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Inefficient or Not, Hospitals Are Overcharging

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Abstract A sizable literature related to the efficiency of the U.S. hospital sector has been produced over the past 30 years. Much of this research is based on stochastic frontier analysis. This approach is problematic for a number of reasons. For one, a functional form for a hospital's cost function must be assumed, and a limited number of forms are tractable. Second, inefficiency is measured as the expectation of a random variable with a pre-determined distribution, with no theoretical justification for the underlying assumption, that observed cost equals minimum cost plus some non-negative, random amount. Thus, the conclusion reached by most of these studies, that U.S. hospitals are inefficient, may not be foregone. Using an entirely different methodology that obviates these shortcomings, the current study suggests that whether or not hospitals are efficient, their revenues have not been increasing in proportion to the minimum cost of providing their services. This study's estimates of the impact of input prices and technology on production costs indicate that between 2000 and 2017, hospital revenues increased at a substantially higher rate than hospital costs. This study suggests that hospitals are pricing their services well above average cost. As a result, in 2017 over $200 billion could have been transferred from patients to the hospital sector, whether due to the proclivity of hospital administrators to purchase more inputs than are necessary for production, or to subsidize activities other than patient care.

Keywords Hospital revenues · Costs · Production efficiency

JEL Classification Codes D22 · D24 · I11

Introduction

Numerous studies have called into question the efficiency of American hospitals. Many of these studies have found that U.S. hospitals use more inputs than are necessary to provide

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the quantity and quality of services that they provide. Typically, inefficiency is measured using a stochastic cost frontier, or by comparison to a set of hospitals identified as efficient providers. The former approach assumes that the difference between observed cost and minimum cost can be decomposed into two independent random variables (Aigner et al. 1977, Zuckerman et al. 1994, Vitaliano & Toren 1996, Rosko 2001). One of these has an expected value of zero. The range of the other is non-negative and hence has a positive expected value. By assuming a particular distribution for the latter, this value can be estimated and used to measure how inefficient hospitals are. The latter approach is referred to as data envelopment analysis. This methodology is designed to determine the relative efficiency of a hospital using linear programming techniques (Hollingsworth 2008). That is, a measure of a specific hospital's inefficiency comes from comparing that hospital's costs to the costs incurred by hospitals identified as efficient. In any case, both approaches are problematic. Therefore, alternative approaches need to be explored, if for no other reason than to corroborate the conclusion that must be drawn from this body of research: hospitals spend more to provide services than is necessary.[1]

The concern that the public has over the efficiency of hospitals presumably arises from the hypothesis that costs determine prices, but even if hospitals are efficient producers, they may not price their services on the basis of costs. If hospitals fail to align prices with average costs, then regardless of how they choose to produce their services, there is an inefficiency, in the same way that a monopoly creates an inefficiency. To the authors' knowledge, no one has considered the possibility that the price of a hospital service is not closely linked to the average cost of providing that service, whether or not cost is being minimized. Consequently, an estimate of the welfare loss that is being imposed on consumers by prices greater than average costs has yet to be made. The purpose of the research presented here is to do just that, to determine if the changes in the prices of hospital services observed over the past 20 years are consistent with how the minimum costs of providing those services have changed. To this end, how hospital revenues have changed over time was compared to how costs would have changed if hospitals were cost minimizers. Clearly, this focus is one degree removed from the question of whether or not hospitals are inefficient, in a technical sense, purchasing more inputs than are needed to provide their services. In fact, this study does not speak to whether or not hospitals are inefficient, in this sense of the term.

Of course, if revenues are growing faster than production costs, hospital administrators are collecting bigger and bigger rents, the disbursement of which they have discretion over. Therefore, consumers are being forced to subsidize those activities and initiatives favored by hospital management, even if they are not being forced to subsidize inefficiency. Regardless of how those rents are being disbursed (e.g., on unneeded inputs, above market wages and salaries, pet projects, to accumulate assets, to provide charity care), there is a compelling normative question. Should consumers be expected to subsidize activities that administrators find worthy of financial support?

In any case, what matters most is the size of these rents, which is what this analysis is intended to shed light on. Obviously, in order to measure the rents being collected

[1] Stochastic frontier analysis has almost always led to the conclusion that hospitals are inefficient. However, as Newhouse (1994, p. 320) pointed out: "Strong and non-testable assumptions must be made to obtain results with these methods." See Mutter et al. (2011) for a more recent discussion of the limitations of these two methodologies.

