Final Progress Report for Research Projects Funded by Health Research Grants

Instructions: Please complete all of the items as instructed. Do not delete instructions. Do not leave any items blank; responses must be provided for all items. If your response to an item is "None", please specify "None" as your response. "Not applicable" is not an acceptable response for any of the items. There is no limit to the length of your response to any question. Responses should be single-spaced, no smaller than 12-point type. The report **must be completed using MS Word**. Submitted reports must be Word documents; they should not be converted to pdf format. Questions? Contact Health Research Program staff at 717-783-2548.

1. **Grantee Institution:** Lehigh University

2. **Reporting Period (start and end date of grant award period):** 1/1/2011 – 12/31/2012

3. **Grant Contact Person (First Name, M.I., Last Name, Degrees):** Nicole M. Corali, MBA, CRA

4. **Grant Contact Person's Telephone Number:** 610-758-4585

5. **Grant SAP Number:** 4100054856

6. **Project Number and Title of Research Project:** 3 - Competition, Health Outcomes, and Resource Use in Hospitals

7. **Start and End Date of Research Project:** 1/1/2011 – 12/31/2012

8. **Name of Principal Investigator for the Research Project:** Shin-Yi Chou, PhD

9. **Research Project Expenses**.

   9(A) Please provide the total amount of health research grant funds spent on this project for the entire duration of the grant, including indirect costs and any interest earned that was spent:

   $ 6,705.65

   9(B) Provide the last names (include first initial if multiple individuals with the same last name are listed) of **all** persons who worked on this research project and were supported with health research funds. Include position titles (Principal Investigator, Graduate Assistant, Post-doctoral Fellow, etc.), percent of effort on project and total health research funds expended for the position. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project	Cost
None			

9(C) Provide the names of **all** persons who worked on this research project, but who *were not* supported with health research funds. Include position titles (Research Assistant, Administrative Assistant, etc.) and percent of effort on project. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project
Deily	Professor	10%
Chou	Principal Investigator	10%

9(D) Provide a list of **all** scientific equipment purchased as part of this research grant, a short description of the value (benefit) derived by the institution from this equipment, and the cost of the equipment.

Type of Scientific Equipment	Value Derived	Cost
None		

10. Co-funding of Research Project during Health Research Grant Award Period. Did this research project receive funding from any other source during the project period when it was supported by the health research grant?

Yes_____ No____X_____

If yes, please indicate the source and amount of other funds:

11. Leveraging of Additional Funds

11(A) As a result of the health research funds provided for this research project, were you able to apply for and/or obtain funding from other sources to continue or expand the research?

Yes_____ No_____X_____

If yes, please list the applications submitted (column A), the funding agency (National Institutes of Health—NIH, or other source in column B), the month and year when the application was submitted (column C), and the amount of funds requested (column D). If you have received a notice that the grant will be funded, please indicate the amount of funds to be awarded (column E). If the grant was not funded, insert “not funded” in column E.

Do not include funding from your own institution or from CURE (tobacco settlement funds). Do not include grants submitted prior to the start date of the grant as shown in Question 2. If you list grants submitted within 1-6 months of the start date of this grant, add a statement below the table indicating how the data/results from this project were used to secure that grant.

A. Title of research project on grant application	B. Funding agency (check those that apply)	C. Month and Year Submitted	D. Amount of funds requested:	E. Amount of funds to be awarded:
None	☐NIH ☐ Other federal (specify:_____) ☐ Nonfederal source (specify:_)		$	$

11(B) Are you planning to apply for additional funding in the future to continue or expand the research?

Yes_____ No____X_____

If yes, please describe your plans:

12. Future of Research Project. What are the future plans for this research project?

Our future plan is to include the data from more states (such as New Jersey) and conduct a cross-state analysis along the same research line.

13. New Investigator Training and Development. Did students participate in project supported internships or graduate or post-graduate training for at least one semester or one summer?

Yes_____ No____X_____

If yes, how many students? Please specify in the tables below:

	Undergraduate	Masters	Pre-doc	Post-doc
Male				
Female				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
Hispanic				
Non-Hispanic				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
White				
Black				
Asian				
Other				
Unknown				
Total				

14. **Recruitment of Out-of–State Researchers**. Did you bring researchers into Pennsylvania to carry out this research project?

    Yes_____ No_____X_____

    If yes, please list the name and degree of each researcher and his/her previous affiliation:

15. **Impact on Research Capacity and Quality**. Did the health research project enhance the quality and/or capacity of research at your institution?

    Yes____X_____ No_____

    If yes, describe how improvements in infrastructure, the addition of new investigators, and other resources have led to more and better research.

    The CURE funds allowed us to purchase the PHC4 data that could be used to study various health-related topics in Pennsylvania. It significantly expands our research horizon.

16. **Collaboration, business and community involvement.**

    16(A) Did the health research funds lead to collaboration with research partners outside of your institution (e.g., entire university, entire hospital system)?

    Yes_____ No____X_____

    If yes, please describe the collaborations:

    16(B) Did the research project result in commercial development of any research products?

Yes_____ No_____X_____

If yes, please describe commercial development activities that resulted from the research project:

16(C) Did the research lead to new involvement with the community?

Yes_____ No_____X_____

If yes, please describe involvement with community groups that resulted from the research project:

17. Progress in Achieving Research Goals, Objectives and Aims.

List the project goals, objectives and specific aims (as contained in the grant agreement). Summarize the progress made in achieving these goals, objectives and aims for the period that the project was funded (i.e., from project start date through end date). Indicate whether or not each goal/objective/aim was achieved; if something was not achieved, note the reasons why. Describe the methods used. If changes were made to the research goals/objectives/aims, methods, design or timeline since the original grant application was submitted, please describe the changes. Provide detailed results of the project. Include evidence of the data that was generated and analyzed, and provide tables, graphs, and figures of the data. List published abstracts, poster presentations and scientific meeting presentations at the end of the summary of progress; peer-reviewed publications should be listed under item 20.

This response should be a DETAILED report of the methods and findings. It is not sufficient to state that the work was completed. Insufficient information may result in an unfavorable performance review, which may jeopardize future funding. If research findings are pending publication you must still include enough detail for the expert peer reviewers to evaluate the progress during the course of the project.

Health research grants funded under the Tobacco Settlement Act will be evaluated via a performance review by an expert panel of researchers and clinicians who will assess project work using this Final Progress Report, all project Annual Reports and the project's strategic plan. After the final performance review of each project is complete, approximately 12-16 months after the end of the grant, this Final Progress Report, as well as the Final Performance Review Report containing the comments of the expert review panel, and the grantee's written response to the Final Performance Review Report, will be posted on the CURE Web site.

There is no limit to the length of your response. Responses must be single-spaced below, no smaller than 12-point type. If you cut and paste text from a publication, be sure symbols print properly, e.g., the Greek symbol for alpha (α) and beta (ß) should not print as boxes (□) and include the appropriate citation(s). DO NOT DELETE THESE INSTRUCTIONS.

Specific Aims:

Public disclosure of data rating the performance of hospitals and physicians -- often referred to as report cards -- has proliferated in the 1990s. The rationale behind this effort stems from the economic belief that "even a small amount of information imperfection" can cause market failure (Stiglitz, 2002). In the context of health care, where asymmetric information is profound (Arrow 1963), providing more information may increase hospitals' incentive to provide a better quality of care, particularly when hospitals engage in quality competition. We have three specific goals in this project. *First*, we examine the impact of online publication of Coronary Artery Bypass Graft (CABG) report cards on quality competition among hospitals in Pennsylvania. *Second*, we examine this impact by patient severity. *Third*, we examine this impact by rural and urban population. Our main hypothesis is that the availability of quality information will intensify hospitals' quality competition as revealed in individual patient outcomes, and the strength of this effect will be stronger in more competitive markets. We have achieved all our aims in the study.

