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Are Hospital Pharmacies More Efficient if They Employ Nurses?

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Abstract

This paper assesses the efficiency of utilizing nurses in Washington State hospital pharmacies. We take the perspective of a pharmacy department manager and model an input oriented hospital pharmacy production process. Data envelopment analysis (DEA) is used to examine both scale efficiency and technical efficiency, and differences across hospital pharmacies that use and do not use nurse staffing are analyzed using cross-tabulations and nonparametric hypothesis tests. The results indicate that the use of nurse staffing does not significantly impact either scale or technical efficiency. Thus, permitting nurses to play a greater role in hospital pharmacies does not adversely affect efficiency. This paper has important policy implications for hospital administrators and pharmacists.

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1. Introduction

Hospitals in the U.S. are facing a growing challenge in providing pharmaceutical services, especially in medically underserved areas (Pickette, Sodorff and Lordan 2002; Traynor, Sorensen and Larson 2007). Some see increased utilization of nurses in hospital pharmacies as a solution. One example is pharmacy-based telemedicine (or "telepharmacy"), where nurses and pharmacy technicians use audio-visual technology to collaborate with pharmacists and other specialized practitioners at distant locations to provide pharmaceutical care (Peterson and Anderson, Jr., 2004; Friesner and Scott 2009).

Many hospital pharmacies employ nurses, either as relief for pharmacy technicians or, for specific tasks, as relief for registered pharmacists (Facchinetti, Campbell and Jones 1999). In addition to relief work, the nursing staff may also collaborate with pharmacists on medication therapy and disease state management activities for chronic illnesses such as diabetes, hypertension and asthma (Leal and Soto 2005). Further, many hospitals integrate pharmacy services into other cost centers or departments to ensure higher quality care. For example, many emergency rooms and trauma centers now contain automated dispensing machines with a limited number of frequently used medications in standardized dosages. (Kester, Baxter and Freudenthal 2006). While it is ultimately the pharmacy department's responsibility to monitor and maintain both the machines and pharmaceutical care services provided, nurses working in these non-pharmacy departments may play a larger role in the provision of pharmaceutical care. Given the potential opportunities for nurses to work in hospital pharmacies, it is interesting to examine whether hospitals that employ nursing staff in their pharmacies are more or less efficient than those that do not use nurses in this fashion.

The debate surrounding the use of nurses in hospital pharmacies can be categorized along two lines: quality and efficiency. Empirical evidence surrounding quality is sparse but does exist (Pickette, Sodorff and Lordan 2002; Casey *et al*. 2008) and a few studies focus specifically on the efficiency of hospital pharmacies (Capettini and Morey 1985; Okunade 1993; Okunade 2001; Schumock *et al.* 2009). We expand this literature by examining the efficiency implications of using nurses to perform tasks traditionally performed by pharmacists. The literature surrounding efficiency in the pharmacy has received scant attention, with only Schumock *et al.* (2009), Okunake (1993, 2001) and Capettini and Morey (1985) focusing on the hospital pharmacy as the unit of observation. None of these studies give primary emphasis to the role that nurses play in the efficient provision of pharmacy services. Given the extensive use of pharmaceutical care in hospitals, the legal restrictions on pharmacy production, and the large variation in how pharmacies are staffed, the efficiency of hospital pharmacy units and the role that nurses play in this process deserves additional scrutiny.

We present an exploratory, empirical investigation of the efficiency of utilizing nurses in Washington State hospital pharmacies. We model an input oriented hospital pharmacy production process, and use a linear programming technique, data envelopment analysis (DEA), to examine both scale efficiency and technical efficiency differences between hospital pharmacies that staff nurses and those that do not. We subsequently present a discussion of our data and empirical results. We conclude with policy implications arising from the analysis, as well as some suggestions for future work in this area.

2. A Simple Model of Efficient Hospital Pharmacy Production

Our analysis takes the perspective of the pharmacy department manager who must provide pharmaceutical care to all patients admitted to the hospital using the available resources allocated to the pharmacy department in the budgeting process. Since the pharmacy manager does not control the number and sickness of the patients admitted to the hospital, and by extension does not control the quantity of pharmacy services provided by his/her staff, the pharmacy manager is faced with an input-oriented production process (Capettini and Morey 1985; Okunade 1993).

