A Comment on Mercy Hospital's Online Bidding for RN Overtime Staffing

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ABSTRACT

A central tenet of economics is that firms with lower costs are better able to meet their operating objectives, whether the goal be profit maximization or, in the case of non-profits, the provision of community service. Thus, any method that may achieve this goal is eagerly received. In health care, attention has recently been paid to the impact that nursing "shortages" have on the costs of health care providers, particularly in terms of overtime pay and/or agency nursing, which often force hospitals to incur labor-related expenses that far exceed the regular nursing wage. Reducing staffing costs while retaining the current quality and quantity of services would be a step in the right direction. One solution may exist in having workers bid for overtime shifts. Historically, the costs of developing and maintaining a bidding system for nurse staffing far outweighed the potential benefits. However, thanks to the Internet, hospitals have an almost costless way of running a bidding system for overtime. Mercy Hospital in Pittsburgh, PA recently implemented such a system and has found evidence that it has been successful in reducing labor expenses. But before other hospitals and health providers start doing the same, it is important to examine Mercy's bidding system to see if it can be improved to further reduce costs. In this paper, we utilize some illustrative examples from game theory to demonstrate that Mercy Hospital's new auction system for R.N. overtime shifts may not maximize the hospital's interests. Our goal in this paper is not to conclusively *prove* that the system is flawed, but rather to demonstrate the *possibility* that the system may be sub-optimal. As such, the hospital may want to change the existing system to better achieve its objectives.

INTRODUCTION

Over the past two decades, the market for hospital services has experienced a series of dramatic changes. Patients and private insurers have become more forceful in demanding increased access and a higher quality of care. In order to reduce the costs of providing coverage to the poor and the elderly, government insurers such as Medicare and Medicaid have also implemented reimbursement systems (including capitation, prospective payment and RBRVS) that reduce hospital reimbursement for treating those patients. The net result is that hospitals have become financially constrained, and are constantly examining any possible way to meet these demands without threatening their financial viability.

Many hospitals have looked to offset lower reimbursement and increased demands for access by attempting to control costs. One particularly important area of cost control is nurse staffing. A recent report by the Center for Studying Health System Change claims that payroll growth is the major cause of overall health cost increases, with nursing and other staff shortages as the most likely source (Struck et al 2002). An analysis by the Federation of American Hospital supports these conclusions (FAHS 2001). Thus, many health care providers are finding it difficult to hire and retain enough nurses to meet their staffing requirements. To make up shortfalls, providers generally take one of two possible actions. First, these providers may turn to agency (or "temporary") nurses, who are able to fill the hospital's staffing needs, but at inflated wage rates (Glover 2003). An alternative is to offer overtime shifts to its full-time employees. The overtime shifts are typically assigned through the use of a bidding system. Unfortunately, the costs of developing and administering a bidding system are often quite high, thereby forcing the firm to bear unnecessarily high labor-related costs.

Recently, several hospitals (including Mercy Hospital in Pittsburgh, PA) have attempted to reduce staffing costs by implementing online bidding systems for overtime nurse staffing. Nurses can place bids for overtime shifts via the Internet, and the nurse with the lowest bid receives the opportunity to work the overtime shift. Mercy hospital claims that their online bidding program has been successful and has saved the hospital money (Glover 2003).

While the use of Internet bidding systems may help the hospital control costs, they may not lead to an optimal outcome for the hospital. That is, it may be possible for the hospital to adapt its bidding system in a manner that allows it to reduce costs beyond the current level of cost savings. Alternatively, Mercy's current bidding system may indeed lower (and perhaps minimize) costs, but may do so through the use of inferior inputs, thereby leading to a lower quality of care. The purpose of this paper is to present a series of counter-examples that demonstrate the potential sub-optimality of Mercy Hospital's bidding system. Our goal in this paper is not to conclusively *prove* that the system is flawed, but rather to demonstrate the *possibility* that the system may be sub-optimal. As such, the hospital may want to change the existing system to better achieve its objectives.

