qualified baccalaureate program applicants in 2001" (JCAHO, 2002, p. 28). A Washington Post story about a nursing shortage in Maryland and a proposed legislative initiative to cope with it asserted that "Maryland's 25 nursing programs, where enrollment has climbed almost 50 percent since 2001, routinely reject qualified applicants because they do not have enough instructors." (Levine, 2007, p. B-1). Another recent press report asserted that "nursing schools turned away 42,866 applicants" in 2007 (Parade, January 6, 2008). Ironic, and relevant to the cyclicality of perceived nursing shortages, is the fact that several decades earlier the concern was with declining enrollments in nursing education programs apparently in part because of declining interest in such training. Thus, the New England Journal of Medicine (Aiken and Mullinix, 1987) noted that "(s)ince 1983, enrollments in nursing schools have dropped by 20 percent…The number of new nurses graduating annually is predicted to fall from a high of 82,700 in 1985 to 68,700 or lower by 1995….The country's demographic profile is

Figure 2: Registered Nurse Vacancy Rates, Real Wages, and Nursing Enrollment



Source for total RN enrollment: 1979-1999: U.S. Department of Health and Human Services (undated) based on National League for Nursing data; 2002-2005: National League for Nursing (2006).
Source for baccalaureate nursing enrollment: American Hospital Association (2007a) and American Association of Colleges of Nursing (2006).
Sources for RN vacancy rates: 1979-2001: Feldstein (2003, p. 264); 2003-06: American Hospital Association (2004, 2005, 2006, 2007b).
Source for RN median weekly earnings: 1983-2003: United American Nurses (2005) based on CPS data; 2004-06: Authors' calculations based on June CPS for full-time RNs (Converted to 2005 dollars using CPI-U).

One of the models we develop below highlights the importance of temporary nurses. "Use of temporary nurses is no longer a stop-gap measure but has become a way of life for many hospitals. Reacting to several years of nurse vacancy rates in the 7% to 10% range, hospital executives surveyed said they use temp nurses for an average of 5% of all nursing hours" (PriceWaterhouseCoopers, 2007, p.1). While time series evidence on changes in the use of temps is unavailable, data from various sources appear to show growing importance. For example, Sullivan (1989) notes that the 1983 AHA hospital survey indicated that 21 percent of responding hospitals had made use of temporary agency registered nurses, while First Consulting Group (2001) reports that "56% [of hospitals] are using agency or traveling nurses to fill vacancies" (p. 5). May, Bazzoli, and Gerland (2006) report 24 of the 32 hospitals in their survey using temporary staff to ameliorate short-term shortages. These reports sometimes seem to imply that the use of temporary nurses does not eliminate the underlying shortage. For example, the First Consulting Group survey question reads "What percentage of your *RN vacancies* are you currently filling with agency or traveling nurses?" (p.39) Such framing does not appear to allow that vacancies are non-existent when temporary nurses fill the positions. A nurse administrator we spoke with

partly responsible…However, interest in nursing as a career has fallen precipitously among college freshmen" (Aiken and Mullinix, 1987, pp. 644).

indicated that her hospital had a shortage consisting of the shortfall in staff RNs, even though this gap had been partly filled by contract nurses.

These reports also bemoan the (perceived) high cost of temporary nurses. "Temporary nurses are often compensated at higher levels, with the basic per-diem mark-up ranging from 25% to 40% above the average employee's wage. This translates into $250,000 to $400,000 that the hospital is paying just for an agency's service and overhead costs for every $1 million spent on supplemental staffing." (PriceWaterHouse Coopers (2007) citing research from Green et al. (2004)). However, for the marginal nurse hour, it is not clear if these additional costs are higher than would be paid for permanent staff. Since many of these shifts would be otherwise filled by permanent nurses working overtime hours (earning time-and-a-half pay) or given bonuses for working unfavorable shifts (and may have received hiring bonuses when hired), a temporary nurse may be a bargain.[4] An additional nonwage cost of permanent employees involve fringe benefits such as vacation time and health insurance, which might easily run as high as 30 percent of average payrolls.[5]

Even if these nursing shortages reflect true economic shortages, are such shortages unusually acute relative to other occupations? Unfortunately, no national data source can directly answer this question. BLS does not collect any systematic data on vacancies by occupation. However, its Job Openings and Labor Turnover Survey asks establishments their number of vacancies each month, and these data can be aggregated by industry. This figure can then be divided by the industry's total employment as reported in the BLS's Current Employment Statistics to compute a vacancy rate. The average vacancy rates for the period from December 2000 to September 2007 are shown in Table 1. The "Health care and social assistance" industry has the highest rate of vacancies amongst the 18 major industry groups. Of course, this industry is going to be comprised of doctors, nurses, janitors, etc. -- so, the nurse vacancy rate could be much higher or lower.

The rest of this paper focuses on the behavior of hospitals in hiring nurses. This focus on the hospital sector is warranted, as most nurses (roughly 60%) are employed by hospitals (AHA 2007a). Moreover, much of the concern regarding nursing shortages is stimulated by pleas from hospital leaders (for example, see American Hospital Association 2007c). For the theoretical discussion that follows, it is important to note that the share of local labor markets dominated by monopsonist hospitals is small; 76% of hospitals are located in MSAs/CMSAs, and these urban areas tend to be served by more than one hospital (Hirsch and

[4] For example, First Consulting Group (2001) notes one hospital paying permanent RNs $6,000 bonuses to work undesirable shifts.

[5] Benefits comprised 29.3% of total compensation for registered nurses in March 2008 (U.S. Department of Labor, Bureau of Labor Statistics, 2008).

Schumacher, 2005). Thus, the labor markets in which most nurses work will be at least somewhat competitive.

Table 1: Vacancy Rates by Major Industry Group

Major Industry Group	Average Vacancy Rate, Dec. 2000 - Sept. 2007
Health care and social assistance	4.0%
Accommodation and food services	3.7%
Professional and business services	3.6%
Arts, entertainment, and recreation	3.0%
Information	2.8%
Finance and insurance	2.8%
Other services	2.5%
Transportation, warehousing, and utilities	2.4%
Retail trade	2.4%
Real estate and rental and leasing	2.0%
Wholesale trade	2.0%
State and local Government	2.0%
Educational services	1.9%
Durable goods manufacturing	1.8%
Construction	1.8%
Nondurable goods manufacturing	1.7%
Federal Government	1.6%
Natural resources and mining	1.5%

Source: Bureau of Labor Statistics, Job Openings and Labor Turnover Survey and Current Employment Statistics

There is little empirical evidence relating hospital nurse shortages to hospital characteristics. However, the existing evidence is consistent with the prediction of one of our models below, that more funds-constrained hospitals should have larger shortages. Seago et al. (2001) consider a sample of acute care hospitals that either did or did not experience a (self-reported) nursing shortage in 1990 and 1992, based on data from American Hospital Association (AHA) surveys. The authors investigated whether environmental, patient, and institutional characteristics were associated with the hospital reporting a nursing shortage. In a cross-sectional probit model using the 1990 data, they find that hospitals with a higher share of Medicaid discharges, more acute case loads, a higher percentage of nonwhites, and hospitals in the Midwest and South were more likely to report a shortage. Another analysis was run comparing hospitals reporting a shortage in both 1990 and 1992 with those reporting either no shortage, or a shortage in only one year. Percent Medicaid discharges, percent

nonwhite, and hospitals in the South were again found to have higher likelihoods of reporting a shortage. Since a higher Medicaid caseload is likely to be correlated with financially-constrained status for the hospital,[6] the Seago et al. evidence suggests shortages are more likely at financially constrained hospitals.

III. LIMITATIONS OF EXPLANATIONS IN THE LITERATURE

A sizable economics literature investigates the notion of shortages in nursing markets. In a recent paper, Burkett (2005) identifies several competing explanations: monopsony, relative wage rigidity, and incomplete contracts. Additional explanations can be found in several health economics texts (Folland, Goodman, and Stano, 2004; Feldstein 2003) and in McKibbin's 1990 monograph on nursing shortages. As we explain below, none of these accounts seems definitive and complete.

Monopsony. A longstanding literature (Burkett (2005) cites Yett (1970) as introducing the idea) applies the monopsony model to the market for nurses.[7] A firm facing an upward-sloping labor supply curve will, by making an employment decision, also be affecting the wage it must pay. The firm has an incentive to choose an employment level where its marginal factor cost, which is above the wage, equals its marginal revenue product. At this solution, the firm would willingly hire more labor at the wage it is offering than is supplied at that wage; thus, there are unfilled openings ("vacancies"), suggesting a "shortage." Lane and Gohmann (1995) characterize the monopsony model as "(P)robably the most popular model to explain shortages in health care markets" (p. 645). Attempts to apply the monopsony model include Sullivan (1989) and Currie, Farsi, and MacLeod (2005), among others.