(implicitly) by hospitals, it is necessary to determine how the minimum cost of providing hospital services has changed. The difficulty of extracting that cost from the available data warrants considering alternative approaches to the problem. Hospital expenses are reported in a fog of accounting laws, regulations, and conventions. For example, looking at a 990 Form filed with the U.S. Internal Revenue Service by a non-profit hospital, one quickly realizes that expenses may woefully misrepresent costs, and extracting production costs from the amounts reported on such a filing is impossible.[2] Part IX of that form shows that grants made by the hospital are an expense, as are disbursements for lobbying, advertising, travel, conferences, and fund raising. Bad debt is also considered an expense. Clearly none of these expenditures are production costs, unless a ridiculously broad definition of production is imposed. Consequently, any estimate of cost based on a hospital's expenses is liable to be misleading. In view of these and the numerous econometric hurdles posed by stochastic frontier analysis, an approach that obviates estimating a production function could be insightful.

By using relationships from standard cost theory, it is possible to estimate the rate at which hospital costs would have increased if hospitals were cost minimizers. Moreover, the elements from cost theory upon which this study relies are independent of the functional form of the cost function. Using this rate of increase and actual hospital revenues, the rents that hospitals are extracting from their patients were calculated. Our estimate of minimum cost and revenue data from the U.S. Department of Health and Human Services (2016, 2018) indicate that these rents may have been as much as $185 billion in 2017. Thus, using an entirely novel methodology, this study concludes that, whether or not the hospital sector is efficient, it is not providing services to consumers at prices based on minimum costs. Also, the calculations indicate that the difference between revenues and costs has been increasing. Projecting revenues and costs to 2027 using the observed rates of change leads to the conclusion that this difference could reach a half trillion dollars annually by then.

Hospital cost function

There is a minimum cost for providing a hospital service, such as room and board, or a particular test or surgery. This cost, *C*, is determined by the number of patients who were provided that service per period (*n*). the standard of care (*s*), a vector of market-determined input prices (***w***) and hospital technology. This cost is defined by the minimization problem,

$$min\ w{\cdot}z\ \ s.t.n = F(s, z), \tag{1}$$

where *z* is a vector of inputs and *F(s, z)* is the hospital's production function, whose form (and arguments) depend on current technology. Let *z(w, n, s)* be the vector of input quantities that solves Eq. (1). Then minimum cost is given by the function

$$C = C(n, w, s) = w{\cdot}\ z(w, n, s). \tag{2}$$

Note that the standard of care is treated as an exogenous variable.

[2] The most commonly used datum for the cost incurred by a U.S. hospital comes from cost reports filed with Medicare, the medical insurance provided to elderly U.S. residents by the federal government of the United States.

Now suppose that by a future date, input prices and technology have changed and consequently, the hospital's cost function becomes

$$D(n, w, s) = w \cdot z'(w, n, s), \tag{3}$$

where *z'* is the vector of inputs solving Eq. (1) when the production function is *G(s,z)*, the production function that reflects the new technology. Thus, the change in cost between the two periods can be decomposed into

$$D(n, w') - C(n, w) = C(n, w') - C(n, w) + D(n, w') - C(n, w'). \tag{4}$$

The first difference on the right-hand side of Eq. (4) is the change in cost due to any change in input prices with the initial technology. The second difference is the change due to the adoption of new technologies with input prices at their values in the latter period.

If a hospital is a cost minimizer, the first difference can be estimated using cost shares and changes in input prices. A first approximation of that difference is

$$C(n, w') - C(n, w) = \sum (\partial C / \partial w_j)(w_j' - w_j). \tag{5}$$

From Shepard's lemma, $\partial C/\partial w_j = z_j$ and thus it follows that this component of the change in cost will, percentage-wise, be approximately

$$(C(n, w') - C(n, w))/C(n, w) = \sum s_j \, (w_j' - w_j)/w_j \tag{6}$$

where s_i is the cost share of input *i*. This sum can be estimated using data on input prices and hospital cost shares.