Rather than attempting to measure pharmacy department output with an intermediate measure, such as the number of prescriptions, consultations by the department staff or similar measures, (Fare *et al.* 1992; Fare, Grosskopf and Roos 1995) we define output as the dollar value of the pharmacy department's output as a proportion of the dollar value of output produced by the hospital. We empirically characterize output using total inpatient pharmacy (billed) charges divided by total hospital inpatient charges as one measure, and total outpatient pharmacy charges divided by total outpatient charges for the hospital as a second output measure[1]. We do this for several, related reasons. Using a simple measure of pharmacy output like the number of prescriptions filled may miss some significant parts of actual pharmacy practice. Pharmacists in hospitals do much more than just fill prescriptions. They visit with patients and consult with physicians, nurses, and dietary staff, among other tasks. These unmeasured but time-draining activities may be better caught by our measures than the number of prescriptions filled, especially since the latter may differ remarkably in complexity and ancillary pharmacy tasks. Also, in our dataset, a hospital pharmacy is not required to report the quantity of dispensing activity[2], nor does it report actual reimbursements at the departmental level. More importantly, pharmaceutical care services are an intermediate output in a much more complex production process where pharmacy services are used to restore a patient's health stock. Patients with more severe illnesses will also likely require more intensive pharmaceutical care (in addition to other services) that may not be reflected in a metric such as the number of medications dispensed. As an example, more severe illnesses may require medications that must be compounded or provided via infusion, and thus may take more time, energy and resources than less sick patients requiring standard medications that can be administered orally. It is reasonable to assume that those more intensive services result in higher billed charges. Measuring these charges separately for inpatient and outpatient care, and

[1] We also note in passing that we used the total (real) dollar value of outpatient and inpatient pharmacy charges (not normalized by inpatient or outpatient hospital charges) as outputs and obtained qualitatively similar results.

[2] On the other hand, community (also known as retail) pharmacies are much more focused on dispensing activities, rather than clinical services. As such, it is more appropriate to measure output in community pharmacies with variables such as prescription volumes (Fare *et al.* 1992; Fare, Grosskopf and Roos 1995).

expressing each as a proportion of hospital charges, allows for a more detailed characterization of pharmacy services (measured in non-monetary units) both across the types of pharmacy services and in relation to the hospital as a whole. It also reflects the assumption that pharmacy services are an integral part of the overall care given patients.

We assume that the manager uses several inputs to produce pharmaceutical care. The manager has pharmacy staff (as measured by full time equivalent employees, or FTEs), which contains registered pharmacists, pharmacy assistants and possibly non-pharmacy staff, including nurses. Legal requirements also necessitate that the ratio of registered pharmacists to non-pharmacists working in a pharmacy does not fall below a pre-specified value. We assume this ratio is not binding. As will be discussed in section 4 of the manuscript (see footnote 4), the data used in this study are consistent with this assumption.

Capital (inclusive of physical space and major equipment) is another input. A third input is the quantity of supplies, primarily medications, used by the pharmacy. We account for differences in patient illness severity using a hospital-wide casemix index. Similarly, the size of the hospital also influences its resource constraints, and by extension the number and complexity of services offered.

Theoretically, the measurement of technical efficiency in an input-oriented production processes is modeled through the use of isoquants, as illustrated in Figure 1. For simplicity, we assume that there are only two inputs (FTEs and capital) used to produce a fixed amount of output. An efficient manager chooses input usage such that it lies on the isoquant, for example, at point X. An inefficient manager utilizes too many inputs to produce the fixed output, and thus lies at a point above the frontier (for example, point Y in Figure 1). In relative terms, inefficiency can be characterized by using a "distance function", which measures the radial distance from the origin, through the efficient frontier, to the actual point of production (Fare and Primont 1995; Coelli, Rao and Battese 1998; Cooper, Seiford and Tone 2007). In the case of Figure 1, a pharmacy operating at point Y would have a distance function equal to the ratio 0X/0Y. This measure is bounded between zero and one, with values of one implying full efficiency; that is, 0Y = 0X, which can only occur if the firm is on the isoquant such that X and Y are identical. Efficiency can also be characterized in terms of physical units by using the reduction in inputs necessary to lie on the isoquant. For the pharmacy in Figure 1, this amount is equal to the difference between the line segments $0FTE_Y$ and $0FTE_X$. Further, the two measures are related; one could also characterize the distance function with the ratio $0FTE_X$ / $0FTE_Y$.