The monopsony model has a number of weaknesses as an explanation for allegedly widespread nursing shortages. First, as Burkett (2005) notes, monopsony power "is likely to be relatively weak in areas with a high density of suitable employers" (p. 586). Moreover, Hirsch and Schumacher (1995, 2005) provide empirical evidence that the monopsony model does not adequately explain the behavior of nursing markets; nursing wages do not seem to rise with population or hospital density. Of course, as is often the case in empirical economics, other researchers disagree.[8] We suggest a further very serious difficulty with the monopsony model: its seeming inability to generate *budgeted* vacancies. The so-called vacancies produced by the monopsony model ("I would

[6] See footnote 28 below for additional supporting evidence.
[7] For other early treatments of monopsony in nursing markets, see Hurd (1973) and Link and Landon (1975).
[8] For example, Staiger, Spetz, and Phibbs (1999) and Currie, Farsi, and MacLeod (2005) find evidence favoring monopsony.

hire more at this wage if I could, but I know I cannot") *are unlikely to represent actually-budgeted positions*. After all, why budget for positions that you know by the nature of the supply conditions you face, you cannot fill? McKibbin (1990) notes that "(V)acancy rates represent the portion of *budgeted* positions for RNs which are unfilled" (McKibbin 1990, p.4; italics added). Thus, the "vacancies" allegedly explained by the monopsony model are not the ones the data actually try to measure.[9]

A Selection Argument for "Low" Wages. An alternative explanation for the attraction of paying "low" wages has recently been offered by Heyes (2005). The population of potential nurses consists of individuals who have a "vocation" for nursing, and those who do not. Those with a vocation are particularly devoted to doing a good job, going beyond the call of duty and administering treatments with "tender loving care" (p. 562). Under plausible assumptions, higher wages result in a pool of nurses with lower proportions of those with a vocation, so that "increasing wages reduces the average quality of applicants attracted" (p. 561). That is, increasing wages "might attract the 'wrong sort' of people" (p.561). This reverse efficiency wage mechanism, if recognized by employers, might make wages "sticky *up*wards" (p. 561). An underlying condition is imperfect contracting, that "the quality of care given by a particular nurse may not be observed by the principal (or may not be verifiable by a third party)" (p.562). Moreover, the ability of the employer to use screening techniques to "allow the individual applicant's vocation to be assessed" (p. 563) is ignored in the modeling.

The Heyes model assumes a single buyer of nurse services (a National Health Service). In a world with competing buyers of nursing services, a higher wage offered by one hospital is likely to attract away nurses from competing hospitals. A nurse with a vocation at hospital A will surely be attracted by the higher wage offered by hospital B. Indeed, Hirsch and Shumacher (2005) find empirical evidence that RNs have "relatively high mobility across employers" (p.25). Heyes does not consider this multi-employer situation, and it seems that the mobility associated with "competitive pull" might vitiate the effect Heyes identifies. Burkett (2005) proposes a different criticism: "While incomplete contracts may explain some persistent shortages, they fail to explain the cases in which employers not only report a shortage but also seek government assistance to enable them to raise wages" (p. 587).[10] Nelson and Folbre (2006) present a wide-ranging critique that rejects the Heyes analysis based among other things on

[9] For a related discussion, see Folland et al., 4th edition, p. 336.

[10] The following anecdote is instructive. An informal conversation with a nursing administrator at a major teaching hospital revealed that that hospital tried to locate itself at the 90th percentile (that is, "close" to the top) of the nursing wage distribution for its labor market. There was no hint of paying low wages to get "devoted" nurses.

effects of low wages on worker morale and motivation, and on how reservation wages vary with competence.

Dynamic Shortages. Feldstein (2003), Folland, Goodman and Stano (2004) and McKibbin (1990) contain related explanations of health personnel shortages.[11] Feldstein (2003) in particular presents a rich historical narrative of a world in which there are major factors shifting demand for nursing services. However, due partially to imperfect information on both sides of the market, there are lags in responses from hospitals (on the demand side), and from the supply of nurses. "A lag of several years always exists before the information on nurses' wages is transmitted to high school graduates and nursing school enrollments change" (p. 267). In a story with some similarities to the earlier "cobweb" models applied to manpower markets,[12] but much more nuanced and less mechanistic, the interplay between shifts in demand and "slow" supply responses creates a history of rising vacancies, followed by rising wages, followed by lagged[13] supply responses, and declining vacancies. Then some force exogenous to the nursing market arises to shift out demand,[14] and the process starts over again. However, even allowing for sluggish supply responses, and thus an inelastic short-run supply curve, one would expect rising wages to bring supply and demand into equilibrium in a relatively short amount of time. Thus, even in this dynamic

[11] The Feldstein and McKibbin versions apply specifically to nursing. Folland et al. contains a brief theoretical explanation of dynamic shortages largely consistent with the Feldstein/McKibbin analyses, but not applied directly to nursing shortages.

[12] Such models were applied for example to markets for technical and scientific personnel. An early example is Richard Freeman's (1976) analysis of the supply and starting salaries of new engineers. A useful discussion is in Ehrenberg and Smith (2006, pp. 313-316), who point out the model's reliance on very myopic expectations. The cobweb model has the mechanistic feature that shortages lead to surpluses which in turn lead to shortages etc; the surplus feature does not seem to fit the nursing market. For a telling critique of cobweb models applied to output markets, see Gary Becker (1971) pp. 92-94.

[13] The lag in supply occurs, in part, due to slow responses of nursing schools in increasing the number of slots to meet the rising demand for those slots, and in lags in funding for the public universities that train most nurses (Spetz and Given, 2003; May, Bazzoli, and Gerland, 2006). One reason for the lagged supply response may be difficulties in finding faculty to teach in nursing programs.

[14] As one example of rising demand since the 1980s, regulatory pressure for shorter length of stay raised the intensity of treatment per patient-day — since on average patients still in the hospital were sicker — which increased the demand for skilled nursing. "In 1975 there were 0.65 RNs per patient; this figure increased to…1.31 by 1990 …and to 1.98 by 2000. The percentage increase in RNs per patient exceeded the decline in patient days. The demand for nurses also increased in outpatient and nonhospital settings" (Feldstein, 2003, p.269).

context, the model needs some additional explanation for a slowly responding wage rate.[15]

Of the three explanations reviewed above, the first two seem unsatisfactory as explanations for possible shortages. The third (Feldstein) narrative identifies what may be important features of the historical experience, but does not explicate the microeconomic behavior of hospitals underlying the nursing market, nor does it explain the existence of persistent shortages (either real or perceived).

In the next section, we present three new explanations that provide a microeconomic foundation to explain persistent economic and "professional standards" shortages, and short-run shortages at "funds-constrained" hospitals.

IV. THREE NEW EXPLANATIONS

In this section, we develop two quite different models that suggest three different explanations for perceived nursing shortages. The first model specifies conditions under which a hospital would choose to hire *both* permanent staff nurses and temporary nurses**.** This use of temporary contract nurses side-by-side with permanent staff nurses can explain hospitals having persistent, budgeted vacancies for permanent nurses. While most economists would not describe these vacancies as true economic shortages, the presence of these vacancies gives the appearance of shortages. *In this situation, the hospital may believe (and therefore report) that the number of their temporary nurses roughly reflects the size of their shortage of permanent nurses.*

The second model produces our second and third explanations. Under a special set of assumptions (limited budgets for a set of "funds constrained hospitals", efficiency wages paid by "premier" hospitals, and limitations in the supply of trained nurses in a local labor market), true economic shortages can result at the funds constrained hospitals. However, these shortages are likely to be short-lived. Thus, this phenomenon cannot explain persistent shortages, but provides an additional more fine-grained microeconomic foundation for the dynamic shortages highlighted in Feldstein (2003). The second model also generates a third explanation for shortages, which we call "professional standards" shortages. While we use the second model to illustrate this third explanation, it is of much more general relevance, and does not depend on the specifics of the second model. *We believe this third explanation may be a large contributing factor explaining the perception of widespread, persistent shortages.*

[15] One contributing factor may be that nursing wages are slower to respond because hospitals cannot raise their charges "at will". They must negotiate changes in charges periodically with insurers.