Now, the second difference in Eq. (4) will be

$$D(n, w') - C(n, w') = w' \cdot (z'(n, w') - z(n, w')), \tag{7}$$

where *z' = z'(n, w')* is input use with the new technology and *z = z(n, w')* is input use with the original technology, both when input prices are *w'*. Therefore, the effect of new diagnostic and treatment methods on the cost of hospital services can be estimated from the changes in input use by hospitals.

Note that these components of the change in cost are predicated on a constant output. This is only slightly problematic, since the objective is to determine if costs and revenues have increased at the same rate, output constant. With a measure of the change in cost with output at its level in period zero (i.e., 2000), one merely needs to adjust revenues in period 1 (i.e., 2017) for any increase in hospital use over that period. This is not impossible to do.

Estimate of the Effect of Input Prices on Hospital Costs

To produce a reliable estimate of the percentage change in minimum hospital costs due to increases in the prices of inputs, cost shares are needed. These are neither easy to find or estimate. However, the Massachusetts Hospital Association (2010, Table 2) conducted a survey on cost shares for Massachusetts hospitals. That survey produced the following costs shares: employee compensation, 59.2%; purchased services, 7%; supplies, 24.8%; plant operations, 2.7%; depreciation, 4.9%; and interest, 1.4%. In order to have shares that are as meaningful as possible, some estimates were made using a sample of non-profit hospitals in Michigan.[3] Specifically, using the 990 Forms filed in 2017 and 2018 by 36 hospitals with 100 or more licensed beds, the following cost shares were estimated: compensation, 49.5%; purchased services, 9%; supplies, 21%; plant operations, 2.3%; depreciation, 4.5%; and interest, 1%.[4] Interestingly, except for compensation, these percentages match up reasonably well. In fact, when the Michigan percentages are normalized, the only substantial differences are compensation and purchased services. However, the sums of those two shares are virtually the same: 0.662 for Massachusetts hospitals and 0.675 for the study sample. Thus, the study used the average of each share, as displayed in Table 1.

The wage in each year was a weighted average of the wages of doctors, registered nurses, other healthcare practitioners, healthcare support workers, office personnel, business and finance personnel, managers, food preparation workers, and grounds and maintenance workers employed by hospitals.[5] The weight for wages was the number of individuals employed in that capacity divided by total employment in 2000.[6] The wage used for purchased services was the average wage over all hospital employees. The price used for supplies came from the producer price index. The percentage change in the price of operating the plant was taken to be the average of the percentage changes in the prices of commercial electricity and natural gas.

To get a weight for capital inputs, the weights for depreciation and interest were added. The percentage change in the price of capital is the weighted average of the percentage changes in the price indexes for structures and equipment computed by the Bureau of Economic Analysis (BEA).[7] Note that the weight here is calculated using values in 2000.[8] Also note that the percentage changes from 2000 to 2009 and 2000 to 2017 were annualized in computing the annual percentage change in minimum cost attributable to changes in input prices. Table 1 contains the changes in input prices over the two periods, and the resulting annual percentage change in production costs due to

[3] 63 Michigan hospitals are listed in the American Hospital Directory (2021). The hospitals used in this study to calculate shares were those whose U.S. Internal Revenue Service 990 Forms were available on the website Propublica (2021).

[4] These percentages do not add to 1 since there are a number of categories of spending on the 990 Form in addition to these six (e.g., spending on lobbying, advertising, travel, and conference attendance).

[5] The Bureau of Labor Statistics industry code is 622000; the occupation codes are, respectively, 29–1060, 29–1141, 29–0000, 31–0000, 43–0000, 13–0000, 11–0000, 35–0000, 37–0000.

[6] The weights were, respectively, 0.0107, 0.259, 0.2367, 0.1272, 0.1514, 0.0171, 0.0386, 0.0298, 0.0393.

[7] See Table 1.1.4, Bureau of Economic Analysis (2021b). For 2000, 2009, and 2017 the index values for structures were 55.283, 92.613, and 112.668, respectively. The values for equipment were 114.224, 103.169, and 97.565, respectively. As a check, the indexes of five types of equipment were examined: air conditioning and refrigeration equipment (1148), electronic computers & computer equipment (115), x-ray & electro-medical equipment (1179–05), office machinery & parts (1193–07), and surgical & medical instruments (1562) (Bureau of Labor Statistics 2017a, 2009a, 2000, Table 6 in the 2000 and 2009 issues, and Table 9 in the 2017 issue). The averages of the percentage changes in these indexes were negative for both periods and comparable to the percentages changes in the Bureau of Economic Analysis (2021b) index for equipment. The percentage change in the prices of supplies was based on producer price index industry data for general medical and surgical hospitals.