In general, an input-oriented production process assumes that a manager controls all of the inputs at her/his disposal, and takes as given the outputs the department must produce. That is, all inputs are deemed "discretionary" (Banker and Morey 1986; Scheel 2000). Within the context of the hospital pharmacy, this is slightly problematic because in addition to not being able to control outputs, the pharmacy manager also has little control over some of the inputs (i.e., those inputs are "non-discretionary"). A manager has control over the number of FTEs utilized in the department, as well as the department's medication supply. In the long run, pharmacy managers likely have control over capital considerations within their department, but likely do not control this variable in short run or intermediate time frames. Hospital-wide variables, including the number of available beds and the casemix index, are also non-discretionary and may be used in the pharmacy at inefficient levels, as higher levels of hospital administration trade-off inefficiency in one cost center for efficiency in another. Any empirical efficiency analysis across hospital pharmacies must take these considerations into account.

In the event that a manager of an input-oriented production process is faced with non-discretionary inputs, one must alter how efficiency is characterized (Banker and Morey 1986; Scheel 2000). For example, suppose that the manager depicted in Figure 1 cannot control capital, making this variable non-discretionary. In such cases, the point X is not a realistic benchmark to measure efficiency, since the firm cannot change (reduce) the amount of capital in order to move to point X. Instead, the appropriate benchmark is point W, where utilization of labor is reduced to the point where the pharmacy is on the isoquant, but capital is unchanged. In this case, the distance function is characterized by the ratio $0FTE_W$ / $0FTE_Y$. Note that efficiency will always be greater when an input is discretionary, because it allows for an efficient reference point that is closer in Euclidean distance to the actual point of production.

3. Empirical Methodology

We investigate whether hospital pharmacies that employ nurses are more or less efficient than those that do not. Because we have sparse prior literature and no *a priori* expectations to guide this determination, we choose the following null hypothesis:

H_0: There is no relationship between the use of nurses in a typical hospital pharmacy and whether that pharmacy is efficient or inefficient.

In a discrete sense, the null hypothesis can be examined in a straightforward manner (Friesner, Rosenman and McPherson 2008; Friesner and Rosenman 2009). More specifically, one can generate cross-tabulations disaggregating whether a pharmacy is efficient or inefficient by whether or not it employs nurses in the pharmacy. Under the null hypothesis hospital efficiency should be independent of nurse staffing. The data are drawn from a random sample and a simple, standard chi-square test of independence (or, in the event of low expected cell counts, Fisher's exact test) can be applied to determine whether the hypothesis is rejected. In all applications of the test, we advocate using a 5 percent significance level.

Two techniques are used to calculate efficiency scores, and each approach has positive and negative attributes (Coelli and Battese 1998; Jacobs 2001; Hollingsworth 2003). Stochastic frontier analysis (SFA) is a regression-based approach that uses the regression's covariates to empirically characterize the technology. The efficiency estimates are subsequently decomposed from the model's error term. SFA is appropriate when the data are randomly drawn from the population, and when the researcher can reliably make *a priori* expectations about both the production technology and the distribution of efficiency scores vis-à-vis the regression's error term. It does not work well when these assumptions are violated.

The alternative, data envelopment analysis (DEA), is a linear programming technique that uses regularities in the data to characterize the production frontier and the resulting efficiency estimates. DEA is more appropriately applied when little is known about the production technology. It is also robust to endogeneity considerations (which may be problematic for input oriented technologies) and can be used with random or convenience samples.