A. A Model for Hospital Use of Temporary Nurse Staff Creating Perceived Shortages

This section sets out a model showing conditions under which a hospital will use both permanent staff nurses and temporary nurses at the same time. This phenomenon provides a mechanism for explaining hospital-based reports of persistent budgeted vacancies.

An individual with training as a nurse can opt to supply his or her labor to the markets for permanent nurses, temporary nurses, other occupations, or can opt to not work. The supply of permanent nurses (N_1) and temporary nurses (N_2) is given by the following equations:

(1) $N_1 = N_1(W_1, W_2, \mathbf{Z})$, with $N_1(0, . , .)=0$, $\frac{\partial N_1}{\partial W_1} > 0$ and $\frac{\partial N_1}{\partial W_2} < 0$.

(2) $N_2 = N_2(W_1, W_2, \mathbf{Z})$, with $N_2(. , 0 , .)=0$, $\frac{\partial N_2}{\partial W_1} < 0$ and $\frac{\partial N_2}{\partial W_2} > 0$.

where W_1 and W_2 are the wages offered to permanent and temporary nurses, respectively, and $\mathbf{Z}$ is a vector of other factors (e.g., wages in other sectors, childcare availability, etc.). We assume heterogeneity among nurses in their preferences for permanent versus temporary positions, such that some nurses might choose permanent and others temporary positions even when W_1 and W_2 are not equal.

We first assume that a single hospital is a monopsonist in the local labor market for nurses. This monopsonist assumption is used only as a starting point, and we discuss the competitive market subsequently. For monopsonist hospital j, profit[16] is given by the following equation:

(3) $\pi_j = PQ_j - W_{1j}N_{1j} - W_{2j}N_{2j} - \mathbf{P_X}'\mathbf{X}_j$

[16] The assumption of profit-maximization is a simplification of the more general idea that hospitals may act to maximize a more general objective function that includes operating surplus, quality of treatment and other desiderata. To list some possibilities: (i) the Newhouse model (1970) assumes a hospital utility function in quality and quantity; (ii) teaching hospitals may "spend" part of their potential revenue surplus to admit "interesting" but unprofitable patients, and so forth. For an early discussion of a range of things that might appear in a hospital's objective function, see Hornbrook and Goldfarb (1983). Our assumption of profit-maximization is consistent with the typical treatment of nursing shortages in monopsony models, including Currie, Farsi, and MacLeod (2005).

where P is the price paid by (or for) the average patient admitted to the hospital, Q is the quantity of patients admitted, $\boldsymbol{X}$ is a vector of other hospital inputs (e.g., staff doctors, janitors, medical equipment, supplies, etc.), and $\boldsymbol{P_X}$ are the prices of those inputs. We assume that P is determined exogenously. For most patient care, hospitals are reimbursed by procedure at fixed rates; Medicare, Medicaid, other governmental payment, and unreimbursed care made up 62.3% of hospitals' revenue in 2005 (AHA, 2007a).[17] While the hospital may have some flexibility in setting prices for the remainder of private paying patients (37.7%) for whom payment is mainly made via insurance, we are assuming that patients have some degree of ability to select among hospitals (even opting for a hospital outside of the local area when there is only one local hospital). Thus, assuming an exogenous price for services seems reasonable as an approximation. We also assume that the prices of other inputs to production ($\boldsymbol{P_X}$) are exogenously determined. So, for example, this means that we are implicitly assuming that other workers (e.g., staff doctors, janitors, etc.) are more mobile than nurses across employers such that the wages for other workers are set competitively.

The quantity of patients that a hospital will attract (Q_j) is a function of patients' subjective views of the hospital's quality of care[18, 19] (C_j):

$$(4) \qquad Q_j = Q(C_j)$$

Patients' subjective evaluation of the hospital's quality of care is a function of the hospital's inputs ($N_{1\,j}$, $N_{2\,j}$, $\boldsymbol{X}_j$). We assume that patients cannot directly evaluate whether a nurse is part of the hospital's permanent or temporary staff. However,

[17] From the revenues reported AHA (2007a), we have deducted the 2.2% received from non-patient care. "Non-patient represents costs for cafeterias, parking lots, gift shops and other non-patient care operating services and are not attributed to any one payer" (p. 8).

[18] The quality of care perceived by the patient may have little relation to objective measures of patient health outcomes. This distinction is important as some literature (see, for example, Fung et al. 2008) suggests that patients have limited knowledge of hospitals' records of producing good health outcomes. Additional literature suggests that even when patients have access to public information on real hospital quality, they typically don't act on it (see for example, Hibbard, Stockard, and Tusler 2003). Moreover, the movement in recent years towards managed care has shifted decision-making about hospital choices from patients towards insurers. Insurers, of course, will be concerned about hospital quality both because they want to avoid the present and future costs of remedying inferior care received by their policy holders, and they do not want to lose policy holders as a result of developing a reputation for only "offering" low quality hospitals. For the model we develop, patients or their insurance companies only need to have some subjective measure of quality and this subjective measure must have some relation to the hospital's "effective" number of nurses (defined below).

[19] Quantity of patients would also depend on the size of the local population. As we are treating this population (and the types of patients that are near the hospital) as exogenous, for simplicity we are omitting population from Equation 4.

the patient may indirectly perceive differences in the quality of care provided by permanent and temporary nurses. For example, permanent nurses may provide better care as a result of efficiencies from being more familiar with hospital procedures, paperwork, etc.[20] On the other hand, if temporary nurses bring more of a fresh, friendly attitude, while permanent nurses tend to be more jaded, then temps might be more efficient in providing quality care from the patient's point of view. Let α be the relative efficiency of temporary nurses, with $\alpha<1$ reflecting temporary nurses providing lower quality care than permanent staff. Let N_j be defined as the "effective" number of nurses, with $N_j = N_{1j} + \alpha N_{2j}$. Thus, quality of care is given as:

$$(5) \qquad C_j = C(N_j, \boldsymbol{X}_j) = C(N_{1j} + \alpha N_{2j}, \boldsymbol{X}_j)$$

The hospital's profit maximization problem is the following (with j subscripts suppressed):

$$(6) \qquad \max_{W_1,\, W_2,\, \boldsymbol{X}} \pi = PQ\big(C\big(N, \boldsymbol{X}\big)\big) - W_1N_1 - W_2N_2 - P_{\boldsymbol{X}}'\boldsymbol{X},$$

subject to the constraint that all inputs are weakly positive.

In forming the Lagrangian, we assume that an interior solution exists such that all inputs included in $\boldsymbol{X}$ are positive, so as to focus the analysis on the choice of nursing wage offers. We take care of the nonnegativity constraints on wages implicitly in the Kuhn-Tucker first order conditions below. The Lagrangian is then as follows:

$$(7) \qquad L = P\,Q(C(N, \boldsymbol{X})) - W_1N_1 - W_2N_2 - \boldsymbol{P_X}'\boldsymbol{X}$$

The Kuhn-Tucker first order conditions[21] are as follows:

$$(8a) \qquad \frac{\partial L}{\partial W_1} \le 0 \rightarrow P\,\frac{\partial Q}{\partial C}\frac{\partial C}{\partial N}\frac{\partial N}{\partial W_1} \;\le\; \left(N_1 + W_1\frac{\partial N_1}{\partial W_1}\right) + \left(W_2\frac{\partial N_2}{\partial W_1}\right)$$

[20] PriceWaterhouseCoopers (2007) (citing evidence given in Daniel et al. (2006)), note that "Temporary staffing can harm staff cohesion. An Institute of Medicine study reports that increased use of agency nurses is associated with a lack of continuity of care and creates vulnerability to quality problems and disconnect on the part of physicians and nurses who must work with temporary staff unfamiliar with the work setting. This in turn causes disruption in a team culture." (p. 29).

[21] We need to use Kuhn-Tucker conditions to generate the optimal solutions for this Lagrangian given the assumed non-negativity constraints on wages/nurse labor inputs. A more formal treatment of this model would also place non-negativity constraints on the use of other inputs, $\boldsymbol{X}$. For simplicity, these additional non-negativity constraints are ignored.