[8] In 2000, the current cost of the net stock of equipment owned by hospitals was $82.2 billion. The value of hospital structures was $336.8 billion. Thus, the weights for structures and equipment were 0.8038 and 0.1962.

Table 1 Hospital average cost shares and percentage changes in input prices

Costs	Cost Share	2000–2009, annualized percent change in price	2000–2017, annualized percent change in price
Compensation	.5795	.0393	.0325
Services	.089	.0394	.0327
Supplies	.2495	.0294	.022
Plant operations	.027	.046	.027
Capital	.0645	.0439	.0319
Annual percentage change in minimum cost of inputs for hospitals		.0377	.03
Percentage change in minimum input costs for hospitals for the period		40.4%	66.5%

Data sources: Authors' calculations, based on data from the Massachusetts Hospital Association (2010), the Bureau of Economic Analysis (2021b), and the Bureau of Labor Statistics (2000, 2009a, 2009b, 2017a, 2017b)

changing input prices if hospitals were minimizing input costs. The annual percentage change in the minimum cost of inputs to hospitals (row 6) comes from multiplying the values under cost share times the values in columns 3 and 4. The percentage change in minimum hospital input costs for the two periods is exp.(0.0377 × 9) - 1 and exp.(0.03 × 17) - 1, respectively. That is, they are the percentage increases in input costs when input costs are increasing continuously at the rates in row 6 (Table 1).

Impact of New Technologies on the Cost of Hospital Service

In order to determine how technological change has affected hospital costs, it is necessary to think about how such a change manifests itself. This estimate of the effect of new technologies on the cost of hospital care is based on Eq. (7). Namely, technological change results in either or both of the following. First, new types of capital goods are employed which may be used along with existing capital goods or they may replace capital goods that the firm had been using to provide services. Second, use of variable inputs changes. New variable inputs may be introduced to the production process, to supplement or replace variable inputs currently being employed. Alternatively, it may be that new technologies induce producers to employ larger or smaller quantities of the variable inputs that they employed prior to the adoption of a new technology.

From this vantage point, any increase in production cost precipitating from the adoption of a new technology can be estimated by costing out the changes in input use that cannot be attributed to changes in the prices of inputs or changes in output. Admittedly, a comprehensive accounting of these changes may be difficult. Nonetheless, this approach should produce a reasonable estimate of the costs resulting from technological change and, by extrapolation, consider the effect of new medical technologies on hospital costs, however rough that measure may be.

Again, let *C(n, w')* and *D(n, w')* be a hospital's cost function initially and after technology changes, respectively, with *w'* input prices in the second period, when the new technology is being used. As noted in Eq. (7), *D(n, w') - C(n, w') = w'· (z'(n, w') - z(n, w'))*. Input and hospital use in 2000 and 2017 are observed at prices in 2000 and 2017, that is, *w*, *w'*, *n*, *n'*, *z'(n, w')*, and *z(n, w')*. Hence, to calculate the above difference, *z'* must be adjusted downward to eliminate the effect of the increase in hospital use on input use. This is hardly problematic. Under the assumption of constant returns to scale, *z'* simply needs to be multiplied by *n/n'*.

Adjusting *z* to account for the change in input prices is another matter. Since *z(n, w')* is cost minimizing when older technology is used and input prices are *w'*, and *z(n, w)* can be used to produce the output *n* when the older technology is used, it must be true that

$$w' \cdot z(n, w) \geq w' \cdot z(n, w') \tag{8}$$

and, therefore,

$$w' \cdot \ (z'(n, w') - z(n, w')) \geq \ w' \cdot (\ z'(n, w') - z(n, w)). \tag{9}$$

Consequently, this may result in an underestimate of the effect of technology on cost when the change in cost due to new technologies is based on observed changes in input use. However, adjusting cost for changes in input use due to changes in their relative prices would require making strong assumptions about production. Therefore, with this caveat, those changes will be ignored.