BACKGROUND AND PROBLEM STATEMENT

Mercy Hospital of Pittsburgh is a 500 bed, church-affiliated, non-profit organization that offers a full range of inpatient and outpatient hospital services to residents in the Pittsburgh metropolitan area. In 2000, the hospital treated more than 24,000 in-patients and 12,000 outpatients. In additional to general hospital services, the facility contains a trauma and burn center, a cancer treatment center and a rehabilitation center. Mercy experiences competition for most of its services from a number of other hospitals in the Pittsburgh metropolitan area, including two hospitals of much larger size and scope. As such, Mercy Hospital very likely exhibits a relatively small degree of monopoly and monopsony power in the market. With regard to this paper, the implication (or assumption) is that Mercy faces substantial competition in attracting and retaining qualified nurses. Assuming a limited supply of qualified nurses, this would also indicate that Mercy faces relatively high wage rates and labor expenses.

Mercy Hospital began accepting online bids for overtime nursing shifts this past May for its critical care and medical progressive care units. Nurses can log on to Mercy Hospital's web site and bid online for shifts, in increments of 25 cents. The web site also provides information to each bidder about the likelihood that their bid will be accepted. Specifically, the web site presents three categories of wages for the bidder: wage bids that the hospital is most likely to accept, likely to accept, and least likely to accept. The qualified nurse who submits the lowest acceptable bid is notified that he/she can work the shift. The system is modeled on RN Jobs, which was created by St. Peter's Health Care Services in Albany, NY. Both hospitals are owned by Catholic Health East.

Mercy's current system should sound familiar to those involved in game theory. Such a bidding structure, called a first price auction, is usually the first model examined in game theory courses. Many bidding systems use a similar methodology; auction houses sell to the highest bidder, and government contracts are awarded to the lowest sealed bid. Obviously, such a bidding structure is not completely useless or inefficient. However, there are several issues raised in the literature that pertain to the optimality of such bidding models. In this paper, we choose to focus on three potential shortcomings:

1) If the hospital's goal is to induce nurses to submit their lowest bids possible, then a first price auction may not be an

appropriate method of auctioning overtime shifts.

2) By evaluating bids solely on the basis of the price for labor, the firm may experience a type of principal-agent problem in the sense that low effort (or low quality) nurses may be more likely to consistently underbid high effort (or high quality) R.N.'s.

3) Suppose that there are multiple shifts available (of different desirability for the nurses), and that the firm evaluates bids solely on the basis of the price for labor. Then the firm may face another principal-agent problem in the sense that low effort (or low quality) nurses may consistently underbid high effort (or high quality) nurses for the more desirable shifts. Consequently, there is self-selection among nurses based on the desirability of the shift.

The remainder of this paper investigates each of these issues, and provides a counter-example to demonstrate the possibility that the current system may be improved upon.

An Illustrative Example of Shortcoming 1

It is well documented that first price auctions do not induce the winning bidder to submit his/her lowest bid (Gardener 1995; Myerson 1991). In this section we provide a simple example and discussion (drawn largely from the aforementioned citations) that illustrates this shortcoming.

Suppose that we have 2 nurses who want to bid for the same 1-hour shift of overtime.[1] Consistent with Mercy Hospital's approach, we assume that the auction is conducted in a sealed bid, first price format. Each nurse costlessly and simultaneously submits a single bid. We also assume that each of the two nurses is risk neutral with utility functions of the form:

$u_i = \quad b_i - c_i$ if nurse i wins the auction by submitting the lowest bid

$\quad = \quad 0$ 0 otherwise (i.e., if nurse i does not submit the lowest bid).

where i = 1,2; b_i is the bid amount (in dollars), which essentially represents the individual's benefit/wages for working the overtime shift; and c_i represents the individual's net dis-utility or cost (again, measured in dollars) from agreeing to work the overtime shift. We assume that each individual's utility function (as well as the corresponding dis-utility of effort) is public information, and that both individuals attempt to submit a bid that maximizes their utility.

Given this information, we are able to create a series of propositions that demonstrate the possibility of this shortcoming.

Proposition 1: Neither of the nurses "underbid", or bid below their costs, c_i.

Proof: Suppose that nurse i under-bids. If nurse i does not submit the lowest bid, then he/she loses the auction and obtains a utility of zero. But if the nurse submits the lowest bid, this individual wins the auction and his/her utility must necessarily be negative. As a result, the expected value of underbidding must also be negative. The nurse could unambiguously improve upon his/her expected utility by placing a bid that is greater than or equal to c_i. In the event that $b_i = c_i$, $u_i = 0$ regardless of whether or not b_i is greater, less than, or equal to b_j. Similarly, if $b_i > c_i$, the worst possible outcome is that $b_i > b_j$ and the individual loses the auction, in which case utility is zero. Alternatively, the best possible case is that $b_i < b_j$ and the individual wins the auction.[2] And

[1] Extending the model to multiple hours of the shift, as well as multiple bidders, does not noticeably affect the results of the model. As such, we will constrain ourselves to this slightly more parsimonious example to easy the exposition of the argument.