(8b) $$\frac{\partial L}{\partial W_2} \le 0 \rightarrow P\ \frac{\partial Q}{\partial C}\frac{\partial C}{\partial N}\frac{\partial N}{\partial W_2}\ \le\ \left(W_1 \frac{\partial N_1}{\partial W_2}\right) + \left(N_2\ +\ W_2 \frac{\partial N_2}{\partial W_2}\right)$$

(8c) $$\frac{\partial L}{\partial \boldsymbol{X}} = 0 \rightarrow P\ \frac{\partial Q}{\partial C}\frac{\partial C}{\partial \boldsymbol{X}}\ =\ \boldsymbol{P}_x$$

(8d) $$W_1 \frac{\partial L}{\partial W_1} = 0$$

(8e) $$W_2 \frac{\partial L}{\partial W_2} = 0$$

(8f) $W_1 \ge 0$ and $W_2 \ge 0$

Suppose that the hospital initially hired *only* temporary nurses (i.e., set $W_1 = 0$ and thus $N_1 = 0$). F.O.C. 8a reduces to:

(9a) $$P\ \frac{\partial Q}{\partial C}\frac{\partial C}{\partial N}\frac{\partial N}{\partial W_1} \le\ W_2 \frac{\partial N_2}{\partial W_1}.$$

The right hand side of Inequality 9a is the change in labor costs that would occur from hiring fewer temps when the wage to permanent nurses is increased, which is clearly negative from Equation 2. The left hand side of Inequality 9a is the marginal change in revenue given an increase in the wage paid to permanent nurses beginning at $W_1 = 0$, which is only negative if an increase in the wage paid to permanent nurses causes a decrease in the hospital's number of "effective" nurses. This result occurs when $\frac{\partial N_1}{\partial W_1} < \alpha \left|\frac{\partial N_2}{\partial W_1}\right|$ (i.e., when the gain in effective nurses coming from the hiring of some permanent nurses is less than the losses caused by the reduction in the temporary nurse staff as some temps switch to permanent employment (or, paradoxically, exit the nursing profession altogether)). This result is very unlikely to hold. If we assume $\alpha=1$, then for Inequality 9a to hold it would require that an increase in the wage paid to permanent nurses would cause some temporary nurses to exit the nursing labor market altogether (rather than switch to permanent positions), and these exits from nursing would need to exceed the number of workers who enter the nursing profession from other occupations. Moreover, if $\alpha<1$, it is even less likely for Inequality 9a to hold.

Now suppose that the hospital initially hired no temporary nurses (i.e., set $W_2 = 0$ and thus $N_2 = 0$). The results parallel those above. F.O.C. 8b reduces to:

$$(9b) \qquad P \frac{\partial Q}{\partial C}\frac{\partial C}{\partial N}\frac{\partial N}{\partial W_2} \leq W_1 \frac{\partial N_1}{\partial W_2}.$$

This result occurs when $\left|\frac{\partial N_1}{\partial W_2}\right| > \alpha \frac{\partial N_2}{\partial W_2}$ (i.e., when the gain in effective nurses coming from the hiring of some temps is less than the losses caused by the reduction in the permanent nurse staff as some permanent nurses switch to temporary employment (or exit nursing)). This condition is possible if α is small. However, if α is close to one, then Inequality 9b is unlikely to hold and the hospital would hire some temps. Thus under plausible conditions an interior solution can exist where the hospital hires both temporary and permanent nurses.

What is the intuition underlying the mathematics of this result? We are considering a situation in which the hospital faces upward sloping supply curves of two kinds of labor that are perfect substitutes in production (where the parameter α represents the relative efficiency of temporary nurses). In that situation, when the hospital's demand for permanent nurses drives its wage W_1 high enough relative to the wage W_2 of temporary nurses, on the margin hiring temporary nurses will become the more attractive alternative because the relative wage of these temporary nurses becomes equal to or lower than their relative efficiency α.[22]

The preceding model is similar to the typical treatment of a monopsonist; the monopsonist will hire labor up to the point at which the marginal revenue product of labor equals the marginal cost of additional labor. In the standard treatment, it is noted that the monopsonist would be willing to hire more labor at their optimal wage, but no additional labor is supplied at that wage creating the appearance of shortages, yet there is no incentive for the firm to raise the wage. In discussing this standard model, Ehrenberg and Smith (1991) note that "(t)he [nursing] shortage is thus more apparent than real" (p. 79).

There is an important difference, however, in our model. The solution to the first order conditions can lead to an interior solution whereby the hospital's optimal wage choices lead to the hiring of both temporary and permanent nurses. In this situation, the hospital may believe that the number of their temporary

[22] Implicit in this single employer story and the mathematics is the idea that "(a)lthough temp RNs are generally paid more than permanent nurses, by hiring temps, health care organizations can gain (staffing) flexibility without having to increase wages for all existing permanent nurses" (Goodman-Bacon and Ono, 2007, p. 2).

nurses roughly reflects the size of the shortage it faces.[23] Furthermore, they may allocate to their nursing department (or human resources department) a budget equal to $W_{2j}N_{2j}$ for the purpose of hiring additional permanent nurses (which would lead to the simultaneous reductions in the temporary staff). Thus, our model can produce *budgeted* vacancies for permanent nurses. As we noted above, it is difficult to see why in the standard monopsonist model the hospital would year-after-year provide such a budget knowing that their wage offer was not high enough to induce additional supply. However, in our model, the confusion is understandable. If we assume that α is less than one, which seems likely, then temporary nurses would be likely to receive lower pay than permanent staff.[24] It might then seem surprising to the hospital that they are unable to recruit additional permanent nurses at their current wage offer which exceeds the wage paid to temporary nurses. It is the heterogeneity in nurse preferences for temporary work that leads to this steady-state.

We now turn to the more typical situation of a for-profit hospital in a competitive labor market.[25] Labor supply is still given by Equations 1 and 2. The hospital's profit is given as:

$$(3') \qquad \pi_j = PQ_j - W_1N_{1j} - W_2N_{2j} - \boldsymbol{P_x}'\boldsymbol{X}_j$$

where the W_1 and W_2 are set exogenously in the competitive labor market. Equations 4-6 still hold[26], with the change that maximization is now done with respect to N_1, N_2, and $\boldsymbol{X}$. Again assuming that an interior solution exists such that all inputs included in $\boldsymbol{X}$ are positive, and with non-negativity constraints on N_1 and N_2, the Lagrangian is as follows,:

$$(7') \qquad L = PQ(C(N, \boldsymbol{X})) - W_1N_1 - W_2N_2 - \boldsymbol{P_x}'\boldsymbol{X}$$

The Kuhn-Tucker first order conditions are as follows:

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[23] Alternatively, they may view one permanent nurse as equivalent to $1/\alpha$ temporary nurses. Thus, they would view their vacancies as somewhat less than their total number of temporary nurses if $\alpha<1$.

[24] As we noted previously, although temporary nurses tend to cost more than the *average* wage of permanent nurses, they may not cost more than the *marginal* wage. This distinction could cause additional confusion to hospitals as to why they cannot persuade more nurses to accept their permanent positions at the going average wage for their permanent staff.

[25] In the Appendix, we show that these results again hold for a not-for-profit hospital that seeks to maximize quality of care (and/or patient quantity).

[26] Note that the function $Q(.)$ in Equation 4 takes into account the degree of attraction of competing hospitals. We assume that the market is sufficiently competitive such that the actions of hospital j have negligible effects on competing hospitals, thus the competing hospitals' behavior is taken as given.

(8a') $$\frac{\partial L}{\partial N_1} \leq 0 \rightarrow P \frac{\partial Q}{\partial C}\frac{\partial C}{\partial N_1} \leq W_1$$

(8b') $$\frac{\partial L}{\partial N_2} \leq 0 \rightarrow P \frac{\partial Q}{\partial C}\frac{\partial C}{\partial N_2} \leq W_2$$

(8c') $$\frac{\partial L}{\partial \boldsymbol{X}} = 0 \rightarrow P \frac{\partial Q}{\partial C}\frac{\partial C}{\partial \boldsymbol{X}} = \boldsymbol{P}_x$$

(8d') $$N_1 \frac{\partial L}{\partial N_1} = 0$$

(8e') $$N_2 \frac{\partial L}{\partial N_2} = 0$$

(8f') $N_1 \geq 0$ and $N_2 \geq 0$

Suppose that the hospital initially hired both temporary and permanent nurses (i.e., $N_1 > 0$ and $N_2 > 0$). Then given the requirements in Equations 8d' and 8e', the inequality signs in first order conditions 8a' and 8b' would be replaced with equal signs. Then, using $\frac{\partial C}{\partial N_1} \Big/ \frac{\partial C}{\partial N_2} = 1/\alpha$ (from Equation 5), the ratio of the first order conditions 8a' and 8b' would be:

(10) $$\frac{1}{\alpha} = \frac{W_1}{W_2}$$

That is, the ratio of the wages must equal the ratio of their marginal productivities. If this equality did not hold, the hospital would hire only permanent (or only temporary) nurses. If we assume that all of the hospitals in the local labor market have comparable values of α_j, then we should expect the market wages to equilibrate such that $W_2 = \alpha W_1$.