Data:

Our principal data set, constructed and obtained from the Pennsylvania Health Care Cost Containment Commission (PHC4), is a record of all of the inpatient claims from Pennsylvania hospitals for the years 1994 to 2005. Distance measures were calculated based on zip code centroids of patients' residences and of hospitals' locations. We obtained some additional information about hospital characteristics, such as bed size, teaching status and technologies, from the American Hospital Association's Annual Survey of Hospitals. In the estimation of individual demand for hospitals, we include hospital report card grades for CABG surgery, which are also obtained from the PHC4. The report card information that is mostly recent to a patient's admission enters the demand equation as a quality characteristic of hospitals. We use the procedure codes to identify patients undergoing CABG surgery during the years 1994 through 2005, but, because our risk adjustments require information for the 12 months preceding a patient's admission, and one of our outcome variables requires information from the 12 months following a patient's CABG surgery, the sample we analyze is the surgeries that occurred during the years 1995 through 2004. The final sample size for the main analysis is 137,239.

Methods:

Our basic specification is:

$$Outcome_{ikht} = \alpha + \gamma(HHI97_k \cdot Post_t) + \beta_1 M_{kt} + \beta_2 P_{it} + \eta_h + \varsigma_k + \tau_t + \varepsilon_{ikht}, \qquad (1)$$

where $Outcome_{ikht}$ is the outcome realized by patient i from 5-digit zip code area k, admitted to hospital h in quarter t, $HHI97_k$ is a measure of market concentration in 1997, and $HHI97_k*Post_t$, our key variable, captures the effect of the publication of online quality information in hospital markets with different levels of concentration. Control variables include M_{kt}, a vector of other market characteristics, P_{it}, a set of patient characteristics (where t for these variables refers to year), and the three variables η_h, ς_k, and τ_t , which are fixed effects for the patient's admitting

hospital, the patient's zip code, and the quarter of the patient's surgery (t = 1, …, 40). Finally, ε_{ikht} is a mean-zero independently distributed error term so that $E(\varepsilon_{ikht} \mid \ldots) = 0$.

Outcome Variables

We focus on three separate outcomes to capture different aspects of the quality of the services a patient receives. The first is the log of the total cost for each patient, which we use as a measure of the amount of resources used on the patient. The "total charge" reported in the PHC4 data is the sum of the list prices of all goods and services the hospital provided to the patient during their stay, not including physicians' fees. However, the actual reimbursement received by the hospital for the patient's care differs from the list price and is unknown. As a more accurate measure of resource use, we calculate the total cost for each patient's treatment by multiplying the patient's total charge by the CMS cost-to-charge ratio for the admitting hospital (Picone et al. 2003; Dafny 2005).

The second outcome variable is in-hospital mortality, a binary variable equal to one if the patient died in the hospital after being admitted as a CABG patient, and zero otherwise. Mortality is a commonly used measure of the overall quality of a patient's experience when death in not so rare an occurrence as to make it unusable, as is the case here. However, this measure is limited to capturing only the most extreme outcome, and only during the length of a patient's stay. Therefore, for our third outcome variable we use readmission rates after a patient has had CABG surgery for any of a set of conditions that are frequently associated with this procedure. That is, the readmission variable is equal to one if a CABG patient was readmitted (to any hospital) for problems related to ischemic heart diseases within 12 months of their CABG, and zero if they were not.

Hospital Market Concentration

We use the variable $HHI97_k$, the Herfindahl-Hirschman index (HHI) in 1997 for zip code k, to measure competition in different hospital markets. Competition measures such as the HHI may be affected by endogeneity: for example, hospitals located in more competitive markets may offer more distinctive services and attract unobservably sicker patients, both of which would affect the HHI. Further, there may be a reverse causal relationship between market competitiveness and quality if higher hospital quality results in more patients. In either case, we may attribute worse (or better) health outcomes to market competition that are fundamentally caused by patients' selection of hospitals. While we include a number of control variables to alleviate this concern, there may nevertheless remain unobserved heterogeneity affecting both the patient's outcome and the competitiveness measure.

We address the issue by calculating the HHIs using predicted rather than actual market shares (Kessler & McClellan, 2000). We first estimate patient-level conditional logit models of hospital choice separately for each year in the sample, 1995-2004. The conditional logits estimate the probability that a patient will choose each of the different CABG hospitals located within a 50-mile radius of their residential zip code as a function of hospital characteristics (size, teaching status, and most recent report card grade) and an array of arguably exogenous distance measures: the extra distance an individual has to travel beyond the closest hospital with the same characteristic to reach the hospital in question, and the extra distance an individual has to travel beyond the closest hospital of differing characteristic to reach the hospital in question. Finally, characteristics of the individual patient making the choice (age, gender, race, source and type of admission, and whether or not live in urban counties) are introduced to the conditional logits by

interacting them with the hospital characteristics (size, teaching status, and most recent report card grade).

We estimate the conditional logits using only the Medicare patients with fee-for-service (FFS) insurance, because these patients are not restricted in their choice of hospital by their insurance plan, and so make their choice of provider solely on the basis of their own tastes for hospital quality and convenience. After estimating the conditional logits with this subsample of patients, we then assume that the parameter estimates hold for all patients, irrespective of their insurance type (Town & Vistnes, 2001; Gowrisankaran & Town, 2003; Ho, 2006), and use the estimates to calculate each patient's probability of going to each hospital in the sample, $\hat{\pi}_{ih}$. (We suppress the subscript for Year here and in the following calculations for greater ease of exposition.) We calculate these probabilities for each of the patients in the predicted HHI sample described above.

As in Kessler & McClellan (2000), calculation of the HHIs based on predicted market shares proceeds in three steps. In step one, we sum the individual probabilities of patients from zip code *k* choosing hospital *h* (*h* = 1, …, *H*), and divide it by the summed probabilities of patients from zip code *k* choosing all hospitals in the sample,

$$\alpha_{hk} = \frac{\sum_{i \in k} \hat{\pi}_{ih}}{\sum_{h=1}^{H} \sum_{i \in k} \hat{\pi}_{ih}},$$

which gives us predicted share of patients from zip code *k* served by hospital *h*. We use this predicted share to calculate the first step zip-code level HHIs:

$$HHI_k^{pat} = \sum_{h=1}^{H} \alpha_{hk}^2.$$

This initial HHI measure represents the availability and attractiveness of hospital options from the patient's point of view, independent of unobservable patient and hospital characteristics. However, it is not appropriate as a measure of competition for our specification because it reflects the level of hospital competition at each patient's residential area instead of the level of competition faced by hospitals, which are likely to draw patients from numerous zip codes.

Therefore, because we are interested in how hospitals differentiate on quality according to the competitiveness of their neighborhoods, our second step is to calculate hospital-level HHIs by averaging the predicted HHIs across zip code-levels for each hospital, with the weight being the predicted share of demand for each hospital from each zip code:

$$HHI_h^{hosp} = \sum_{k=1}^{K} \beta_{kh} * HHI_k^{pat},$$

where the weight,

$$\beta_{kh} = \frac{\sum_{i \in k} \hat{\pi}_{ih}}{\sum_{i=1}^{N_h} \hat{\pi}_{ih}},$$

is those patients of hospital *h* that live in zip code *k*, as a fraction of the hospital's total predicted demand.