The percentage change in hospital use was estimated using data on inpatient visits and outpatient days. That is, the percentage increase in total patient days was used as an estimate of the change in hospital use with an inpatient visit counted as one patient day. Data from the American Hospital Association (2016, 2019) indicate that total patient days increased from 713.82 million days in 2000 to 844.09 million days in 2009, an 18.2% increase. From 2000 to 2017, the percentage increase was 33.4%. Consequently, any increase in input use above (or below) 18% and 33% respectively will be attributed to the adoption of new technologies. While total hospital employment rose by only 22.2% from 2000 to 2017, hospital employment of registered nurses and doctors went up substantially more than 33%. Specifically, from 2000 to 2017, employment of registered nurses increased by 40.5% and the number of medical doctors employed increased by 223%. Table 2 displays the raw data on patient days and hospital employment.

Had employment increased by18 % from 2000 to 2009, the numbers of nurses and doctors employed by hospitals would have risen to 1,501,338 and 61,892 respectively. Therefore, in 2009, the employment of 229,018 nurses and 67,178 doctors could be attributed to the adoption of new technologies. Had the employment of nurses and doctors simply kept pace with increased hospital use from 2000 to 2017, the numbers employed in 2017 would have been 1,692,159 and 69,759, respectively. Thus, as many as 95,041 nurses and 99,611 doctors could have been employed in 2017 due to the adoption of new technologies.

Thus, one component of the cost of new technologies is the cost of those medical personnel. The average wages of registered nurses and medical doctors employed by

Table 2 Hospital utilization, employment, and wages

	2000	2009	2017
Inpatient hospital visits[a] millions	192.42	195.37	186.2
Outpatient days[a] millions	521.4	648.72	766.08
Registered nurses employed by hospitals millions[b]	1.2723	1.5719	1.7872
Doctors employed by hospitals[b]	52,450	129,070	169,370
Total hospital employment millions[b]	4.9131	5.6221	6.0018
Annual wage registered nurses employed by hospitals[b]		$67,746	$71,635
Annual wage doctors employed by hospitals[b]		$142,522	$184,995
Price index for equipment[c]	114.2	103.2	97.6
Price index for structures[c]	55.3	92.6	112.7
Value of hospital capital stock billions[d]	$419.0	$741.4	$965.3
Hospital revenues billions[e]	$415.5	$779.9	$1142.6

Data Sources: a) American Hospital Association (2019**)**, Appendix 3, Supplementary Data Tables, Utilization and Volume, Table 3.1 and Table 3.4; b) Bureau of Labor Statistics (2009b, 2017b), Occupational employment and wage statistics: national industry-specific and by ownership; wages are national averages; c) Bureau of Economic Analysis (2021b), Domestic Product and Income, Table 1.1.4: Price indexes for gross domestic product; d) Bureau of Economic Analysis (2021a), Fixed Assets Accounts Tables, Table 3.2ESI: Chain-type quantity indexes for net stock of private fixed assets by industry; e) U.S. Department of Health and Human Services (2016) Table 94 for 2000 data and 2009, and U.S. Department of Health and Human Services (2018) Table 43 for 2017 data.

hospitals in 2009 and 2017 were used to calculate this cost. Data from Vaudrey and Loos (2013) indicate that, as a percentage of wages, fringes for doctors were 20%. However, to account for other employment costs, such as payroll taxes which currently add up to just under 8%, that percentage was increased to 30%. Thus, the cost of employing a doctor or nurse was assumed to be 1.3 times average wages. Using the wages for these occupations in 2009 and 2017 (Table 2), the cost of the doctors and nurses employed because of the adoption of new diagnostic and treatment technologies could be as high as $31.64 billion in 2009 and $42.12 billion in 2017.