The same results then hold for the competitive hospital as for the monopsonist. The hospital may perceive its temporary staff as reflecting a shortage in its permanent staff. It may advertise open positions at rate W_1 and get no takers even if $W_1 > W_2$! Given nurses' heterogeneity in preferences for temporary employment, there will always be some nurses willing to accept a

lower wage for the benefit of flexibility. Surely these apparent shortages would cause the concerns we see expressed by the AHA.

If we relax the assumption that permanent and temporary nurses are perfect substitutes in producing quality care (at ratio $1/\alpha$), then the motivation for the hospital to hire some temporary nurses would be strengthened, and therefore would not rely on the wage ratio being in perfect balance at $1/\alpha$. In particular, the flexibility of temporary nurses in filling short-term staffing needs or working shifts that are difficult to staff would make such temporary hires complements to the permanent staff.

Moreover, this model could explain the countercyclicity in vacancy rates. During tight labor market periods, temporary positions will become more attractive because it frees the nurse to explore outside options. Also, nurses should have less fear of not finding work in a tight labor market, and thus the job security of a permanent nursing position becomes less attractive. Of course, a simpler explanation is that a tight labor market could lead to higher vacancies if nursing is less attractive than other professions. Another possibility is that RNs are more likely to have unemployed spouses in downturns, so they may increase their labor supply in downturns to maintain household income. We believe that our temporary nurse market model augments these simpler explanations.

This section has specified conditions under which a hospital would choose to use temporary contract nurses *side-by-side with permanent staff nurses*. This joint-use phenomenon can explain hospitals having persistent budgeted vacancies for permanent nurses.[27] While most economists would not describe these vacancies as true economic shortages, the presence of these vacancies gives the appearance of shortages. Indeed, the hospital may believe that (and therefore report that) the number of their temporary nurses is a rough reflection of the size of their shortage of permanent staff nurses. In the following section we present a

[27] A quite different reason for the use of temporary contract nurses, one which implies that temporary nurses might be a quasi-permanent feature of hospital staffing, is the use of these contract personnel to deal with hard to predict time variance in the demand for hospital services, or for staffing work shifts that regular staff nurses are less willing to cover, or to cover leaves and vacations. Consistent with the idea that temporary nurses might fill a number of different needs (unforeseen temporary increases in demand, shift coverage problems, etc) Goodman–Bacon and Ono point out that temporary RNs hired through staffing agencies have at least two alternative kinds of arrangements, known as "per diem nurses" and "traveling nurses." "Per diem nurses work wherever they are needed on a given day, responding to last-minute requests, such as filling in for sick nurses. Some per diem assignments may last for weeks, for example, to substitute for permanent nurses on vacation or maternity leave….[T]ravel nurses are [typically] assigned for 13 weeks to a certain hospital or health care organization." (2007, p. 3). We have not modeled this phenomenon. A model incorporating this feature of temporary nurses would require treating temps and permanent nurses as not perfect substitutes. Nonetheless, even if these two types of nurses are somewhat complementary, a hospital may still view some of their temporary hires as filling a vacant permanent position.

model that generates two explanations for shortages quite different from this temporary-permanent nurse staffing distinction.

B. Shortages at "Funds-Constrained" Hospitals

Our second explanation is one that can explain short-run shortages for "funds-constrained" hospitals. Because it is limited only to funds-constrained hospitals, it does not account for the perception of widespread persistent shortages across a broad range of hospitals. However, it adds to the first explanation in two ways: it provides an additional more fine-grained micro foundation for the Feldstein (2003) dynamic model, and it provides a framework for setting out our third "professional standards" explanation of reported nursing shortages. For convenience, we use the "funds-constrained hospital" model to illustrate that third explanation. However, this third explanation has much broader applicability, and does not depend on the existence of funds-constrained hospitals.

The model's building blocks: the premier hospital's situation and behavior. The model posits that some local markets contain both "premier" and "funds-constrained" hospitals. The premier hospitals specialize in relatively high quality care. A premier hospital is assumed to have some ability to attract patients who will pay more for their services (for example, by attracting patients who are privately insured) by offering a higher quality of care.[28] One way they produce this higher quality care is by reducing nurse turnover.

Nurses with experience at the hospital know the hospital's routines and procedures, its practice style, the needs of specific attending physicians, they become familiar with the idiosyncrasies of specific patients, and so forth. Rapid turnover means newly-hired nurses are unfamiliar with hospital and ward-specific procedures and routines. (Note that, for analytical simplicity, temporary "contract" nurses are not explicitly considered in this model.) Costs are incurred showing these new personnel the ropes, mistakes get made due to hospital-specific inexperience, and quality of care suffers more generally. The premier hospital can reduce nurse turnover by paying an efficiency wage.[29, 30, 31]

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[28] Consistent with this distinction between funds-constrained and premier hospitals, there is some evidence available that "profitability" varies among hospitals. Using data for four states (704 hospitals), Friedman et al. (2004) show that per-patient profitability varies across hospitals with different mixes of patients (Medicare, privately insured, Medicaid, self-pay, and charity). Generally speaking, higher proportions of Medicare and privately-insured patients are associated with higher profits per patient. See also Fisher (1992).

[29] The idea that profit-maximizing firms with turnover costs (such as hiring and training costs) would set a wage taking account of these costs to maximize profits (by lowering quit rates) has a long history in the labor economics literature, going back at least to the 1970s (see, for example, Parsons (1972), Pencavel (1972), Salop (1973), Hamermesh and Goldfarb (1970)). In a well-

Given the higher wage paid by these premier hospitals, all nurses offer their services to these hospitals first. Those nurses who are not hired by the premier hospitals (PH) may then offer their services to the funds constrained hospitals.[32] Thus, these funds-constrained hospitals (FCHs) hire their nurses from the residual nurse supply curve.

The funds-constrained hospital's situation and behavior. The funds-constrained hospital is likely to be nonprofit and is possibly in the public sector. This hospital may serve a disproportionately low-income clientele, with high percentages of uninsured and Medicaid patients, and be dependent for part of its support on a local government or governments. The reimbursements received by these funds-constrained hospitals for various services are therefore largely constrained by Medicaid reimbursement levels. Thus, we assume that a FCH's price for its services is externally determined. We further assume that patient quantity is exogenously determined. This rests on the idea that a separating equilibrium exists whereby all high-income patients select premier hospitals, all low-income patients select funds-constrained hospitals, and funds-constrained hospitals must admit all patients who seek services.[33] The result is that a FCH's total revenue (PQ_{FCH}) is externally determined.

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known article on the idea of efficiency wages, Yellen (1984) lists turnover considerations as the basis for one class of efficiency wage models.

[30] The wage offered to nurses should be thought of as a "working-condition-adjusted" wage. That is, a hospital can provide a higher wage by increasing the hourly pay, or by putting resources into improving the working conditions (e.g., lowering the pace of work). For a more extended discussion of the connection between wages, working conditions, and nurse turnover, see Jones (2004, 2005) and May, Bazzoli, and Gerland (2006).

[31] One possible example of a class of premier hospitals are those with the designation "magnet hospitals," selected for this designation because they seem to be successful at recruiting and retaining RNs. While there is a large literature describing the magnet hospital program and investigating some features of these hospitals, our search of the literature was unsuccessful at finding any comparisons of wage levels at these hospitals with other hospitals.

[32] For modeling purposes we ignore the possibility that heterogeneous preferences among nurses might lead some nurses to prefer working for the funds-constrained hospital(s) because, for instance, they want to work with a disadvantaged patient population. We would expect that a relatively small percentage of nurses, if any, would have such preferences. Moreover, these preferences would only affect behavior (that is, which hospital to apply to first) if the wage premium offered by the premier hospital failed to compensate for this preference. Even if there were a number of such nurses, the analysis that follows would hold, after these nurses were "netted out" of the analysis.

[33] While the premier hospital may be legally required to admit all patients, it can create barriers to entry by low-income patients it considers undesirable by, for example, locating itself away from low-income communities.

For a non-profit FCH, the revenue of the hospital would equal its input costs:[34]

(3") $PQ_{FCH} = WN_{FCH} + \boldsymbol{P_x}'\boldsymbol{X}_{FCH}$

Hospitals consist of multiple departments or units, such as the radiology department, the intensive care unit, the pediatric unit, and so forth. A central authority at the hospital makes budget decisions, deciding how available funds it receives and oversees are to be split among multiple department or unit claimants. We assume that this administrator maximizes his/her utility by allocating budgets to these departments in such a way as to provide the best care (from his/her perspective) to the hospital's patients.[35] Because the hospital is funds-constrained, the administrator cannot always provide budgets to each department at the levels that the departments will view as essential to generating the level of care each wants to provide.