[2] In the event that $b_i > c_i$ and $b_i = b_j$, the actual outcome in terms of i's utility depends on the tie breaking mechanism employed by the auctioneer. It may be that

since $b_i > c_i$, the individual receives a positive utility. As such, bidding a value equal to or greater than c_i always provides the individual with higher expected utility than underbidding. So the individual never underbids. An analogous argument can be made for nurse j.

Proposition 2: Assume that nurse i is the low bidder, and that (s)he knows it. Then this individual should always "shave" his/her bid in an upward fashion. That is, (s)he should raise his/her bid above their minimum level (c_i) as much as possible such that the bid still allows him/her to win the auction.

Proof: Suppose that $b_i = b_j + \varepsilon$, where $\varepsilon >$ minimum bid increment > 0. Also suppose that the individual knows both the minimum bid increment (denoted as α) as well as ε, the difference between his/her bid and the competitor. For simplicity, let the relationship between ε and α be given by $\varepsilon = 2\alpha$.[3] Then if nurse i places a bid of b_i, she will win the auction and will obtain a utility equal to $b_i - c_i$. However, the individual could also place a bid of $b_i' = b_i + \alpha$. It then follows that $b_i' < b_j$, so the individual still wins the auction. Additionally, nurse i is made better off by increasing her bid, since $u_i' = b_i' - c_i > u_i = b_i - c_i$. Consequently, the winning nurse's best strategy is to increase her bid beyond her minimum level, but not so much that (s)he loses the auction.

The net result of these propositions is that in certain situations the hospital may not accept the lowest possible bid. Three questions immediately present themselves. The first is "how close to the minimum will the accepted bid be?" The answer to this question is ambiguous, and depends on a number of factors. The first factor is the risk aversion of the participating nurses. In this simple example, both nurses were risk neutral. In this case, the nurse with the winning bid is very likely to continue raising her bid until the difference between her bid and her competitor's is equal to the minimum bid increment. However, if the winning individual is risk averse, or if there is some amount of uncertainty involved (or lack of information that the individual attempts to avoid), the amount of bid shaving is reduced (Gardener 1995; Myerson 1991). Risk loving tendencies would have the opposite effect on bidding. Another factor is the number of participants in the auction. As the number of participants grows, the likelihood that a participating nurse has extremely high risk aversion, as well as a lower disutility of working overtime would increase, thereby leading to an accepted bid much closer to the minimum possible. Additionally, as the number of participants grows, the assumption of perfect information becomes suspect.[4] And as the amount of available information decreases, so does the difference between the accepted bid and the minimum possible bid.

A second question that presents itself is whether there is any method by which the hospital can always guarantee that an individual

the individuals split the hour of overtime, in which case utility is still positive, or the award may be made through some probabilistic mechanism. In either case, as long as the costs of submitting the bid are negligible, the individual will still obtain a non-negative (expected) utility.

[3] The same result is obtained regardless of which constant of proportionality is chosen, so long as it is greater than 1.

[4] Allowing more participants in the auction has two effects on the amount of available information in the game. First, allowing for more bidders makes it less likely that each nurse will have a full set of information on the other nurses' utility functions and dis-utilities of effort. However, as the number of participants grows, the ability of nurses to bid shave is reduced because there is a greater likelihood that either i) another nurse has a lower dis-utility of effort, and thus can underbid you, or ii) even if you have the lowest dis-utility of effort, the likelihood that the next lowest dis-utility of effort is closer to your dis-utility increases, thereby reducing your ability to bid shave and still win the auction. This would likely be true even though Mercy's auction system gives the bidders information about the probability that a particular bid value would be accepted.