However, the impact of new technologies on the cost of the human resources used by hospitals is considerably less because the employment of all other workers did not keep pace with increased hospital use. Total employment by hospitals (net of nurses and doctors) went from 3,588,320 in 2000 to 3,921,190 in 2009 and 4,045,210 in 2017. If employment of these workers had increased by the same percentage as hospital use, their employment would have been 4,234,218 in 2009 and 4,772,466 in 2017. Consequently, the technological changes that took place in hospital operations resulted in a 313,028 worker decrease in employment in 2009 and a 727,256 decrease in 2017. Using the average wage of all hospital workers and 30% for fringes and taxes, these decreases produced a $21.2 billion reduction in the cost of human resources in 2009, and a $60.5 billion reduction in 2017. Subtracting the $21.2 billion reduction in human resource cost from the $31.64 billion cost arising from increased employment of doctors and nurses, the human resource requirements of new technologies increased hospital costs by only $10.4 billion in 2009. Similarly, in 2017, the adoption of new technologies actually decreased the cost of human resources by $18.4 billion. This is a generous (to hospital administration) interpretation of those numbers. After all, some of those observed differences in the employment of doctors and nurses could be due to technical inefficiency, that is, hospitals choosing to employ more nurses and medical doctors than needed to treat the number of patients they have at the desired standard of care.

In order to calculate the additional capital spending annually due to new technology, another counterfactual was needed, the value of the capital stock if it increased merely due to higher capital goods prices and increased hospital use. To inflate the capital stocks of hospitals for changing prices, indexes from the Bureau of Economic Analysis () were also used: the price indexes for gross private investment, equipment and structures. The index for equipment was 114.2 in 2000, 103.2 in 2009 and 97.6 in 2017. Since the net current cost of hospital equipment was $82.2 billion in 2000, the value of equipment in 2009, assuming it increased in proportion to hospital use, would be 1.18 x .9037 x $82.2 billion = $87.7 billion. That value for 2017 would be 1.33 x .8546 x $82.2 = $93.4.

Unlike that for equipment, the price index for structures increased substantially from 2000 to 2017. From 2000 to 2009, it increased by 67.5%. From 2000 to 2017, it increased by 103.8%. When the value of hospital structures in 2000 ($336.8 billion) is inflated for higher prices and increased hospital use, the resulting values are 1.18 × 1.675 x $336.8 billion = $665.7 billion for 2009, and 1.33 × 2.038 x $336.8 billion = $912.9 billion for 2017. Thus, the total capital stock of hospitals would be $753.4 billion in 2009 and $1006.3 billion in 2017. Since the actual capital stocks (equipment plus structures) were $741.4 billion in 2009 and $965.3 billion in 2017, it follows that technological change enabled the hospital sector to reduce capital costs by $12 billion in 2009 and $41 billion in 2017.

The question now becomes, how will the difference in the two stocks, actual minus counterfactual, be converted into a decrease in operating cost? It seems that at least two approaches can be taken. First, operating cost could be calculated on the basis of depreciation and opportunity cost. In that case, the operating cost of so many billion dollars of capital goods would equal the depreciation rate plus an interest rate times that amount. An estimate of the depreciation rate for hospital capital can be made using the data from the Bureau of Economic Analysis (2021a). Depreciation of the current cost capital stock of the hospital sector was $43.7 billion in 2009. When that value is divided by the sector's capital stock, the depreciation rate is 5.8%. That rate is 6.2% for 2017. Adding the rate of interest on triple A bonds for the year leads to rates of 11.41% and 9.88% for 2009 and 2017, respectively.[9] These rates imply that new technologies led to a reduction in capital costs of 0.1141 x $12 billion = $1.37 billion in 2009 and 0.0988 x $41 billion = $4.05 billion in 2017.

A second way of measuring the decrease in cost from this capital savings would be to expense it. In other words, the reduction in annual expenditure on capital needed to have $12 billion less capital by 2009 could be calculated. To reduce capital stock by $12 billion over a nine-year period, and $41 billion over a 17-year period, respectively, $1.33 billion and $2.41 billion less would have had to have been spent per year, on average. Since these amounts are less than the amounts calculated using depreciation

[9] The data on depreciation are from the Bureau of Economic Analysis (2021a, Table 3.1ESI and Table 3.4ESI). The bond rates are from the St. Louis Federal Reserve Bank (2021).

and interest to measure capital costs, they were used as the capital costs saved by hospitals through their adoption of new technologies. Therefore, the adoption of new technologies increased human resource and capital costs by $9.07 billion in 2009. On the other hand, technical progress resulted in a $20.81 billion decrease in human resource and capital costs in 2017.