Assume for modeling convenience that the nursing budget—the allocation of funds to hire nurses—goes to a particular decision-making department or unit, the "nursing department."[36] Suppose the nursing unit receives a budget of B_{FCH} dollars. It then faces the following budget constraint:

(11) $W_{FCH}\, N_{FCH} = B_{FCH}$

Equation 11 traces out a rectangular hyperbola in (N,W) space, where the number of nurses N_{FCH} that can be hired = B_{FCH}/W_{FCH}.

Market-level analysis: demand- supply interactions. For analytical transparency, we focus our modeling on local markets with just one FCH and at least one PH.[37] This FCH has a choice of any (N, W) pair satisfying Equation 11.

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[34] If the funds-constrained hospital is a for-profit enterprise, its profit maximization problem then reduces to a cost-minimization problem. If Q_{FCH} were truly exogenous, then the cost minimizing strategy would be to hire no inputs. Of course, such a strategy would be thwarted by potential regulatory constraints on nurse-patient ratios, or concerns for avoiding lawsuits due to malpractice.

[35] Thus, the hospital administrator will consider the implications for nurse turnover when deciding a budget to allocate to the nursing department. However, the budget limitations make it impossible to pay efficiency wages.

[36] In practice, each patient-care unit of the hospital is likely to be given its own nursing budget. Our "nursing department" is simply the aggregate of all units' nursing budgets. We use this assumption to avoid having to model each department's hiring individually, then aggregate them up.

[37] Suppose there are several funds-constrained hospitals in a local labor market. There are two analytical possibilities. One is that these hospitals interact strategically—for example, they might tacitly collude—to pick the wage. Our "one FC hospital" model can be thought of as also covering the case of several FC hospitals that effectively collude. The second possibility is that the wage paid by these hospitals may be set competitively. Thus, define $\bar{W}_{FCH}$ as the competitive

Figure 3 displays various supply-demand scenarios for the nurse labor market. In each panel, the nursing supply curve to the entire labor market is given by ABC. The vertical portion on the supply curve (at N_{Limit}) represents the idea that there is an upper limit at any point in time on the number of nurses available in the local labor market given the number of people who are credentialed and have an interest in working as a nurse. This assumption of verticality in the supply curve, which is critical to our subsequent model, is only realistic as an assumption in the *short-run*.

In evaluating this assumption, note that those nurses who are already trained but either working in other sectors, working part-time, or not currently in the labor force, are included in the upward sloping part of the local labor market supply curve (as a high enough wage could prompt their entry into the hospital sector). However, there is some upper limit on the number of such people locally available. The vertical portion of the *short run* local labor market supply curve reflects that local upper limit.[38] In the longer-run, the supply curve becomes nonvertical (upward sloping) because nurses can be attracted to the labor market from other locations, supply increases can come from local schools, etc. This assumption is consistent with the Feldstein model of lags in responses of nursing supply due to the time it takes to encourage enrollment and train new nurses.

Each panel depicts a different "residual" supply curve faced by the FCH. In the top panel, it is assumed that the premier hospitals pay nurses W_{PH} at the level where the supply curve becomes vertical (at point B).[39] The premier hospital(s) hire N_{PH} nurses (horizontal length FB=ED), with $N_{PH} < N_{Limit}$ so that there is excess supply of applicants at the wage being offered. In the top-panel we assume that the premier hospital(s) hire from the "bottom" of the reservation wage distribution; that is, the nurses who get the jobs at the premier hospital(s) have low supply prices (below point D).[40] The residual supply curve under this

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wage paid at local funds constrained hospitals, with $\bar{W}_{FCH} < W_{PH}$. In this circumstance, any particular FCH will set $N_{FCH} = B_{FCH}/\bar{W}_{FCH}$ and have no *budgeted* vacancies. If there are multiple funds-constrained hospitals in this "competitive and noncollusive" version, our model can be thought of as applying to the most funds-constrained hospital within a market with several hospitals. That is, if the local market has more than one non-colluding funds-constrained hospital, our model applies to the worst-off hospital.

[38] Inelasticity in the overall regional or national *short-run* supply of registered nurses would help reinforce any local market inelasticity. Surveys of existing elasticity estimates are largely consistent with the proposition that *short run* supply elasticities are low, see Burkett (2005) Table 2, and Shields (2004). Shields notes that at least in the short-run, "RN labour supply appears to be fairly unresponsive to wage changes" (Shields, 2004, p. F464).

[39] Premier hospital(s) may choose to set W_{PH} above point B to lessen turnover. The effects on the FCH would remain unchanged from the analysis shown in the top panel of Figure 3.

[40] The same problem — that there are alternative possible assumptions about where on the labor supply curve the workers in question come from — arises in theoretical treatments of minimum

condition is given by the bold lines EFG (which is identical to DBC shifted leftward). We add two possible budget constraint curves (B_1 and B_2) for the funds constrained hospital. Given budget constraint B_1, if the funds-constrained hospital's nursing department recognizes the reality of the supply curve it faces, the most plausible solution is for it to go to point H, and offer a salary W_H. If it offers a salary lower than W_H, it can "afford" more positions, but it will actually fill fewer. It is paying a salary considerably below that paid by the premier hospitals, but there are no unfilled budgeted positions. That is, there is a distribution of nursing salaries since $W_H < W_{PH}$, but no budgeted vacancies. Thus, the "very funds-constrained" budget situation B_1 produces salary differentials but no unfilled vacancies (i.e., no "economic shortages").

Compare this outcome with the situation if the budget is B_2. In this case, the hospital maximizes the number of nurses it can obtain by going to point F, paying salary W_{PH}. A higher salary yields no additional nurses because the hospital is on the vertical section of the residual supply curve it faces. At F, there are budgeted vacancies, equal to the horizontal difference between point F and the budget line B_2 (equal to the length FI, the gap between demand and the residual supply curve at $W_H = W_{PH}$). So if the budget is large enough such that the budget constraint intersects the vertical portion of the supply curve, there will be budgeted vacancies (an "economic shortage"). Note, however, that in this case, there is no salary differential between the funds-constrained and the premier hospitals. If the FCH tried to lure some nurses to leave the premier hospital by raising the wage above W_{PH}, the premier hospital(s) would respond by outbidding the FCH. Knowing this, the FCH would not have an incentive to attempt to raise the wage above W_{PH}. Thus, there is a short-run nursing shortage at the FCH that is ameliorated after more trained nurses enter the local labor market, shifting out N_{Limit}, and making the formerly vertical sections of both supply curves nonvertical and upward sloping.