will bid his/her lowest value possible. Game theory has shown that a second price auction always induces the participants to bid their reservation value (i.e., $c_i + \alpha$, where alpha is either the minimum bid increment, or zero).[5] Essentially, a second price auction is identical to the first price auction, with one exception. The individual who bids the lowest price still wins the auction. However, the winning bidder does not pay his/her bid price. Instead, they pay the price bid by the *second lowest bidder*. The formal proof behind this result is rather challenging, and we refer the reader to Rasmusen (1994) and Fudenberg and Tirole (1991) for a formal discussion. In this paper, we will only briefly sketch the intuition behind the proof. To do so, we utilize the same model outlined in Propositions 1 and 2, except that the nurses are bidding in a second price auction. The basic idea behind the proof is that, if a participant (for example, nurse i) bids her reservation value, she can do no worse than obtain a non-negative utility. For example, suppose that nurse i sets her bid to $b_i = c_i + \alpha$. Then if her bid is the lowest, she wins the auction and is paid the second lowest bid b_j, where $b_j \geq b_i$. And since $b_i \geq c_i$, then the individual's utility must also be non-negative. Alternatively, if her bid is not the lowest, then she is not awarded the overtime and receives a utility equal to zero. Either way, the individual receives a non-negative (expected) utility from bidding her reservation value.

Alternatively, if she does not bid her reservation value (whether it be above or below this value) she cannot guarantee herself a non-negative (expected) utility. Rather, her utility may be positive, zero, or negative, depending on the specific bids and auction outcomes. But since the individual can guarantee a non-negative outcome if she bids her reservation price, then bidding this price becomes a *dominant strategy*, or best rational choice.

A final question of interest is whether there is an alternative type of auction that not only induces the bidders to submit a bid that is as low as possible, but also allows the firm to capture these rents.[6] If the firm were to do so, it would be able to minimize its labor costs for overtime nurse staffing. In general, no auction method consistently allows the firm to do so. However, Vickrey (1961) has shown that, although the firm's *actual* labor costs for overtime nursing labor may fluctuate based on the type of auction and the risk preferences of the players, its *expected* labor costs are the same under either type of auction. Thus, at least theoretically this issue is irrelevant, particularly if the auction is used repeatedly over time (so information uncertainty is less of a problem) and if nurses formulate their bids in a rational fashion.

However, a second price auction may be more useful in practice, especially if there is a substantial amount of information uncertainty due a large number of auction participants or if there are differences in risk preferences across bidders. The reason is that second price auctions (particularly those currently being conducted over the Internet) often allow for a certain amount of equity across bidders in the event of imperfect information. For example, a second price auction allows the auctioneer to provide more detailed and accurate suggestions to potential bidders about successful bidding strategies in an ethical manner.[7] Additionally, many second-price auction formats (for

[5] As the minimum bid increment becomes smaller and smaller, so will alpha. However, if, as in the case of Mercy's bidding system, bid increments are relatively large (they use increments of 25 cents), the minimum value of alpha may not be zero.

[6] Recall that in a second price auction, even though bidders submit a bid equal to their reservation value, the firm does not capture the entirety of this gain, since they pay the winner the wage submitted by the second lowest bidder.

[7] Ebay, for example, conducts many of its auctions using a second price format (Roth and Ockenfels, 2002; Marcoux, 2003). Since second price auctions should induce rational, informed participants to bid their reservation values, Ebay can subsequently make this information publicly available to all individuals participating in the auction without presenting the appearance of "rigging" the auction.

example, those conducted by Ebay and Amazon) allow participants to "nibble" in the bidding process, thereby providing participants with the ability to sequentially acquire information about the other participants over the course of the auction. And since the auction's winner still receives the second best bid, the participants are able to employ a bidding strategy that is rational, parsimonious and achieve a better outcome (for the winning auction participant) than under a first price auction.[8] Lastly, we note that while second price auctions have some advantages over first price auctions, they are not without their potential drawbacks. Most notably, those second price auctions that are conducted over a fixed time frame (i.e., "hard close" auctions) are subject to "sniping" – the situation in which participants do not submit a bid until the final few seconds of the auction, and thus intentionally introduce additional uncertainty into the bidding process. While sniping is not without its risks for bidders, it has become prevalent, and thus a problem – both ethically and in terms of efficiency - in Internet auctions (particularly Ebay auctions) because it sometimes allows a sniper with a very high (or low) reservation value to win the auction while not having to bid his/her true reservation value.[9]

[8] In many online, second price auctions (such as those on Ebay and Amazon), the auction is conducted over a given length of time, and participants are allowed to submit multiple bids. "Nibbling" is the practice of submitting a bid that is one increment higher than the best bid currently submitted. And every time a new, better bid is submitted and registered, the nibbler will out bid the last participant by one more bid increment. Nibblers repeat this process continuously over the course of the auction and, ultimately, deduce the other participants' reservation values (Roth and Ockenfels, 2002; Marcoux, 2003).