There are two primary drawbacks to DEA. The procedure is based on a linear programming algorithm, and therefore lacks well-defined statistical properties (Banker 1993; Simar and Wilson 2007; Kneip, Simar and Wilson 2009). Moreover, studies indicate that the efficiency scores are not easily amenable to secondary regression analysis to determine which factors increase or decrease efficiency.[3] Second, when applying DEA to convenience or randomly collected samples, the results may be severely distorted by outliers or out-of-sample information (Simar and Wilson 2007). In these cases, DEA-based efficiency scores are biased upwards, and overstate efficiency. Therefore, even if the data come from a randomly collected sample, it is difficult (and if one has a small sample or few covariates, impossible) to make meaningful statistical inferences using parametric or semi-parametric techniques (Banker 1993). Consequently, for data drawn as a random sample, mean or median differences across a small number of exogenous factors may be analyzed using non-parametric (rank-order) hypothesis tests (Clement *et al.* 2008; Friesner, Rosenman and McPherson 2008; Friesner and Rosenman 2009). For other types of data sets, a conservative approach is to place observations into discrete classes and examine differences across groups of efficiency metrics.

We use DEA for several reasons. First, the data have multiple outputs, and thus are more amenable to DEA. Second, the null hypothesis is, by definition, relative in nature; we examine whether hospitals using nurses are more or less efficient than those that do not. Consequently, the upward bias in DEA scores is not of substantial concern because we are interested in relative differences in efficiency across the two types of pharmacies. The relative manner in which DEA constructs the efficient frontier is highly consistent with our relative hypothesis. Also, we face data limitations on the number and types of covariates to explain efficiency differences across pharmacies, which would likely create omitted variable bias using SFA. When applicable, we use rank-order nonparametric tests; hence the autocorrelation in DEA scores is not a significant concern.

A final issue concerns the use of discretionary and non-discretionary inputs. Since this analysis is conducted from the perspective of the pharmacy department manager, it is likely that the manager can control the number of pharmacy FTEs, making this variable discretionary. Supplies (i.e. medications) are also treated as discretionary. However, the pharmacy department's capital, as well as the hospital-wide variables, including size and patient case-mix, are likely non-discretionary. To account for these issues, we use Banker and Morey's (1986) formulation of the input-oriented DEA linear program (LP), and refer the reader to that citation for the formal linear program. All DEA calculations are conducted using the EMS program (Scheel 2000). Subsequent analyses of all DEA results are conducted using SPSS, Version 16.0 (SPSS 2008).

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[3] The efficiency scores are highly serially correlated in an unknown manner (Simar and Wilson 2007) that makes it impossible to correct. Thus, any estimates in the secondary regression would be biased, also in an unknown manner.

4. Data

Our data come from Washington State hospitals for the years 2005 - 2007. Each year, the Washington State Department of Health requires each hospital in the State to report detailed financial and operating information. This information is made publicly available on the Department's website (http://www.doh.wa.gov/EHSPHL/hospdata/YearEnd/Default.htm). The data are reported both at an aggregate level and, to the extent possible, at the level of the cost center or department. Information on the number of full-time equivalent employees (including a binary indicator of whether nurses are included in the pharmacy department's FTEs), and the square footage of the pharmacy cost center (which we use as a proxy for capital) are culled. Supply utilization is measured by calculating the proportion of the pharmacy's total expenses that are allocated to supplies. We use two measure of pharmacy output: total inpatient pharmacy (billed) charges divided by total hospital inpatient charges; and total outpatient pharmacy charges divided by total outpatient charges for the hospital as a second output measure. To control for the number and mix of services provided by the hospital as a whole (which necessarily impacts pharmacy department utilization), the total number of available hospital beds is included. We assume that a larger number of beds indicates greater physical, technological and human resources, which in turn suggests the potential to provide a wider and more advanced set of services. Patient illness severity is measured using a hospital wide casemix index generated by the Washington State Department of Health.