Finally, because we ultimately want a measure of the competitiveness of the hospital market within which each patient resides, the third step is to translate this new HHI back to the zip-code level. We calculate the HHI for the hospital market as experienced by each patient using a weighted average of hospital-level HHIs, where the weights are the estimated probability of a hospital being chosen by those living in the patient's residential zip code:

$$HHI_k^{pat^*} = \sum_{k=1}^{H} \hat{\alpha}_{kk} \times HHI_k^{hosp}.$$

This final version of HHI is a competition metric that functions like the traditional HHI, being bound below by zero and above by one, and increasing in concentration. We use these predicted HHIs to represent the competitiveness of the hospital market within which a zip code is located. They are based on exogenous factors of patient demand, rather than potentially endogenous actual patient flows, and take into account differentiation arising from the locations and characteristics of potentially competing hospitals.

We calculate predicted HHIs for each zip code for each year of our sample, but we use the predicted HHIs for just one year, 1997, so that $HHI97_k$ captures the variation in the level of market competition across zip code areas *before* the release of online report cards. Fixing the competitiveness of markets at the year before the report cards went online allows us to avoid the confounding effects of changes in quality due to changes over time in market competition.

Our initial estimations suggested that the effect of competition was nonlinear. To get a clearer idea of the marginal impact of competition, we follow Kessler & McClellan (2000) and Kessler & Geppert (2005) by grouping zip codes into different categories of market competitiveness, with the categories based on the distribution of zip-code level HHIs over the entire study period. We then replace the continuous variable HHI97 with two dummy variables: the variable *Most Competitive* equals one if the patient lives in a zip code that was located in one of the most competitive hospital markets in 1997, where most competitive means in the lowest quartile of the predicted HHI measure, and the variable *Competitive* equals one if the HHI in 1997 for the patient's zip code lies in the second or third quartile of the HHI distribution. The reference group is the most concentrated quartile of predicted HHIs in 1997.

Figure 2 shows the degree of market competition for different zip codes in Pennsylvania in 1997. The map reflects the influence of the locations of CABG hospitals, shown in Figure 1: areas with more CABG hospitals, those in the more populated Philadelphia and Pittsburgh areas, have more zip codes in the *Most Competitive* category, while other areas of the state, with fewer CABG hospitals, have more zip codes in the *Least Competitive* category. Blank areas on the map represent zip codes for which we could not predict an HHI in 1997 because there were no CABG patients from those zip codes in that year.

Our key variable, $HHI97_k$*$Post_t$, becomes two variables: *(Most Competitive*$Post_t$)* and *(Competitive*Post)*, where the indicator variable $Post_t$ equals one for all quarters after quality data went online, that is, from the third quarter of 1998 through 2004. The coefficients of these variables thus measure the average change in the outcome variable, after grades went online, in most competitive and competitive markets, relative to the change in the outcome variable in the least competitive markets, ceteris paribus. If outcomes for patients using hospitals located in most competitive or competitive markets changed more than those in the least competitive markets after report cards went online, the coefficients of these interacted variables will be significant.

<u>Control Variables</u>

The vector M_{kt} represents market level factors that control for variation in hospital supply that may affect the structure of individual markets (Kessler & McClellan, 2000). These variables, predicted hospital size (number of beds) and teaching status, are calculated for each zip code

using the same method as was used to create the predicted HHI.[1] Thus, the variables represent the predicted hospital size and teaching status of hospitals used by patients from each zip code, as determined by the patients' choices.

The vector P_{it} of patient characteristics includes: age (measured between 45 and 84 in 5-years categories, or as above 84; the base group is below 45), gender (with female as the base group), ethnicity or race (Hispanic or African-American, with white or other race as the base group), insurance type (Medicare, Medicaid, and private insurance, with other types or uninsured as the base group), whether the patient was an HMO enrollee (as opposed to other insurance plans), patient admission source (physician referral, transfer from a hospital, or transfer from a skilled nursing facility; the base group is transfer from some other source such as a clinic or an ambulatory surgical center), whether the admission was an emergency (as opposed to scheduled), and the distance to the closest CABG hospital for patients living in zip code *k* (measured between the centroids of the zip code of the patient and the zip code of the hospital).

We use variables based on the Charlson index to measure the severity of a patient's illness (Charlson et al., 1987). The Charlson index contains 19 categories of comorbidity, each associated with a weighting score (ranging from 1 to 6) that reflects the adjusted risk of one-year mortality associated with the comorbidity. We calculate a Charlson index for each patient using their diagnosis codes at the time of admission for CABG as well as their diagnosis codes from any hospital admission during the 12 months preceding their surgery: for our sample, values for the Charlson index range from zero (no comorbidity) to 15 (very severe burden of comorbidity). We created six dummy variables, one for each value of the Charlson index from one to five, and a sixth that indicates if the patient has a Charlson index that is greater than or equal to six, with zero as the reference group.

Finally, we include fixed effects for the patient's zip code, for the admitting hospital, and for the quarter of the year the patient had their surgery. The use of zip code fixed effects captures the unobserved, time-invariant geographic variances in consumer taste, health status, and public facilities, all of which affect the consumption of hospital services, as well as time-invariant levels of hospital market competition, because market competition ($HHI97_k$) is measured at the zip code level. Hospital fixed effects absorb all time-invariant differences among admitting hospitals that may affect the patient's outcome (while avoiding the introduction of endogeneity that including at least the observable characteristics directly in the specification might involve.) Quarterly dummy variables control changes over time that may be affecting outcomes for all patients in Pennsylvania.

<u>Quality and Patient Severity</u>

Even if releasing hospital quality information makes competition more effective in improving the quality of care on average, it is not clear that all patients would benefit equally. For example, Kessler & Geppert (2005) found that hospital competition affected the resources used to treat different types of patients. We therefore incorporate the illness severity of the patient into our key variables, so that we can examine whether the extent to which quality information enhances the effects of market competition varies for patients with different degrees of illness.

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[1] For example, the predicted bedsize is: $\text{Bedsize}_k^{pat} = \sum_{h=1}^{H} \hat{\alpha}_{hk} + \left(\sum_{k=1}^{K} \beta_{kh} \times \sum_{h=1}^{H} \hat{\alpha}_{hk} + \text{Bedsize}_h\right)$.

To do so, we add to equation (1) interactions between $(Most\ Competitive_k \cdot Post_t)$ and $(Competitive_k \cdot Post_t)$ and the patient's weighted Charlson index, $Severity_{ikht}$, so that our main specification is now:

$$Outcome_{ikht} = \alpha + \gamma_1(Most\ Competitive_k \cdot Post_t) + \gamma_2(Competitive_k \cdot Post_t) + \theta_1(Most\ Competitive_k \cdot Post_t \cdot Severity_{ikht}) + \theta_2(Competitive_k \cdot Post_t \cdot Severity_{ikht}) + \beta_1 M_{kt} + \beta_2 P_{it} + \eta_h + \varsigma_k + \tau_t + \varepsilon_{ikht}, \quad (2)$$

where $Severity_{ikht}$ is treated as a continuous variable increasing in the patient's illness severity. (In our sample, the mean of the weighted Charlson index is 1.71, and the standard deviation is 1.51.) A non-zero estimate of θ implies that the increased availability of quality information caused hospitals facing different amounts of competition to treat patients differently according to the severity of their illness.