[9] Some auctions, including those run by Amazon, prevent sniping by conducting second price auctions with a variable time limit (Roth and Ockenfels, 2002; Marcoux, 2003). These auctions automatically extend the time length of the auction in the event that a participant tries to snipe. As such, all other participants in the auction are given the opportunity to respond to the attempted sniper's bid.

An Illustrative Example of Shortcoming 2

To illustrate the first principal-agent problem that may be caused by Mercy's auction system, we again utilize a simple game theoretic example. As before, suppose that we have 2 nurses who want to bid for the same 1-hour shift of overtime.[10] Consistent with Mercy Hospital's approach, we assume that the auction is conducted in a sealed bid, first price format. Each nurse costlessly and simultaneously submits a single bid. We also assume that each of the two nurses is risk neutral with utility functions of the form:

$u_i = \quad b_i - c_i$ if nurse i wins the auction by submitting the lowest bid

$\quad = \quad 0$ 0 otherwise (i.e., if nurse i does not submit the lowest bid).

Both individuals still attempt to submit a bid that maximizes their utility. But now suppose that the two nurses differ in their effort and/or ability to impart high quality care. Let nurse i be a high ability (or high effort) nurse, while nurse j is a low ability (or low effort) nurse. Further, we assume that each nurse is altruistic in the sense that they perform to the best of their abilities, so that the high ability nurse always does a better job and/or exerts more effort than the low effort/quality nurse.[11] However, higher effort also requires the individual to bear a larger net disutility from working the hour of overtime. As a result, we are implicitly assuming that $c(e_H) > c(e_L)$, where $c(\bullet)$ represents the net disutility of effort of working overtime, while e_H and e_L represent the high and low levels of effort put forth by the high and low effort nurses, respectively.

Each nurse must decide whether or not to submit a bid for the overtime shift. If one of the nurses does not submit a bid, the other nurse's bid is accepted. However, if both

[10] The same caveat discussed in footnote 1 applies here as well.

[11] To the extent that higher effort and/or ability translates into a higher quality of care, these findings may also be interpreted within the context of health care quality.

nurses submit a bid, then the rules of the first price auction outlined in the previous section determine the winner. Lastly, we assume both players know that there is another bidder of differing ability that is considering whether to participate in the auction, whose utility function is public information. What they do not know is whether that other nurse has or has not submitted a bid. As such, the game can be considered as a simultaneous move game, where each player makes its decisions independent of the other.

The outcomes of the game (expressed as the utilities of each player) can be depicted using the matrix in Figure 1. There are two possible pure strategy Nash equilibria for this game: one where both players submit bids, and one where only the low effort player submits a bid.[12] The reasoning behind this result is straightforward. If the low effort nurse does not submit a bid, then she receives a utility of 0, regardless of what her competitor does. But if this player submits a bid, regardless of the actions of the high effort nurse, the low effort nurse will receive a positive expected utility (especially given proposition 1, which ensures that players never underbid). If the high effort nurse does not submit a bid, then the low effort nurse automatically wins the auction and receives a utility of $b_L - c(e_L)$. If both players submit, the low effort nurse receives the same payoff with (1-p) probability, where $0 \leq p \leq 1$. In general, since the low effort nurse experiences a lower disutility than the high effort nurse from working the shift, we would expect this nurse to underbid the high effort nurse, and thus win the auction. As a result, we also expect p = 0. The high effort nurse (being rational) knows this, and is subsequently caught in a "catch-22" situation. If they do not submit a bid, they will obtain a null utility. But if they submit the bid, and if higher effort translates into higher disutility/costs, then they receive the same outcome. As a result, the high effort nurse is ambivalent between submitting and not submitting a bid, thereby giving the two Nash equilibria.

Figure 1

		Low Effort Nurse	
		Submit Bid	**Do Not Submit Bid**
High Effort Nurse	**Submit Bid**	$p(b_H - c(e_H))$, $(1-p)(b_L - c(e_L))$	$b_H - c(e_H)$, 0
	Do Not Submit Bid	0, $b_L - c(e_L)$	0, 0

It is also important to note that the game's equilibria are highly sensitive to its underlying assumptions. For example, we have assumed that submitting a bid is costless. But should the transaction costs be significant, it would be in the high effort nurse's best interest not to submit a bid at all, as submitting a bid (and losing the auction) may force the individual to endure a negative utility. In that case, the low effort nurse would dominate the auction process. Additionally, we have assumed that high effort translates into higher costs. If the opposite were true, so that $c(e_H) < c(e_L)$, then the high effort nurse would be able to underbid the low effort ability nurse. In that case, the high effort nurse's dominant strategy would be to submit a bid, regardless of the low effort nurse's actions, while the low effort nurse would be ambivalent between submitting and not submitting a bid.