The initial sample contains 97 hospitals and 291 observations.[4] A potentially confounding issue in the analysis is the nature of the hospital being examined. For example, hospitals in rural areas may have difficulty recruiting pharmacists and technicians to work in the pharmacy, and thus be forced out of necessity to use nurse staffing in the pharmacy. On the other hand, urban hospitals (which also tend to be larger) may be better able to incorporate nurses into the pharmacy production process via the use of technology: for example, placing an automated dispensing machine in an emergency room or trauma department. As a result, we choose to limit our analysis to two specific groups of pharmacies that are of great public policy concern, are likely to use similar production technologies, produce similar services, and provide similar levels of health care quality: pharmacies housed in rural, non-specialty, community-owned hospitals with less than 125 beds; and pharmacies located in urban, non-specialty, private, not-for-profit hospitals with more than 125 beds. We also eliminated those pharmacies which allocate no square footage to the pharmacy cost center, which allocate 0.0 FTEs to the pharmacy cost center, and which fail to report any productive activity at the level of the hospital. Finally, all remaining hospitals except one provide both inpatient and outpatient pharmacy services. We eliminate this observation to ensure consistency across our data. We are left with two panels: 20 rural, general, community-owned hospital pharmacies

[4] The dataset is available at https://www.ndsu.edu/pubweb/~dfriesne/ProfessionalInfo.htm.

with 56 observations; and 25 urban, private, not-for-profit hospitals pharmacies with 74 observations. We apply DEA and test our hypotheses separately for each of these panels.

Table 1 contains the names, definitions and some basic descriptive statistics for each variable. Panel A contains information pertaining to rural, general, community-owned hospital pharmacies. The hospitals housing these pharmacies have, at the mean (median), 34.46 (29) available beds per facility, and casemix indices of 0.69 (0.69). The pharmacies located in these hospitals exhibit mean (median) FTEs of 4.05 (2.95) and a standard deviation of 3.61. Approximately fourteen percent of these hospital pharmacy FTEs are nurses. The mean (median) square footage of these pharmacies is 690.55 (720), with a standard deviation of 529.82. Sixty-two percent of the pharmacy's expenses were generated by supplies. Lastly, the pharmacy generates, at the mean (median) 6.7 (6.2) percent of all outpatient billed hospital charges and 11.5 (11.5) percent of all inpatient billed charges.

Table 1, Panel B contains information for urban, non-specialty, private, not-for-profit hospitals. The hospitals housing these pharmacies are much larger in the number and extent of services offered. At the mean (median), these hospitals have 269.05 (242) available beds per facility, and casemix indices of 1.04 (1.03). The pharmacies located in these hospitals have mean (median) FTEs of 49.30 (41.30) and a standard deviation of 28.83. Approximately twenty-six percent of these hospital pharmacy FTEs are nurses. The mean (median) square footage of these pharmacies is also much larger, at 5,622.34 (4,503), with a standard deviation of 3,467.32. In addition, 70.2 (68.0) percent of the pharmacy's expenses were generated by supplies. Lastly, the pharmacy generates, at the mean (median) 7.8 (7.5) percent of all outpatient billed hospital charges and 12.1 (12.2) percent of all inpatient billed charges.

More generally, our dataset is defined by information hospitals make available. For example, our dataset is unique in that total FTEs and nursing FTEs in the pharmacy cost center are reported. There is, however, no disaggregation between non-nursing FTEs, which for the most part are pharmacists and technicians. This is of little consequence since the vast majority of non-nursing hospital pharmacy staff are, in fact, registered pharmacists.[5] Similarly, there are no quality or service intensity metrics available similar to those used in previous studies of primarily community pharmacy efficiency (Fare *et al.* 1992; Fare, Grosskopf and Roos 1995). To the extent possible, we control for these differences by narrowly defining the types of hospitals included in our analysis, as well as by carefully defining our output variables. However, the lack of quality measures is certainly a limitation of our

[5] In 2007, for example, 78 of the hospital pharmacies report information on FTEs and expenses (salary and benefit) per FTE. These hospitals, on average, employee 23 FTEs, and the mean expense per FTE is $93,684. Given that pharmacists and nurses earn substantially higher salaries than do pharmacy technicians (or interns), this implies that the non-nursing staff are primarily pharmacists (Desselle 2005; Scott and Halvorson 2007). As mentioned earlier, this also implies that the ratio of technicians (and other non-pharmacist staff) to pharmacists is well below the legal maximum.

analysis, and future research is necessary to examine how the inclusion of such metrics affect our findings.