<u>Pre-Existing Trends</u>

We are particularly concerned that the estimated γ*'s* might reflect pre-existing trends instead of the actual effects of online report cards. We therefore estimate equation (2) with variables to test for pre-trends in markets with different levels of market competition:

$$Outcome_{ikht} = \alpha + \gamma_1(Most\ Competitive_k \cdot Post_t) + \gamma_2(Competitive_k \cdot Post_t) + \theta_1(Most\ Competitive_k \cdot Post_t \cdot Severity_{ikht}) + \theta_2(Competitive_k \cdot Post_t \cdot Severity_{ikht}) + \rho_1 \cdot (Most\ Competitive_k \cdot Pre_t) + \rho_2 \cdot (Competitive_k \cdot Pre_t) + \beta_1 M_{kt} + \beta_2 P_{it} + \eta_h + \varsigma_k + \tau_t + \varepsilon_{ikht.} \quad (3)$$

Pre_t is a dummy variable that equals one for the four quarters preceding the release of online report card, namely the third quarter of 1997 through the second quarter of 1998. The interaction of our market concentration measures with Pre_t separates the effect of pre-existing trends in the outcome variables from the response to the introduction of online information.

<u>Results</u>

<u>Sample Statistics</u>

Summary statistics for the three patient outcomes variables for the whole sample and for surgeries occurring before and after publication of the report card online, as well as the change in the outcomes, are shown in Table 1. (Sample sizes for readmissions are slightly smaller than those given on the table because they exclude patients that died during their original admission to the hospital for CABG surgery.) Overall, total costs increased and mortality rates as well as readmission rates decreased after the online publication of the report card. Descriptive statistics for the variables used in the analysis are reported in Table 2.

<u>Basic Results</u>

Table 3 shows the estimation results from equations (1) – (3) for each of the three different dependent variables: total cost of a patient's CABG surgery, whether the patient died, and whether the patient was readmitted in the twelve months following their CABG surgery for a

related problem. Robust standard errors are clustered by 3-digit zip codes and year to account for any correlation in the errors within zip code-year groups;[2] they are reported in brackets.

The estimated coefficients for the variables *(Most Competitive*$_k$ *·Post*$_t$*)* and *(Competitive*$_k$ *·Post*$_t$*)*, reported on the first two lines of columns (1) and (7) in Panel A, indicate that on average, after report cards went online, all patients in the most competitive and competitive markets had significantly more resources expended on their cases and had significantly lower readmission rates compared to patients in the least competitive markets. (The non-monotonic relationship between market competition and the effect of information on total cost, and the positive but marginally significant result for mortality, both disappear in subsequent estimations so we do not discuss them.) Conversely, the estimated coefficients on the triple interaction terms *(Most Competitive*$_k$ *·Post*$_t$ *·Severity*$_{ikht}$*)* and *(Competitive*$_k$ *·Post*$_t$ *·Severity*$_{ikht}$*)*, reported in columns (2), (5), and (8), suggest that mortality rates fell only among the more severely ill patients, despite the fact that hospitals in these areas used more resources on all patients. These extra survivors did not seem to be in marginal health because the readmission rates were also lower among severely ill patients in the most competitive and competitive markets.

Before analyzing these results further, we note that the estimated coefficients of the pre-trend control variables, *(Most Competitive*$_k$*·Pre*$_t$) and (*Competitive*$_k$*·Pre*$_t$), reported in columns (3), (6) and (9), are insignificant for costs and mortality rates. This suggests that relative to the least competitive markets, most competitive and competitive markets did not experience significant change in these two outcomes in the four quarters preceding online report cards compared to the period before that in our sample, the first quarter of 1995 through the second quarter of 1997. However, there is clear evidence of a pre-existing trend in the readmission rate in competitive markets, which may be included in the estimated effect of competition in the post-period.

A possible confounding effect is changes over time in hospital characteristics that influence patients' outcomes. Although we include hospital fixed effects to control for constant differences across hospitals, these fixed effects will not eliminate effects that vary over time, such as those related to technology adoption or nurse staffing. We therefore re-estimated equations (1), (2), and (3) adding a linear time trend for each hospital, created by interacting each hospital dummy η_h with a linear time trend variable Y_t, where t in this case represents years rather than quarters, so that $Y_t = 1$ in 1995, …, 10 in 2004.

The results of these re-estimations are in Table 4. In these estimations, the coefficients of the pre-trend interaction variables, again shown in columns (3), (6), and (9), are of only marginal significance for mortality and readmission rates, suggesting that the use of hospital-specific linear time trends helps control for pre-existing trends. Consequently, we include a hospital-specific linear trend for each hospital in all following estimations.

Otherwise, the set of results in Table 4 reinforces our findings in Table 3. While hospitals in the more competitive areas responded to the online report cards by using more resources on all patients, only the more severely ill patients in the most competitive and competitive areas are significantly less likely to die in hospital or to be readmitted within the subsequent 12 months. We now find no evidence that mortality or readmission rates are affected for all patients as the estimated main effects of competition on patient mortality and readmission rates in the post-period become small and insignificant.

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[2]We cluster our standard errors by 3-digit rather than 5-digit zip codes to account for spatial correlation. There are 46 3-digit zip codes in Pennsylvania, and, depending on the year, about 2014 5-digit zip codes.

The estimates in column (3) of Panel 4 suggest that the costs increased by 7.1% (=exp(0.0691)-1) in the most competitive markets after the online publication of report cards, which represents an increase of $1,810 relative to the mean in the pre-period of $25,495 in these markets (figures are in 1995 dollars). For patients with the average level of severity in our sample (Charlson index = 1.71), the mortality rate in the most compared to the least competitive markets was approximately (0.0021*1.71-0.0021) or 0.15 percentage points lower, and the readmission rate was approximately (0.0053*1.71-0.0053) or 0.38 percentage points lower, while for patients in competitive markets the corresponding reductions were 0.17 percentage points and 0.31 percentage points.

Main Results

Since our identification strategy relies on comparing changes in outcomes before and after report cards went online, we need to be particularly careful to control for contemporaneous events that may also have affected how hospitals responded to their competitive environment, potentially altering their patients' outcomes, during the sample period. We re-estimate our specification adding variables to control for four contemporary shocks to insure that our results show the effects of report cards, as opposed to the effects of these other contemporaneous changes, on hospital quality competition.

First, HMO penetration increased during our sample period. Our specification already includes, as a patient characteristic, a variable indicating whether the patient is an HMO enrollee, thus controlling for any direct effects of being enrolled in an HMO on a patient's outcomes. However, there may be indirect effects. Hospitals in high HMO penetration areas may be under greater financial pressure, which may in turn limit their ability to adopt new technologies, hire more skilled nurses, or spend money on other quality-improving resources. To the extent that these resources are shared by all patients, HMO penetration could have a spillover effect on health outcomes of non-HMO patients. On the other hand, greater scrutiny of their performance by HMOs might force hospitals to improve efficiency and quality in ways that again may spill over to all patients. We control these possible spillover effects by including the HMO penetration each year for the county containing the patient's zip code. We obtained HMO penetration rates in Pennsylvania counties from the Pennsylvania Department of Health, *Managed Care Reports*.