[12] There is also a mixed strategy Nash equilibrium for the game, in which each player randomly chooses a strategy with a particular probability. We chose to ignore this equilibrium for simplicity, but note in passing that ignoring it does not impact the validity of our counter-example, since each player could (with a particular probability) chose a strategy that leads to a sub-optimal outcome for the hospital. Thus, the mixed strategy equilibrium simply presents the same arguments given by the pure strategy equilibria in a slightly more complicated format.

The implications for Mercy Hospital are quite clear. If higher effort translates into higher costs, and if submitting a bid is costless, the current bidding mechanism may result in the hospital staffing its facility with low effort/ability nurses. To the extent that nursing effort/ability translates into quality of care, the hospital may actually be diminishing its reputation and financial position by employing the current auction system. If the hospital is interested in avoiding this problem, it needs to ensure that the costs of high effort nurses are lower than for the low effort nurses.

One possible method for dealing with this would be award a bonus to excellent rated nurses and a penalty to poorly rated nurses. In such a system, the hospital, in selecting the "lowest" bid, may treat an excellent nurse's bid as if it was lower by some set bonus amount. At the same time, the hospital could decide to treat a low rated nurse's bid as if it was higher by a certain amount. In other words, b_H = Actual b_H – "good" bonus and b_L = Actual b_L + "bad" penalty. The hospital could decide, depending on the value it places on the various nurse qualities, how much to offer as a bonus or penalty. Indeed, there might be an added bonus in that nurses that depend on overtime might work harder to get a "good" rating in order to help secure more overtime bidding success.[13]

An Illustrative Example of Shortcoming 3

We can extend the game from the previous discussion to demonstrate the possibility of the third shortcoming: that low effort nurses may be self selecting into the more desirable shifts, while the high effort nurses may self-select into the less desirable shifts. Suppose that there are now two shifts to bid for: a "good" shift, which is highly desirable for workers (for example and 8am to 5pm shift) and a "bad" shift, which is less desirable (for example a graveyard shift). Each player may bid for neither, one or both shifts. However, if a player does win a bid to work both shifts, we assume that they incur an extra cost or disutility (d). Essentially, this parameter is intended to capture increasing or decreasing returns to working "extra overtime". Positive values for d indicate decreasing returns, while negative values indicate increasing returns. For simplicity, we distinguish bids and costs for the "good" shift with the superscript G, while bad shift bids and costs are denoted by the superscript B. As before we assume that higher effort leads to higher costs, so that $c(e_H) > c(e_L)$.

Figure 2 presents the utility payoffs of the game in matrix form. Clearly, there are several pure strategy Nash equilibria, depending on the relative sizes of the d's, bid values and costs for each shift and effort level.[14] Table 1 lists each of the possible equilibrium. Of primary interest are the conditions under which the high and low effort nurses separate into specific shift types. Note that, if d_L is a sufficiently small positive, zero, or negative number, then the low effort nurse will always be better off submitting a bid for both shifts, because her low costs of effort allow it to underbid her high effort counterpart. As before, this would force p_1, p_2 and p_3 (the probabilities that the high effort nurse would win in each of these situations) to zero, and the low effort/ability nurse would win the auctions for both shifts. Alternatively, sufficiently large positive values for d_L reduce the expected utility payoff for the low effort/ability nurse to the point where it is not longer in their best interests to submit a bid for both shifts.[15] As a

13 The difficulty, of course, with adopting this type of "carrot – and – stick" system is that it is difficult for hospital administrators to establish parsimonious, complete and ethically viable indicators of "good" and "bad" performance.

14 The same caveat discussed in footnote 12 applies here as well.

15 Should the assumption about the costs of effort be reversed, so that higher effort/ability leads to lower costs, then so too are the equilibria of the game. Now the equilibria depends on the relative sizes of d_H. If this parameter is sufficiently small and positive, zero or negative, then the high effort/quality nurse dominates

result, each type of nurse would self-select into an equilibrium where the shifts are split, with each nurse taking one type of shift. Whether high effort ability nurses end up with the good or the bad shifts is an empirical question (and similarly for the low effort nurse), which depends on the relative sizes of the good and bad costs of high and low effort/ability.