5. Results

Table 2 contains an analysis of technical efficiency for rural, non-specialty, community-owned hospital pharmacies. Panel A contains efficiency scores. This category of hospitals has a mean (median) level of technical efficiency equal to 0.849 (0.933), implying that most pharmacies are closer to being fully efficient than fully inefficient. The standard deviation of 0.171 corroborates this statement; most hospital pharmacies have efficiency scores between approximately 1.0 and 0.68.

Table 2, Panel B contains the results from cross-tabulations disaggregating technical efficiency by nurse allocation for rural, non-specialty, community-owned hospital pharmacies. Of the 56 hospital pharmacies in this category, 48 do not allocate nurses to the pharmacy and 8 allocate nurses. Of the 48 hospital pharmacies, 20 are technically efficient and 28 are not. Similarly, of the 8 pharmacies that employ nurses, half are efficient (4) and half are inefficient. Given the relatively even distribution of efficient and inefficient pharmacies that do and do not use nurse staffing, we conclude that allocating nurses to the pharmacy does not noticeably impact efficiency in these practice settings. Thus, we fail to reject our null hypothesis. The chi-square and Fisher's exact tests corroborate these findings; none of the statistics and their corresponding probability values indicate rejection of the null at the 5 percent level.

Technical efficiency results for urban, non-specialty, private not-for-profit hospital pharmacies are contained in Table 3, Panel A. This category of hospitals has a median level of technical efficiency (0.828) which is slightly higher than the corresponding mean (0.840), implying that most pharmacies are closer to being fully technically efficient than fully technically inefficient. A standard deviation of 0.135 implies most firms have efficiency scores between approximately 0.98 and 0.71.

Table 3, Panel B contains the results from cross-tabulations disaggregating technical efficiency by nurse allocation. The results generally mimic those from Table 2. Of the 74 hospital pharmacies in this category, 19 allocated nurses to the pharmacy and 55 did not. Of these 55 pharmacies, 14 (or 25 percent) were technically efficient. At the same time 5 of the 19 pharmacies that employ nurses (or 26 percent) are technically efficient. Once again, the chi-square and Fisher's exact tests fail to find any significant association between technical efficiency and nurse allocation at the 5 percent level.