Second, many studies have concluded that greater hospital volume is associated with better patient outcomes for CABG (Halm & Chassin, 2002; Peterson et al., 2004). While the use of hospital fixed effects should control for much of the variation in outcomes associated with hospital volume, we also include the predicted demand for CABG surgery from the patient's zip code, so that we may control, without introducing endogeneity, for any benefit patients from the zip code receive from having their surgery, on average, at higher-volume hospitals. We calculate the predicted demand from each zip code using the same procedure as is used to predict the HHIs, as well as the size and teaching status of hospitals for each zip code. In this case, we count the number of CABG patients in each hospital, and then aggregate the measure to the zip-code level using predicted patient flows from that zip code.

A third possible source of confounding contemporaneous change arises from Pennsylvania's termination of CON regulation for CABG programs in 1996, when a number of new CABG programs entered the market. New entrants reduced concentration directly in individual markets, and may also have disrupted tacit agreements among existing providers (Scherer & Ross, 1990; Ivaldi, et al., 2003), so that hospitals in markets experiencing entry are

likely to be under greater competitive pressure. Further, previous research has shown that in health care markets entry may result in a redistribution of consumers (Cutler, et al., 2010), also increasing competition in the markets. Finally, as our measure of competition is based on market shares, competition will also change if patients shift to higher-quality hospitals in response to the publication of quality data.

We isolate the impact of new entry from the effect of the online report cards, and also minimize endogeneity problems, by adding a variable that is the predicted share of CABG procedures performed at hospitals that entered the CABG market after 1996. We calculate this variable by summing the predicted patient demand each year, by zip code, for hospitals that opened after 1997, divided by the total predicted demand from each zip code each year.

Finally, passage of the Balanced Budget Act (BBA) in 1997 may also have affected patient outcomes. The BBA imposed substantial reductions in Medicare payments to hospitals, and empirical research suggests that these reductions were particularly hard on those hospitals with a greater reliance on Medicare reimbursements (Wu, 2010). We control for possible effects of the cost-containment legislation (while continuing to avoid potential endogeneity) by including a variable that is the number of Medicare patients admitted to the hospitals in a county each year, divided by the total number of inpatients to hospitals in a county in that year. Hospitals located in counties with a greater share of Medicare patients are more likely to have experienced financial pressure due to the passage of the BBA.

Descriptive statistics for each of these variables are shown in Table 2.

Table 5 presents the results of estimations that include these four variables. First, we find that our main results are not affected by the inclusion of the variables: hospitals in the most competitive and competitive markets had higher total costs for all patients, and had lower in-hospital mortality and one-year readmission rates for more severely ill patients. The magnitudes of these effects are almost entirely unaffected.

Second, the estimated coefficients for the HMO penetration variable indicate that the HMO penetration is associated with lower costs, which is not surprising, but also with better patient outcomes, which suggests that any negative spillover effect from the financial pressure introduced by HMOs is not as strong as the impact HMOs have on hospital quality and efficiency. Otherwise, we find no evidence that predicted market demand, predicted entrant share, or the percentage of Medicare patients had any independent effect on our outcome variables. We also note, however, that introduction of these new control variables causes all evidence of a pre-trend to disappear, and so we continue to include the variables in all subsequent estimations.

Tables 6-8 show the effects of various changes in the construction of the HHIs. As noted above using the hospitals within in a 50-mile radius around a patient's zip code to identify their choice set of hospitals for the conditional logits seemed reasonable, 50 miles is an arbitrary cutoff. In Tables 6 and 7 we report estimates where the conditional logits are estimated giving each patient the choice of all CABG hospitals within a 75-mile radius (Table 6) and within a 100-mile radius (Table 7). Inspection of these estimates shows that our findings remained unaffected when we used these alternative measures to calculate HHIs and define our *Most Competitive* and *Competitive* dummy variables. The one change in our results is that the estimated coefficient for *Competitive*Post* is now positive and significant for readmission rates, possibly because as the radius identifying the choice set of hospitals increases, hospitals are more likely to attract patients that have traveled further because they are sicker.

Next, we replace our dummy variables *Most Competitive* and *Competitive*, which are based on the HHIs measured in 1997, with two dummy variables that measure the competitiveness of a market with the HHI as measured in 1996, before hospitals could react to the discontinuation of the CON regulations. The results in Table 8 repeat our main findings, with stronger results for total cost and one-year readmission for competitive markets.

Results by Urban and Rural Areas

In Tables 9 and 10 we show the results of splitting our sample into patients living in rural areas and patients living in urban areas, using the percent urban population in the patient's zip code to sort zip codes into urban and rural categories. Here we find similar results for patients living in urban areas in Table 9: after the report cards went online, hospitals in more competitive markets used more resources per patient, and achieved lower mortality and readmission rates among more severely ill patients. However, results in Table 10 are generally not statistically significant for patients living in rural areas.

In sum, there is some suggestion that information about grades had an impact on patients located in urban areas before affecting those located in more rural areas. However, our results cannot determine whether it was the patients themselves or their physician, whether primary care or cardiologist, who might have been responding to the new information.

Figure 1. CABG Hospital Locations in Pennsylvania, 1995 (Circles) and 2004 (Squares)

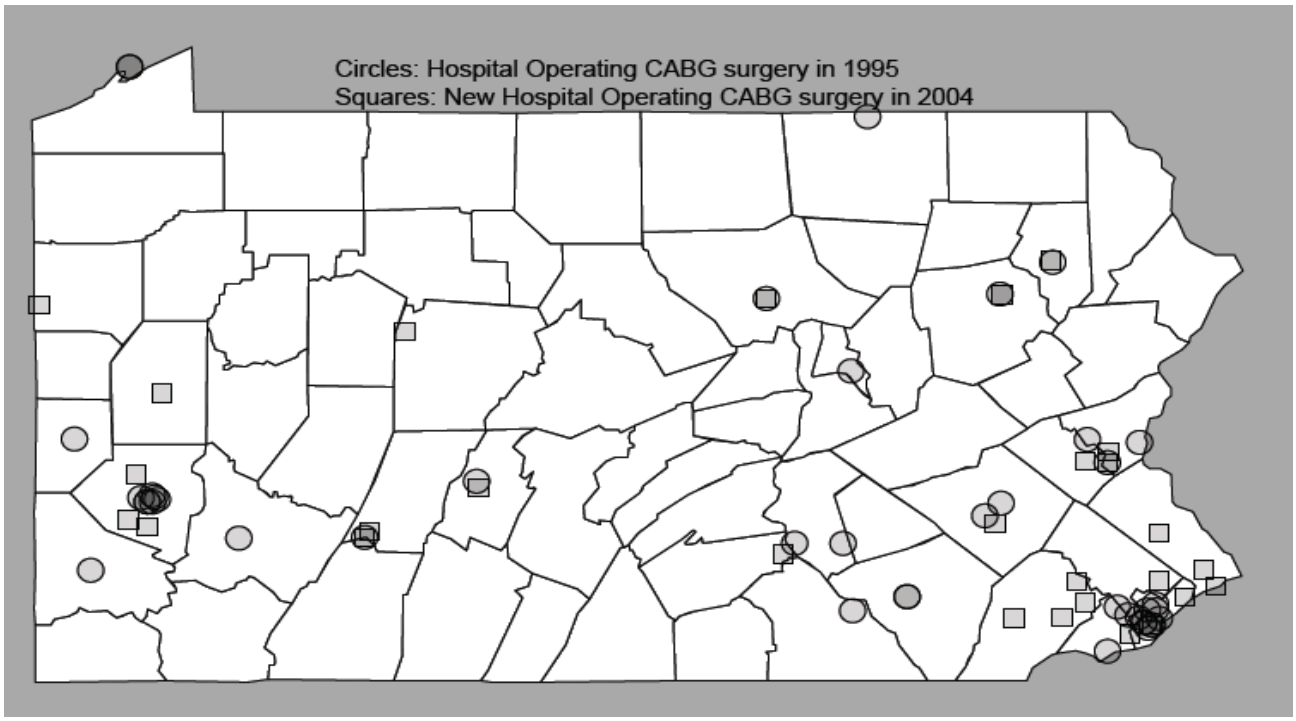

Figure 2: Map of Pennsylvania Zip Codes by Competitiveness of Hospital Market in 1997