Table 1: Possible Pure Strategy Nash Equilibria for Figure 2

High Effort Nurse Action	Low Effort Nurse Action
Do not submit a bid	Submit bid for both shifts
Submit bid for good shift only	Submit bid for bad shift only
Submit bid for good shift only	Submit bid for both shifts
Submit bid for bad shift only	Submit bid for good shift only
Submit bid for bad shift only	Submit bid for both shifts
Submit bid for both shifts	Submit bid for good shift only
Submit bid for both shifts	Submit bid for bad shift only
Submit bid for both shifts	Submit bid for both shifts

CONCLUSIONS AND IMPLICATIONS FOR POLICY

The idea of using a bidding mechanism to minimize cost is not new to the hospital industry. However, the near "costlessness" of the internet may lead to more acceptance of using a bidding process, both for hospitals and perhaps all industries in general. After all, a shortage of professionally-licensed, qualified workers is growing phenomenon. Indeed, in a world of growing technological complexity, more and more firms could face similar staffing problems down the road. The first price auction is the simplest solution and one that often comes to mind for the lay person. Such an auction may, as Mercy announced to the press, be an improvement on whatever staffing solution is used as an alternative to bidding. The question is, is it optimal?

Mercy's bidding system, while not completely unique, is not commonly used in the health care industry. This commentary grew out of curiosity with this fact. Will this bidding system begin to be adopted elsewhere? Was it considered by other institutions and if so, why wasn't it adopted? Are there circumstances that gave arise to this bidding system that may or may not be applicable elsewhere? And, of course, is it optimal?

The economic literature dealing with optimal bidding systems and strategies is both lengthy and detailed. This commentary is just a first look at a practical application of some game theory. However, the implications are quite important. As health costs continue to grow, there will be more and more pressure for finding any way to cut costs. Other groups may decide to adopt this first price auction and indeed, Mercy is considering expanding its bidding to other areas of nursing and staffing. As that happens, it is important to see not only is the firm saving as much as possible, but also to ensure that long-run success and quality are not compromised.

the bidding process. And if d_H is very large and positive, then it is in this nurse's best interest to place a bid for only one shift.

Figure 2

Low Effort/Ability Nurse

High Effort/Ability Nurse	**Do Not Submit Bid**	**Submit Bid for Good Shift Only**	**Submit Bid for Bad Shift Only**	**Submit Bid for Both Shifts**
Do Not Submit Bid	0,0	$0, b^{G}_{L} - c^{G}(e_L)$	$0, b^{B}_{L} - c^{B}(e_L)$	$0, b^{B}_{L} - c^{B}(e_L) + b^{G}_{L} - c^{G}(e_L) - d_L$
Submit Bid for Good Shift Only	$b^{G}_{H} - c^{G}(e_H),0$	$0, b^{G}_{L} - c^{G}(e_L)$	$b^{G}_{H} - c^{G}(e_H), b^{B}_{L} - c^{B}(e_L)$	$p_1(b^{G}_{H} - c^{G}(e_H)), (1-p_1)(b^{B}_{L} - c^{B}(e_L))+ b^{G}_{L} - c^{G}(e_L) -(1-p_1)d_L$
Submit Bid for Bad Shift Only	$b^{B}_{H} - c^{B}(e_H),0$	$b^{B}_{H} - c^{B}(e_H), b^{G}_{L} - c^{G}(e_L)$	$0, b^{B}_{L} - c^{B}(e_L)$	$p_2(b^{B}_{H} - c^{B}(e_H)), (1-p_2)(b^{B}_{L} - c^{B}(e_L))+ b^{G}_{L} - c^{G}(e_L) -(1-p_2)d_L$
Submit Bid for Both Shifts	$b^{B}_{H} - c^{B}(e_H) + b^{G}_{H} - c^{G}(e_H) - d_H, 0$	$b^{B}_{H} - c^{B}(e_H), b^{G}_{L} - c^{G}(e_L)$	$b^{G}_{H} - c^{G}(e_H), b^{B}_{L} - c^{B}(e_L)$	$p_3(b^{B}_{H} - c^{B}(e_H) + b^{G}_{H} - c^{G}(e_H) - d_H), (1-p_3)(b^{B}_{L} - c^{B}(e_L) + b^{G}_{L} - c^{G}(e_L) - d_L)$

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