6. Conclusions and Policy Implications

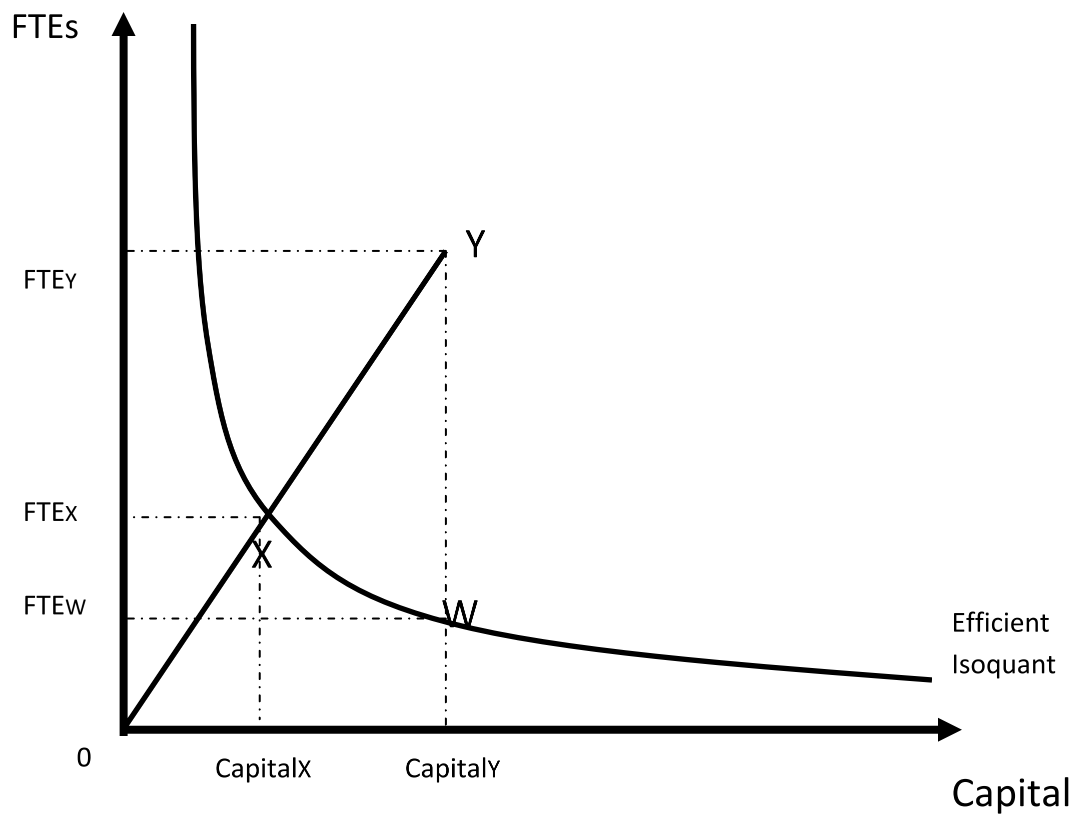
Our empirical analysis investigates whether hospital pharmacies that employ nurses are more or less efficient than those that do not. Using two panels of annual data on Washington State, non-specialty hospitals (urban, private not-for-profit and rural, community-owned) over the period 2005-2007, we find that the use of nurses does not affect technical efficiency.

Our work has an important policy implication for hospital administrators and pharmacists. Hospitals and other health systems often have difficulties recruiting staff. In cases where a hospital has relatively more difficulty acquiring adequate pharmacy staff, one option is to allow nurses greater opportunities to collaborate with pharmacy staff in the provision of pharmaceutical care. Since most nurses (especially those who do not have advanced clinical training) are trained as generalists, and are not well versed in the nuances of pharmacotherapy, this collaboration inevitably begs two questions: "Does allowing nurses a greater role in the pharmacy impact the quality of pharmacy services, including medication errors and patient safety?" and "Does allowing nurses to play a greater role impact the pharmacy's efficiency?" The first of these questions has been addressed in the literature, although the evidence is limited (Bond, Raehl and Franke 2002; Pickertte, Sodorff and Lordan 2002; Peterson and Anderson, Jr., 2004; Casey *et al.* 2008). To the best of our knowledge, our paper is the first in the literature to address the latter of these issues, and the conclusion we draw is that there is not an adverse effect on efficiency.

Our study has a number of limitations. The data are not exhaustive, and we do not explore efficiency across all ownership and/or practice types; most notably we do not assess proprietary and specialty hospitals. Additionally, the data come from a single U.S. state. While regulatory and professional standards are relatively (but not perfectly) consistent across U.S. states[6], and thus suggest (but in no way proves) generalizability within the U.S., it is unclear whether our findings are generalizable to hospital pharmacies in other countries. Third, we do not fully account for positive (i.e., reduced medication interactions) or negative (i.e., medication errors) quality metrics commonly utilized in the provision of pharmaceutical care. Fourth, we only assess two types of efficiency: technical efficiency and scale efficiency. Thus it is also important to examine other efficiency-based metrics, most notably cost efficiency, congestion and dynamic productivity change, to fully explore this issue. Lastly, data limitations (including the small sample sizes and the use of convenience samples) and the empirical technique used to estimate efficiency (DEA) prevent us from using regression or other appropriate statistical techniques to undertake an extensive analysis of the determinants of efficiency. Further work that examines hospital pharmacy efficiency while accounting for these factors would provide valuable information for pharmacy managers, hospital administrators and policy makers.

[6] A comparison of regulatory similarities and differences across U.S. states can be conducted by viewing information contained on the National Association of Boards of Pharmacy website (www.nabp.net). This website contains links to each of the state board websites (which in turn contain state-specific regulations), as well as information on the national competency exam (NAPLEX). It also contains links to several international pharmacy boards, including Canada, Australia and New Zealand.