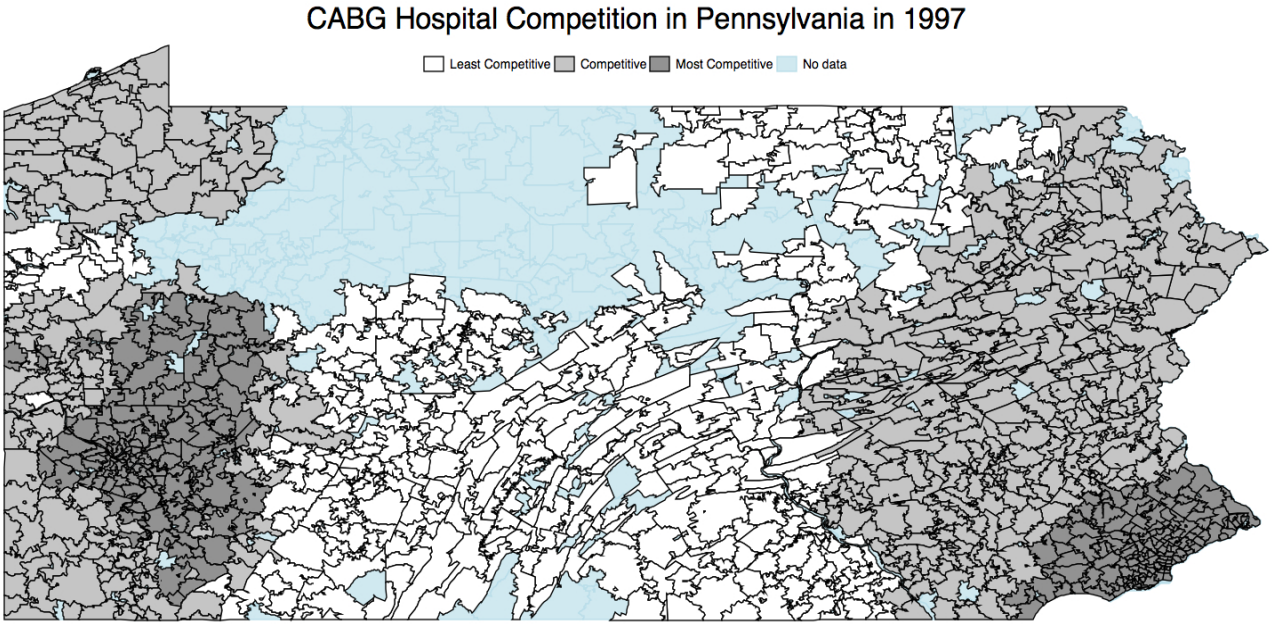

Table 1. Sample Statistics for Patient Outcomes[a]

	Whole Sample	Online Publication of Report Card		
		Before	After	Change
Total costs	$23,040	$22,925	$23,112	$187
	(14,361)	(13,731)	(14,739)	
In-hospital mortality	0.023	0.026	0.021	-0.005
Readmission	0.182	0.201	0.170	-0.030
N[b]	137,239	52,600	84,639	

[a] Standard deviations are in parentheses. [b] Sample sizes for readmissions are slightly smaller because they exclude patients that died during their original admission to the hospital for CABG surgery.

Table 2. Descriptive Statistics for Variables Used in Main Analysis, 1995-2004

Patient Characteristics			
Distance to the closest CABG hospital	9.918	Charlson index=1	0.323
	(10.202)	Charlson index=2	0.235
Age below 45	0.025	Charlson index=3	0.132
Age 45-49	0.043	Charlson index=4	0.06
Age 50-54	0.077	Charlson index=5	0.026
Age 55-59	0.108	Charlson index>=6	0.022
Age 60-64	0.133		
Age 65-59	0.177		
Age 70-74	0.195	Market Characteristics	
Age 75-79	0.158	Bed size	396.349
Age 80-84	0.07		(197.715)
Male	0.69	Teaching status	0.654
Black	0.036		(0.374)
Hispanic	0.01	Contemporaneous Events	
Emergency admission	0.347	HMO penetration rate (county level)	0.41
Medicare	0.56		(0.144)
Medicaid	0.038	Predicted market demand (zip code level)	32.938
Private insurance	0.395		(9.170)
HMO plan	0.262	Predicted entrant share (zip code level)	0.063
Referred by a physician	0.576		(0.141)
Transferred from another hospital	0.183	Percentage of Medicare patients (county level)	0.423
Transferred from another nursing home	0.043		(0.061)

Table 3: Basic Results (Without Controlling Hospital-Specific Linear Trend)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES		Log of Total Cost			In-Hospital Mortality			One Year Readmission	
Most Competitive*Post	0.0669**	0.0638**	0.0648*	0.0008	0.0043*	0.0020	-0.0242**	-0.0143	-0.0187*
	[0.032]	[0.031]	[0.033]	[0.002]	[0.003]	[0.003]	[0.010]	[0.010]	[0.011]
Competitive*Post	0.1256***	0.1249***	0.1335***	-0.0032	0.0008	-0.0006	-0.0269***	-0.0190*	-0.0319***
	[0.032]	[0.032]	[0.034]	[0.002]	[0.003]	[0.003]	[0.010]	[0.010]	[0.011]
Most Competitive*Post*Severity		0.0017	0.0017		-0.0020***	-0.0020***		-0.0056***	-0.0056***
		[0.002]	[0.002]		[0.001]	[0.001]		[0.002]	[0.002]
Competitive*Post*Severity		0.0004	0.0004		-0.0024***	-0.0024***		-0.0047**	-0.0047**
		[0.002]	[0.002]		[0.001]	[0.001]		[0.002]	[0.002]
Most Competitive*Pre			0.0014			-0.0065			-0.0106
			[0.033]			[0.004]			[0.013]
Competitive*Pre			0.0252			-0.0038			-0.0370***
			[0.032]			[0.004]			[0.013]
Observations	137,239	137,239	137,239	137,239	137,239	137,239	134,151	134,151	134,151
R-squared	0.451	0.451	0.451	0.027	0.027	0.027	0.182	0.182	0.182
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	NO	NO	NO	NO	NO	NO	NO	NO	NO