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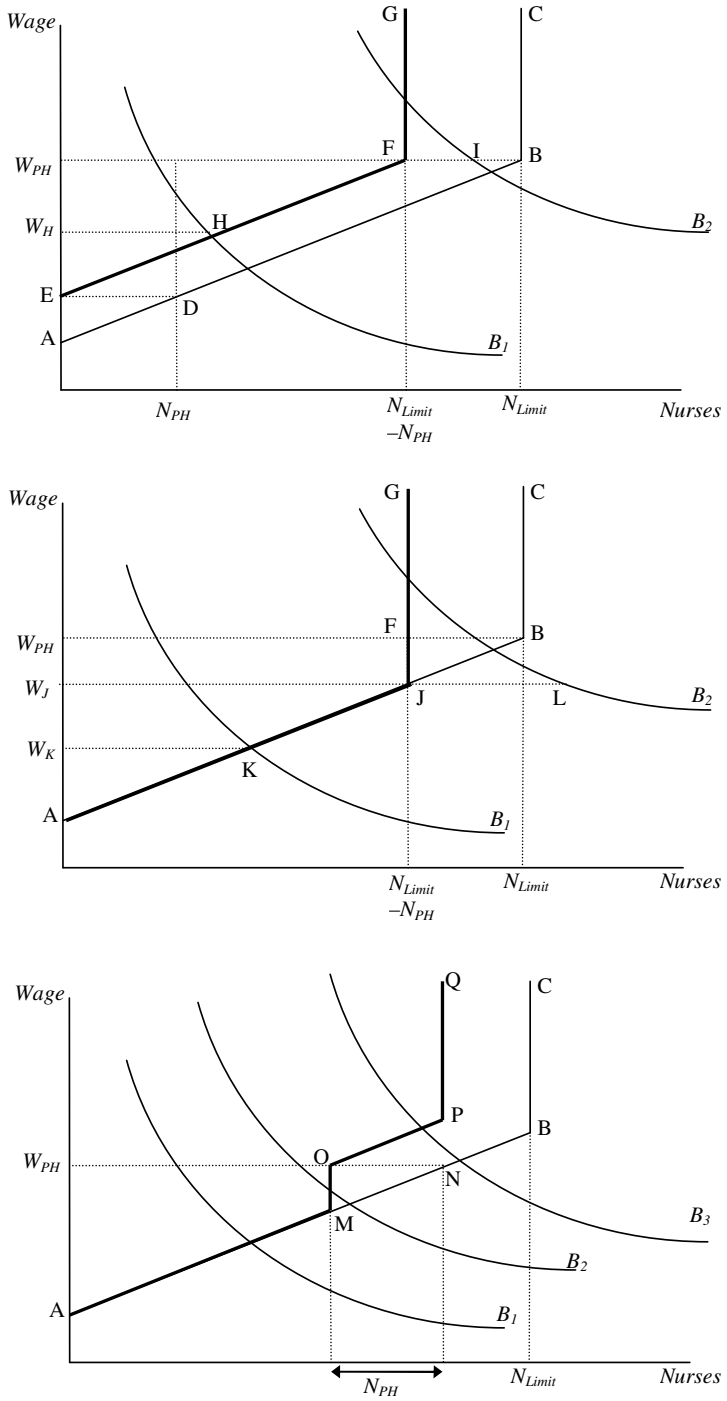
wage effects in models with covered and uncovered sectors. For example, in a well-known theoretical treatment, Welch (1974) points out that determination of the supply to the uncovered sector and therefore the wage in the noncovered sector requires knowledge of which workers (from which part of the overall supply curve) get the rationed minimum wage jobs. He points out that "It may be tempting to assume that workers with lower reservation wages would implicitly bid higher prices by queuing longer for premium jobs, because they have more to gain. This argument is only partly correct." (p.302). Gramlich (1976), citing Welch, copes with this problem by citing two alternatives: if the covered jobs went to those with the lowest reservation wages, "the workers on the covered supply curve to the right of [the level of demand at the minimum wage] would move to the uncovered sector and shift out the supply by an appropriate amount above their reservation wages. If the covered jobs were allocated randomly, the uncovered supply would shift out in the manner drawn" (which is a rotation) (p.413).

Figure 3: Wage Setting for the Funds-Constrained Hospital Given a Fixed Budget and Various Residual Supply Curves



In the middle panel of Figure 3, we again assume that the premier hospitals pay nurses W_{PH} at the level where the supply curve becomes vertical (at point B), but here we assume that the premier hospital(s) hire from the "top" of the reservation wage distribution (above point J). The residual supply curve is then AJG. For the very constrained budget, B_1, the analysis is the same as in the top panel; the FCH would go to K, set its wage at $W_K < W_{PH}$ and have no budgeted vacancies. Under the less constrained budget, B_2, the FCH would choose to set their wage at W_J and have vacancies equal to the distance JL, the gap between demand and residual supply at W_J. In this case, it would take a substantial increase in the wage to convince any nurses at premier hospitals to switch jobs, and any such effort would be undone by the premier hospital(s) offering a higher efficiency wage. Thus, the best such an FCH can do is to accept the shortage. Note that as the funds constrained hospital's budget rises from B_1 to B_2, the wage gap falls, while vacancies rise. That is, vacancies in this scenario are not caused by tight budgets *per se*, but rather by insufficient local supply relative to the number of hires the hospital's budget allows. Again, such vacancies would be ameliorated in the long run as newly trained nurses enter the local market.

The bottom panel of Table 3 again assumes that the premier hospitals hire nurses from the higher portions of the available nurse supply distribution, but now we set W_{PH} to a level below where the supply curve becomes vertical (that is, below point B). The premier hospital thus hires nurse applicants along the MN section of the supply curve. The residual supply curve is thus AMOPQ, where OPQ reflects a leftward shift of NBC. For this panel, we present three possible budgets. The analysis under budget B_1 is just like the prior two panels; the very funds-constrained hospital would offer a low wage, but have no vacancies. Under the least constrained budget, B_3, the funds constrained hospital would pay a wage where B_3 crosses line segment OP. As this wage is above W_{PH}, it would prompt the premier hospital(s) to raise their wage to maintain their efficiency wage position. Such a response would then shift the analysis to that shown in the middle panel of Figure 3.

Budget B_2 presents a much more interesting case. Under this budget constraint, the funds constrained hospital would choose to set their wage at point M and have vacancies equal to the horizontal distance between M and B_2. This hospital could not recruit additional nurse applicants without raising the wage above point O. However, by doing so, given their limited budget, they would actually hire fewer nurses. *Moreover, this condition has the interesting property that the results are not dependent on our assumption of a vertical supply curve at* N_{Limit}. This result suggests that these vacancies could remain permanent as there would be no upward pressure on wages that would induce future supplies of nurse applicants. Nonetheless, we consider it likely that such shortages would not be reflected in permanent *budgeted* vacancies. The administrator who allocates

funds to various departments would likely reallocate funds from the nursing departments to other inputs.

As noted previously, the vertical labor supply constraint will only hold in the short-run, and become upward sloping in the longer-run. *Once the supply curve becomes upward sloping instead of vertical, economic shortages disappear from our model.* The change to an upward sloping supply curve is due to overall market adjustments to widespread vacancies /economic shortages. Eventually, the existence of these widespread vacancies in this and other labor markets, and the attendant pressure on wages will result in increased labor supply to this local market due to increased entry of students into nursing schools, possible labor force participation effects, and to immigration into this local labor market. That is, there are exactly the lagged adjustments hypothesized by the "dynamic shortage" framework of Feldstein and others described above. What we have added to that analysis is a more concrete fine-grained microeconomic theory explanation at the local labor market level, based on the existence of funds-constrained hospitals and their budgeting processes, of *why wages do not immediately adjust on the local level to rapidly eliminate the economic shortage.* Note, however, that if the shortages are occurring at funds-constrained hospitals, and if there is a commitment by premier hospitals to pay efficiency wages (which eliminates the incentive for funds-constrained hospitals to raise their wages attempting to lure applicants), then upward pressure on wages may be slow to occur. Thus, this process provides an explanation for observed shortages that last for several years.

C. "Professional Standards" Shortages

In this section, we propose a quite general explanation for perceived persistent nursing shortages. This explanation produces perceived shortages that are not real economic shortages: they do not generate *actual budgeted vacancies.* We believe this explanation may in fact account for some sizable percentage of actual claims about nursing shortages. While we use our funds-constrained hospital model to illustrate this kind of perceived shortage, *the existence of this kind of shortage is far more general, and does not depend on the existence of funds-constrained hospitals.*

In the FCH model from the previous section, define N_{min} as the minimum number of full-time-equivalent nurses the nursing department head (and/or hospital administrator) believes is required to provide adequate care to Q_{FCH} patients. Since the hospital is severely funds-constrained, it is plausible that most departments or units will receive a budget allocation inadequate for meeting its perceived needs. This will also be true of the nursing unit. That is, it is very likely that N_{min} may be greater than N_{FCH} given the limitations in budgets. N_{min}

will appear as a vertical line (not shown explicitly) in any one of the diagrams in Figure 3. When $N_{min} > N_{FCH}$ we define this condition as a "professional standards" shortage.[41] Thus, for example, in the top panel of Figure 3, the vertical line $N_{min} > N_{FCH}$ would create a professional standard shortage of the horizontal distance between N_{min} and N_{FCH} .

This is not a shortage in the economic sense, because no actual budgeted vacancies are involved. That is, the hospital is not able to ameliorate this shortage since it does not have the funds available to do so. Moreover it is arguable that this kind of shortage would be exacerbated by the fact that hospitals do not bill directly for nursing time – nursing time is part of the "daily bed rate". Thus, there is no clear financial incentive to provide more nursing care to ameliorate this kind of perceived shortage, since nursing care is a cost with no associated revenue.

It is worth noting that while vacancies (economic shortages) may increase as the hospital's available nursing budget rises (as shown in the middle panel of Figure 3), the hospital's professional standards shortage is reduced by budget increases (as the gap between N_{FCH} and N_{min} narrows).

Note that, while we have set out this explanation in the context of the FCH model, the explanation does not rest on that particular institutional setting. All it requires is that the medical professionals at the hospital who judge standards for "good treatment" believe that the budgeted nursing supply does not quite "measure up" to the kind of quality of care they would, in an ideal world, be able to supply. Thus, the explanation has the potential to apply across a wide range of hospital settings.