Figure 1: A Simple Illustration of Technical Efficiency in Hospital Pharmacies



Note: FTEs = full time equivalent employees.

Table 1: Variable Names, Definitions and Descriptive Statistics

Panel A: Rural, Non-Specialty, Community-Owned Hospitals and Their Pharmacy Departments

Variable	Description	Mean	Median	Deviation
Fte	Number of full time equivalent employees allocated to the pharmacy	4.049	2.950	3.612
Psupp	Proportion of total pharmacy operating expenses spent on supplies, primarily medications	0.620	0.617	0.154
Avlbeds	Number of hospital-wide available beds	34.464	29.000	16.382
Cmi	Hospital casemix index	0.690	0.689	0.103
Sqfeet	Square footage of the pharmacy	690.554	720.000	529.820
Pctiprev	Pharmacy's inpatient billed charges, divided by the hospital's inpatient billed charges	0.115	0.115	0.038
Pctoprev	Pharmacy's outpatient billed charges, divided by the hospital's outpatient billed charges	0.067	0.062	0.030
Nursedummy	Binary variable identifying whether nursing FTEs are allocated to the pharmacy	0.143	0.000	0.353
Number of Observations		56		
Number of Firms		20		

Panel B: Urban, Non-Specialty, Private Not-for-Profit Hospitals and Their Pharmacy Departments

Variable	Description	Mean	Median	Deviation
Fte	Number of full time equivalent employees allocated to the pharmacy	49.296	41.295	28.832
Psupp	Proportion of total pharmacy operating expenses spent on supplies, primarily medications	0.702	0.680	0.143
Avlbeds	Number of hospital-wide available beds	269.054	242.000	128.334
Cmi	Hospital casemix index	1.036	1.026	0.217
Sqfeet	Square footage of the pharmacy	5622.338	4503.000	3647.316
Pctiprev	Pharmacy's inpatient billed charges, divided by the hospital's inpatient billed charges	0.121	0.122	0.029
Pctoprev	Pharmacy's outpatient billed charges, divided by the hospital's outpatient billed charges	0.078	0.075	0.039
Nursedummy	Binary variable identifying whether nursing FTEs are allocated to the pharmacy	0.257	0.000	0.440
Number of Observations		74		
Number of Firms		25		

Table 2: Efficiency Results for Rural, Non-Specialty, Community-Owned Hospital Pharmacies

Panel A: Efficiency Results for Rural, Non-Specialty, Community-Owned Pharmacies

Variable	Description	Mean	Median	Standard Deviation
TE	Input-oriented technical efficiency score	0.849	0.933	0.171

Panel B: Cross-Tabulations Disaggregating Technical Efficiency by Nurse Allocation to the Pharmacy

	Do Not Allocate Nurses to the Hospital Pharmacy	Allocate Nurses	Total
Not Technically Efficient	28	4	32
Technically Efficient	20	4	24
Total	48	8	56
Chi-Square Statistic		0.194	
2-Sided Probability		0.659	
Fisher's Exact Test			
2-Sided Probability		0.713	
1-Sided Probability		0.473	

Table 3: Efficiency Results for Urban, Non-Specialty, Private Not-for-Profit Hospital Pharmacies

Panel A: Efficiency Results for Urban, Non-Specialty, Private Not-for-Profit Pharmacies

Variable	Description	Mean	Median	Standard Deviation
TE	Input-oriented technical efficiency score	0.840	0.828	0.135

Panel B: Cross-Tabulations Disaggregating Technical Efficiency by Nurse Allocation to the Pharmacy

	Do Not Allocate Nurses to the Hospital Pharmacy	Allocate Nurses	Total
Not Technically Effic	41	14	55
Technically Efficient	14	5	19
Total	55	19	74
Chi-Square Statistic		0.005	
2-Sided Probability		0.941	
Fisher's Exact Test			
2-Sided Probability		1.000	
1-Sided Probability		0.581	

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