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Basic Results (Controlling Hospital-Specific Linear Trend)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES		Log of Total Cost			In-Hospital Mortality			One Year Readmission	
Most Competitive*Post	0.0635***	0.0617***	0.0691**	-0.0015	0.0021	-0.0013	-0.0115	-0.0024	-0.0016
	[0.022]	[0.022]	[0.027]	[0.003]	[0.003]	[0.004]	[0.010]	[0.011]	[0.012]
Competitive*Post	0.0349*	0.0332*	0.0337	-0.0019	0.0022	0.0005	-0.0059	0.0015	-0.0072
	[0.018]	[0.018]	[0.022]	[0.003]	[0.003]	[0.004]	[0.010]	[0.010]	[0.012]
Most Competitive*Post*Severity		0.0010	0.0010		-0.0021***	-0.0021***		-0.0053**	-0.0053**
		[0.002]	[0.002]		[0.001]	[0.001]		[0.002]	[0.002]
Competitive*Post*Severity		0.0010	0.0010		-0.0024***	-0.0024***		-0.0044**	-0.0044**
		[0.002]	[0.002]		[0.001]	[0.001]		[0.002]	[0.002]
Most Competitive*Pre			0.0160			-0.0074*			0.0018
			[0.026]			[0.004]			[0.012]
Competitive*Pre			0.0002			-0.0037			-0.0207*
			[0.023]			[0.004]			[0.012]
Observations	137,239	137,239	137,239	137,239	137,239	137,239	134,151	134,151	134,151
R-squared	0.497	0.497	0.497	0.027	0.028	0.028	0.185	0.185	0.185
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Main Results on Information, Competition and Patient Outcomes
(Whole Sample, Distance = 50 miles, HHI1997)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Log of Total Cost		In-Hospital Mortality		1 Yr Readmission	
Most Competitive*Post	0.0684**	0.0666**	-0.0039	-0.0003	-0.0082	0.0008
	[0.028]	[0.028]	[0.004]	[0.004]	[0.012]	[0.012]
Competitive*Post	0.0417*	0.0399*	-0.0026	0.0015	-0.0116	-0.0042
	[0.023]	[0.023]	[0.004]	[0.004]	[0.011]	[0.012]
Most Competitive*Post*Severity		0.0010		-0.0021***		-0.0053**
		[0.002]		[0.001]		[0.002]
Competitive*Post*Severity		0.0011		-0.0024***		-0.0044**
		[0.002]		[0.001]		[0.002]
Most Competitive*Pre	0.0189	0.0189	-0.0066	-0.0066	0.0042	0.0042
	[0.027]	[0.027]	[0.004]	[0.004]	[0.012]	[0.012]
Competitive*Pre	0.0065	0.0065	-0.0031	-0.0031	-0.0181	-0.0181
	[0.024]	[0.024]	[0.004]	[0.004]	[0.012]	[0.012]
HMO Pentration Rate	-0.2840**	-0.2841**	-0.0281**	-0.0279**	-0.0921**	-0.0916**
	[0.129]	[0.129]	[0.012]	[0.012]	[0.039]	[0.039]
Predicted Market Demand	-0.0014	-0.0014	0.0002	0.0002	0.0004	0.0004
	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Predicted Entrant Share	-0.0492	-0.0491	0.0033	0.0031	-0.0090	-0.0095
	[0.054]	[0.054]	[0.010]	[0.010]	[0.035]	[0.035]
Percentage of Medicare Patients	0.1472	0.1473	-0.0265	-0.0265	0.0078	0.0075
	[0.162]	[0.162]	[0.028]	[0.028]	[0.092]	[0.091]
Observations	137,239	137,239	137,239	137,239	134,151	134,151
R-squared	0.498	0.498	0.028	0.028	0.185	0.185
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	YES	YES	YES	YES	YES	YES

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Information, Competition and Patient Outcomes
(Whole Sample, Distance = 75 miles, HHI1997)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Log of Total Cost		In-Hospital Mortality		1 Yr Readmission	
Most Competitive*Post	0.0715**	0.0702**	-0.0021	0.0013	0.0075	0.0179
	[0.028]	[0.028]	[0.004]	[0.004]	[0.012]	[0.012]
Competitive*Post	0.0387*	0.0357	0.0015	0.0054	0.0179*	0.0252**
	[0.023]	[0.023]	[0.004]	[0.004]	[0.011]	[0.011]
Most Competitive*Post*Severity		0.0007		-0.0019**		-0.0060***
		[0.002]		[0.001]		[0.002]
Competitive*Post*Severity		0.0017		-0.0023***		-0.0042**
		[0.002]		[0.001]		[0.002]
Most Competitive*Pre	0.0301	0.0301	-0.0062	-0.0062	0.0122	0.0122
	[0.028]	[0.028]	[0.005]	[0.005]	[0.012]	[0.012]
Competitive*Pre	0.0162	0.0162	-0.0001	-0.0001	-0.0018	-0.0016
	[0.026]	[0.026]	[0.004]	[0.004]	[0.011]	[0.011]
HMO Pentration Rate	-0.2700**	-0.2701**	-0.0258**	-0.0255**	-0.0965**	-0.0959**
	[0.127]	[0.127]	[0.012]	[0.013]	[0.039]	[0.039]
Predicted Market Demand	-0.0014	-0.0014	0.0000	0.0000	-0.0002	-0.0002
	[0.001]	[0.001]	[0.000]	[0.000]	[0.001]	[0.001]
Predicted Entrant Share	-0.1253	-0.1253	0.0003	-0.0001	-0.0476	-0.0490
	[0.079]	[0.079]	[0.009]	[0.009]	[0.033]	[0.034]
Percentage of Medicare Patients	0.1361	0.1361	-0.0262	-0.0263	0.0232	0.0230
	[0.162]	[0.162]	[0.028]	[0.028]	[0.093]	[0.093]
Observations	138,528	138,528	138,528	138,528	135,419	135,419
R-squared	0.498	0.498	0.028	0.028	0.184	0.185
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	YES	YES	YES	YES	YES	YES

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Information, Competition and Patient Outcomes
(Whole Sample, Distance = 100 miles, HHI1997)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Log of Total Cost		In-Hospital Mortality		1 Yr Readmission	
Most Competitive*Post	0.0791***	0.0796***	-0.0034	0.0002	0.0076	0.0159
	[0.027]	[0.027]	[0.004]	[0.004]	[0.011]	[0.011]
Competitive*Post	0.0376*	0.0362*	-0.0024	0.0017	0.0211**	0.0226**
	[0.021]	[0.021]	[0.004]	[0.004]	[0.010]	[0.011]
Most Competitive*Post*Severity		-0.0003		-0.0021***		-0.0049**
		[0.001]		[0.001]		[0.002]
Competitive*Post*Severity		0.0008		-0.0023***		-0.0008
		[0.002]		[0.001]		[0.002]
Most Competitive*Pre	0.0504*	0.0504*	-0.0063	-0.0063	0.0105	0.0105
	[0.027]	[0.027]	[0.005]	[0.005]	[0.011]	[0.011]
Competitive*Pre	0.0344	0.0344	-0.0023	-0.0023	-0.0004	-0.0004
	[0.024]	[0.024]	[0.004]	[0.004]	[0.011]	[0.011]
HMO Pentration Rate	-0.2934**	-0.2934**	-0.0245*	-0.0243*	-0.1006***	-0.1004***
	[0.131]	[0.131]	[0.013]	[0.013]	[0.039]	[0.039]
Predicted Market Demand	-0.0005	-0.0005	0.0002	0.0002	-0.0001	-0.0001
	[0.001]	[0.001]	[0.000]	[0.000]	[0.001]	[0.001]
Predicted Entrant Share	-0.1219	-0.1220	0.0071	0.0068	-0.0601*	-0.0614*
	[0.082]	[0.082]	[0.010]	[0.010]	[0.034]	[0.034]
Percentage of Medicare Patients	0.1109	0.1111	-0.0325	-0.0328	0.0225	0.0226
	[0.163]	[0.163]	[0.028]	[0.027]	[0.092]	[0.092]
Observations	138,542	138,542	138,542	138,542	135,433	135,433
R-squared	0.498	0.498	0.028	0.028	0.184	0.185
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	YES	YES	YES	YES	YES	YES