Before comparing hospital revenues to the study's estimate of costs, there is one other issue to address, the impact on hospital costs of any change in the mix of services they provide. Some may argue that a substantial portion of the increase in spending on hospital services is attributable to a disproportionate increase in the numbers of costly treatments being demanded from, and provided by, hospitals. If so, the estimate of the cost of providing services would need to be adjusted upward to account for that effect.[10] However, in our view, a cost-increasing change in the product mix of hospitals is something that may not need to be reckoned with. Consider first that from 2000 to 2017 the number of surgeries did not go up dramatically (8.1%). Second, a greater percentage of surgeries were performed on an outpatient basis, presumably because of advances in surgery and post-op care and cost-effectiveness. Third, the number of inpatient days fell by 3.2%. Fourth, the number of outpatient and emergency room visits increased, however, the number of ER patients treated for injuries from accidents decreased.[11] Thus, if surgery and the treatment of accident victims are more costly services than other inpatient, outpatient and emergency room treatments, and if it is cheaper to treat someone as an outpatient than as an inpatient, then any argument that steep increases in hospital costs are due to a change in the service mix is attenuated.

In short, gross changes in the mix of services provided by hospitals do not suggest that the increase in spending on hospital services has been exacerbated by a disproportionate increase in the numbers of expensive treatments provided by hospitals. Consequently, in our opinion, there is no compelling reason to adjust our estimate of the change in hospital costs to allow for changes in the mix of services provided by hospitals over time.

Revenues Versus Costs

Having calculated the percentage change in minimum production costs due to the changes in input prices which occurred between 2000 and 2009 and between 2000 and 2017, and the changes in production costs due to the adoption of new technologies, the minimum costs of providing services in 2009 and 2017 can be compared to hospital revenues. Recall that holding output constant, the increase in cost between 2000 and 2009 due to higher input prices would be 40.4%, and between 2000 and 2017, 66.5%. In 2000, hospital revenues were $415.5 billion. Assume that in 2000 hospital revenues were equal to the minimum cost of the services provided by hospitals that year plus a 5% margin, the margin calculated by the American Hospital Association (2016). Then, with technology and output constant, costs plus a 5% margin would be 1.404 times

[10] Technically, a change in the product mix would affect cost shares. If the shares of higher priced inputs (e.g., doctors) increased due to a change in the mix, the increase in costs over time would be greater than otherwise.

[11] The number of injury-related visits to emergency rooms fell from 31.7 million in 2006 to 30.4 million in 2013 (U.S. Department of Health and Human Services 2016, Table 75, p. 284).

$415.5 billion in 2009 and 1.665 in 2017; that is, $583.4 and $691.8 billion, respectively. Since outputs in 2009 and 2017 were, respectively, 18% and 33% greater than in 2000, those figures need to be increased proportionally, to $688.4 and $920.1 billion. The estimated changes in capital and human resource costs due to new technologies were $9.07 billion in 2009 and $20.81 billion in 2017. These figures imply that the minimum cost of the services provided by hospitals in 2009 was $697.5 billion. The figure for 2017 is $899.3 billion.

Data on hospital revenues (Table 2) show that hospital revenues went from $415.5 billion in 2000 to $779.9 billion in 2009. In 2017, they were $1142.6 billion. Hence, hospital revenues in 2009 were, possibly, $82.4 billion greater than the minimum cost of services provided. In 2017, revenues may have been $243.3 billion greater than costs. By dividing the difference between revenues and estimated costs by estimated costs, a measure can be obtained of the inefficiency of the hospital sector, comparable to the measure typically made by stochastic frontier analysis. Those percentages are 11.8% for 2009 and 27.1% for 2017.[12] Thus, these calculations indicate that the difference between revenues and costs, and implicitly, between prices and average costs, has been increasing.

It is worth taking a moment to consider the implications of this growing divide. Based on this analysis, minimum cost increased from $415.5 billion in 2000 to $899.3 billion in 2017, implying an annual increase of 4.5%. On the other hand, revenues were increasing by 5.9% a year. If these respective percentage changes persist for the next ten years (to 2027), the difference between revenues and costs will be $650.8 billion. With a 2% inflation rate, this would be 532.8 billion 2017 dollars. Thus, the real rent collected by the hospital sector will more than double.