In short, perceptions of widespread, persistent shortages may be generated by the belief that current staffing levels are insufficient. For example, Cramer et al. (2006), who estimate urban and rural county-level nursing shortages, compute shortages based on comparisons of the "actual number of RNs employed in hospital-based settings with targets of RN need", where RN needs are estimated based on "the amount of labor thought necessary to deliver safe, effective, or

[41] Suppose that the hospital were required, by state law, to hire a minimum number of nurses. If this legally-mandated minimum were between points H and F, the hospital with budget B_1 would be out of compliance with the law and potentially subject to some fine. Such a hospital could meet the standard by reallocating budget away from other departments to the nursing department. However, the hospital may be willing to risk being out of compliance if such a reallocation would entail greater costs than the potential legal penalty. If the legally-mandated minimum were to the right of point F, then no funds-constrained hospital could meet the legal standard in the short-run, regardless of the size of its budget, due to the position of the residual supply curve. May, Bazzoli, and Gerland (2006) report that some hospitals in California restrict patient volume to meet the legal staffing requirement, which represents a deviation from the assumption in Equation 4 that all patients are admitted. A similar analysis would apply to considerations of whether to meet a minimum standard to obtain accreditation through the Joint Commission on the Accreditation of Healthcare Organizations (with failure to do so entailing some penalty to the hospital). A thorough analysis of such provisions is beyond the scope of our paper**.**

high-quality care" (p. 250). Moreover, much public policy attention to nursing shortages has been produced by projections of future shortages as the population ages (see US DHHS 2002). These projections are clearly based on perceived needs for particular nurse-patient ratios, rather than on expected differences in nurse supply and demand at future wage levels.

V. CONCLUSION AND POLICY IMPLICATIONS

There is no doubt that vacancies for nurses sometimes exist. It is also plausible that these vacancies are sometimes larger than at other times. But the mere existence of vacancies does not by itself imply an economic shortage; it only implies that adjustment to changing supply and demand is not instantaneous in a world of imperfect information. To show that nursing markets display persistent and lasting shortages, one would want to demonstrate a continuing level of vacancies "considerably higher" than that for a sample of other occupations involving some skill.[42] But there does not seem to be a definitive source of vacancy data that allows comparison of vacancy levels in nursing versus other occupations involving some skill. Claims of nursing shortages rely on vacancy data collected specially for nursing by the medical community, rather than data collected across occupations by agencies with expertise in collecting labor market data. As a result, we find it plausible that some portion of the supposed "acute" shortage may well be a deficit of nurses relative to an ideal number rather than an economic shortage in the sense of wage adjustments not clearing the market.

This paper has set forth three alternate explanations for persistent nurse shortages. The first explanation posits that given heterogeneity in preferences for working in temporary and permanent positions, an equilibrium will exist where some hospitals will hire both permanent and temporary nurses. Those hospitals may continue to advertise and budget for permanent nurse positions that are seldom filled, even if the wage offered to permanent nurses is above the wage offered to temps. We have offered some anecdotal evidence that hospitals do not perceive temps as filling their vacant positions. Thus, vacancies appear permanent. However, to an economist, these vacancies do not reflect true economic shortages. Our belief is that the existence of these temp positions fills the vacancies. A full empirical test of our hypothesis would require obtaining hospital-level data on the number of permanent budgeted vacancies along with the hospital's number of temporary staff. We leave such an empirical test to future work.

Second, we provide a model that explains the existence of both short-run economic nursing shortages and persistent perceived shortages due to gaps

[42] We owe this point to Don Parsons.

between the current nursing staff and the minimum number of nurses needed to satisfy medical professional standards. The model posits variation in the degree to which hospitals' budgets are constrained within a specific labor market and the likely budgeting process at funds-constrained hospitals. With "premier" hospitals offering efficiency wages in order to lower nursing turnover, we show that the residual labor supply of nurses available to "funds-constrained" hospitals combined with these hospitals' meager budgets can produce both economic and professional standards nursing shortages. These two explanations are consistent with several stylized facts about nurse labor markets. Moreover, the model provides a firm microeconomic grounding for the so-called "dynamic shortage" explanation for nursing shortages. An interesting prediction of the model (which could be empirically tested) is that an expansion of a funds-constrained hospital's budget can reduce the professional standards nursing shortage, while increasing the number of unfilled, budgeted nursing positions. We stress again that, while we use the FCH model to set out a professional standards explanation for perceived persistent shortages, the explanation itself has much more general applicability, and does not depend on the existence of funds-constrained hospitals.

Understanding the true nature of the apparent persistent nursing shortage is critical to determining appropriate policy responses. The U.S. federal government appropriated $150 million in fiscal year 2007 to fund Nursing Workforce Development programs (authorized under Title VIII of the Public Health Service Act). If the existing vacancies for permanent nursing staff result from wages not adjusting upwards due to the availability of temporary contract nurses (mitigating the need for hospitals to raise their wage offers to recruit permanent staff), then the need for such federal government intervention is limited. If, on the other hand, nurse shortages are mainly cyclical and reflect slow market adjustments due to slow diffusion of information about the increased demand or restrictions on available supply due to limitations in the capacity of nursing schools, then there may be a role for federal policy in speeding these adjustments. Finally, if persistent shortages simply reflect levels of nurse staffing that are below the medical profession's standards for quality patient care—and federal shortage models seem to be typically based on "professional standards" concepts of shortages, or similar ideas—then that would certainly re-orient the discussion of the need for federal intervention. We believe that further empirical investigation is warranted, and caution policymakers about basing their decisions on the evidence that is currently available.

APPENDIX: NURSING DEMAND BY A NON-PROFIT HOSPITAL IN A COMPETITIVE MARKET

This appendix extends the model in the text to examine the demand for permanent and temporary nursing staff by a non-profit hospital operating in a competitive market. For a non-profit hospital in a competitive market, Equation 3 becomes:

(3''') $PQ_j = W_1 N_{1j} + W_{2j} N_{2j} + \boldsymbol{P_x}' \boldsymbol{X}_j$

Equations 4 and 5 again hold. We assume that the non-profit hospital administrator desires to maximize quality of care (or quantity, since in our model quantity is a function of quality as price is exogenous), subject to the constraint that the inputs are weakly positive and that profit is zero.

The Lagrangian is the following (with *j* subscripts suppressed):

(7'') $L = Q(C(N, \boldsymbol{X})) + \mu\{PQ(C(N, \boldsymbol{X})) - W_1 N_1 - W_2 N_2 - \boldsymbol{P_x}' \boldsymbol{X}\}$

The Kuhn-Tucker conditions are as follows:

(8a'') $$\frac{\partial L}{\partial N_1} \le 0 \rightarrow \frac{\partial Q}{\partial C}\frac{\partial C}{\partial N_1} + \mu\left\{P\frac{\partial Q}{\partial C}\frac{\partial C}{\partial N_1} - W_1\right\} \le 0$$

(8b'') $$\frac{\partial L}{\partial N_2} \le 0 \rightarrow \frac{\partial Q}{\partial C}\frac{\partial C}{\partial N_2} + \mu\left\{P\frac{\partial Q}{\partial C}\frac{\partial C}{\partial N_2} - W_2\right\} \le 0$$

(8c'') $$\frac{\partial L}{\partial \boldsymbol{X}} = 0 \rightarrow \frac{\partial Q}{\partial C}\frac{\partial C}{\partial \boldsymbol{X}} + \mu\left\{P\frac{\partial Q}{\partial C}\frac{\partial C}{\partial \boldsymbol{X}} - P_X\right\} = 0$$

(8d'') $$N_1\frac{\partial L}{\partial N_1} = 0$$

(8e'') $$N_2\frac{\partial L}{\partial N_2} = 0$$

(8f'') $N_1 \ge 0$ and $N_2 \ge 0$

(8g'') $$\frac{\partial L}{\partial \mu} = 0 \rightarrow PQ(C(N, \boldsymbol{X})) = W_1 N_1 + W_2 N_2 + \boldsymbol{P_x}' \boldsymbol{X}$$

Assuming that the hospital hires both temporary and permanent nurses, it is fairly easy to show (by combining Equations 8a" and 8b" with their inequality signs replaced by equal signs) that W_2 must again equal αW_1, as in Equation 10. Again, if this equality did not hold, the hospital would hire only permanent (or only temporary) nurses. However, if the equality did hold, the hospital would hire both temporary and permanent nurses and the hospital would perceive that vacancies exist for permanent nurses even given $W_1 > W_2$.

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