These differences are predicated on the assumption that costs were being minimized in 2000. Given evidence from two dozen (or so) stochastic frontier analysis studies that have been conducted using data from U.S. hospitals, this is a rather tenuous assumption, and if relaxed, increases the rent that hospitals collected in 2009 and 2017. For example, suppose that in 2000, minimum cost plus a 5% margin was 95% of revenues. Then minimum cost in 2017 would be 1.665 × 1.33 x $394.7 billion - $20.8 billion = $853.2 billion, and so the difference between revenues and minimum cost would be $289.4 billion.

Conclusion

The framework and calculations presented in this paper suggest that the rate at which the prices of the services provided by U.S. hospitals has been rising cannot be attributed to higher input prices and the adoption of new diagnostic and treatment regimens. These estimates of the impact of input prices and technology on production costs indicate that between 2000 and 2017, use-adjusted hospital revenues have increased at a substantially higher rate than hospital costs. Hospitals are pricing their services so that revenues are well above average cost. As a result, it is possible that over $200 billion is being transferred from patients, either directly or through their agents (insurers and

[12] The 19 stochastic frontier analysis studies in Rosko and Mutter (2008) found that costs were anywhere from 8 to 38% greater than minimum costs (Table 1). These studies span a 20+ year period (1985–2006).

governmental bodies) to those agents and activities favored by hospital administrators. While there is no theoretical reason for criticizing the transfer being affected by the pricing decisions of hospital administrators, the inefficiency resulting from prices in excess of average cost is another matter.[13]

Estimating the welfare gain net of transfer that could precipitate from bringing prices down to average costs is problematic due to the role that health insurance plays in the market for hospital services. However, if one suspends any present disbelief, and treats the market as if it were a spot market for services, it is possible to derive some idea as to what the loss may be. For instance, with aggregate spending on hospital care in 2017 at \$1142 billion, and minimum cost at \$899.3 billion, the prices of hospital services could be reduced by 21.3%. A first order estimate of the welfare gain that such a reduction would produce is $(1142)\,(0.213)^2\,\varepsilon/2 = 51.8\,\varepsilon$ billion dollars, where ε is the elasticity of demand for hospital services. So, with ε equal to 0.5, the annual welfare gain would be \$25.9 billion. Of course, this elasticity may be even smaller. Therefore, the welfare gain net of transfer could be quite small compared to the transfer. Be that as it may, the transfer that hospital administrators are affecting through their ability to charge prices well above average costs is, on purely distributional grounds, highly questionable.

In any case, if the failure of hospitals to price on the basis of minimum cost is a problem, this analysis indicates that the problem worsened for an obvious reason. As noted, the demand for hospital services increased by about 33% between 2000 and 2017, when measured as inpatient days plus outpatient visits to community hospitals. Though the number of community hospitals increased by 7.2%, the number of hospital beds decreased from 823,560 to 798,921 (−3%), and the number of hospitals in hospital systems increased, from 2542 to 3494 (American Hospital Association, 2016, Tables 2.1 and 2.2). This is an increase from 51.7% of community hospitals to 66.4%. These developments indicate an increase in market concentration and a decrease in the sector's capacity to provide certain services, in other words, a decrease in supply. It is quite possible that these changes contributed mightily to the increase in the difference between the revenues and minimum production costs that this study calculated.

It is also possible that some state governments adopted policies that could be contributing to the problem. Here we allude to the imposition of certificate of need regulations. These regulations are intended to constrain health care costs, presumably by eliminating excess capacity. However well-intended these regulations are, and whatever logic lies behind that intent, the possibility that they may enable hospital inefficiency should be given serious attention (Mutter & Rosko 2014). After all, conventional wisdom holds that competition leads to the lowest possible price being charged. Still, excess capacity may be costly. Whether or not higher prices brought on by less competition is greater than the cost of excess capacity is a topic for another study. Nonetheless, whatever pricing paradigm hospitals follow, this study's calculations point in the direction of so many others, that hospitals are not setting the prices of their services on the basis of minimum costs. As banal as this conclusion may be, it emerges from a different methodology than has been brought to bear on the question and reveals that hospital pricing could be transferring huge sums away from those in need of services, regardless of how efficient the sector may be.

[13] Some of the difference between revenues and input costs finances charity care from hospitals. Whether or not this is the most efficient way of providing hospital care to those unable to pay for that care is beyond the scope of this study.

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Declarations

Declarations of Interests None.

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