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Information, Competition and Patient Outcomes
(Whole Sample, Distance = 50 miles, HHI1996)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Log of Total Cost		In-Hospital Mortality		1 Yr Readmission	
Most Competitive*Post	0.0631**	0.0603**	-0.0043	-0.0014	0.0001	0.0093
	[0.027]	[0.027]	[0.004]	[0.004]	[0.012]	[0.012]
Competitive*Post	0.0514**	0.0476**	-0.0027	0.0013	-0.0041	0.0051
	[0.021]	[0.022]	[0.004]	[0.004]	[0.012]	[0.012]
Most Competitive*Post*Severity		0.0016		-0.0016**		-0.0054**
		[0.002]		[0.001]		[0.002]
Competitive*Post*Severity		0.0022		-0.0024***		-0.0054***
		[0.002]		[0.001]		[0.002]
Most Competitive*Pre	0.0240	0.0239	-0.0087*	-0.0087*	0.0043	0.0043
	[0.027]	[0.027]	[0.005]	[0.005]	[0.012]	[0.012]
Competitive*Pre	0.0234	0.0233	-0.0056	-0.0055	-0.0178	-0.0177
	[0.025]	[0.025]	[0.004]	[0.004]	[0.012]	[0.012]
HMO Pentration Rate	-0.2865**	-0.2867**	-0.0271**	-0.0269**	-0.0965**	-0.0958**
	[0.129]	[0.129]	[0.013]	[0.013]	[0.039]	[0.039]
Predicted Market Demand	-0.0015	-0.0015	0.0002	0.0002	0.0004	0.0004
	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Predicted Entrant Share	-0.0509	-0.0507	0.0026	0.0025	-0.0131	-0.0137
	[0.055]	[0.055]	[0.010]	[0.010]	[0.035]	[0.035]
Percentage of Medicare Patients	0.1373	0.1372	-0.0226	-0.0225	0.0213	0.0212
	[0.163]	[0.163]	[0.029]	[0.029]	[0.094]	[0.094]
Observations	135,741	135,741	135,741	135,741	132,685	132,685
R-squared	0.498	0.498	0.028	0.028	0.185	0.186
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	YES	YES	YES	YES	YES	YES

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Information, Competition and Patient Outcomes
(Urban Sample, Distance = 50 miles, HHI1997)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Log of Total Cost		In-Hospital Mortality		1 Yr Readmission	
Most Competitive*Post	0.0875***	0.0841***	-0.0075*	-0.0042	-0.0326**	-0.0237
	[0.029]	[0.030]	[0.004]	[0.004]	[0.014]	[0.015]
Competitive*Post	0.0378	0.0371	-0.0063	-0.0026	-0.0284**	-0.0213
	[0.026]	[0.027]	[0.004]	[0.004]	[0.013]	[0.013]
Most Competitive*Post*Severity		0.0020		-0.0020**		-0.0053**
		[0.002]		[0.001]		[0.002]
Competitive*Post*Severity		0.0004		-0.0022***		-0.0043*
		[0.002]		[0.001]		[0.002]
Most Competitive*Pre	0.0430	0.0430	-0.0116**	-0.0115**	-0.0050	-0.0050
	[0.029]	[0.029]	[0.005]	[0.005]	[0.015]	[0.015]
Competitive*Pre	0.0034	0.0034	-0.0064	-0.0063	-0.0252*	-0.0252*
	[0.028]	[0.028]	[0.005]	[0.005]	[0.015]	[0.015]
HMO Pentration Rate	-0.1686	-0.1689	-0.0249	-0.0247	-0.0190	-0.0184
	[0.145]	[0.145]	[0.015]	[0.015]	[0.043]	[0.043]
Predicted Market Demand	-0.0015	-0.0015	0.0002	0.0002	0.0003	0.0003
	[0.001]	[0.001]	[0.000]	[0.000]	[0.001]	[0.001]
Predicted Entrant Share	-0.0366	-0.0365	0.0044	0.0044	-0.0297	-0.0296
	[0.056]	[0.056]	[0.010]	[0.010]	[0.042]	[0.042]
Percentage of Medicare Patients	-0.0319	-0.0319	-0.0591*	-0.0585*	0.0273	0.0281
	[0.217]	[0.217]	[0.032]	[0.032]	[0.115]	[0.115]
Observations	105,952	105,952	105,952	105,952	103,697	103,697
R-squared	0.466	0.466	0.025	0.025	0.188	0.188
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	YES	YES	YES	YES	YES	YES

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 10: Information, Competition and Patient Outcomes
(Rural Sample, Distance = 50 miles, HHI1997)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Log of Total Cost		In-Hospital Mortality		1 Yr Readmission	
Most Competitive*Post	0.0315	0.0371	0.0079	0.0120	0.0371*	0.0484**
	[0.000]	[0.000]	[0.008]	[0.008]	[0.020]	[0.022]
Competitive*Post	0.0627	0.0565	0.0052	0.0109	0.0300	0.0374*
	[0.000]	[0.000]	[0.007]	[0.008]	[0.019]	[0.020]
Most Competitive*Post*Severity		-0.0031		-0.0022		-0.0060
		[0.000]		[0.002]		[0.004]
Competitive*Post*Severity		0.0035		-0.0032*		-0.0041
		[0.000]		[0.002]		[0.004]
Most Competitive*Pre	-0.0368	-0.0369	0.0068	0.0068	0.0209	0.0210
	[0.000]	[0.000]	[0.007]	[0.007]	[0.018]	[0.018]
Competitive*Pre	0.0294	0.0294	0.0033	0.0034	0.0021	0.0024
	[0.000]	[0.000]	[0.009]	[0.009]	[0.022]	[0.023]
HMO Pentration Rate	-0.7127	-0.7133	-0.0317	-0.0320	-0.0987	-0.0997
	[0.000]	[0.000]	[0.027]	[0.027]	[0.080]	[0.080]
Predicted Market Demand	-0.0015	-0.0015	-0.0001	-0.0001	0.0006	0.0006
	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
Predicted Entrant Share	-0.0762	-0.0768	0.0022	0.0024	0.0323	0.0322
	[0.000]	[0.000]	[0.021]	[0.021]	[0.046]	[0.046]
Percentage of Medicare Patients	0.5736	0.5757	0.0564	0.0557	-0.0020	-0.0018
	[0.000]	[0.000]	[0.047]	[0.047]	[0.145]	[0.146]
Observations	31,287	31,287	31,287	31,287	30,454	30,454
R-squared	0.571	0.571	0.040	0.041	0.190	0.190
Cluster	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr	id_zip_yr
HospXyear	YES	YES	YES	YES	YES	YES

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Presentations

1. Eastern Economic Association Annual Conference, Feb 2011, New York City, NY
2. International Industrial Organization Conference, April 2011, Boston, MA
3. American Society of Health Economists, June 2012, Minneapolis, MN

18. Extent of Clinical Activities Initiated and Completed. Items 18(A) and 18(B) should be completed for all research projects. If the project was restricted to secondary analysis of clinical data or data analysis of clinical research, then responses to 18(A) and 18(B) should be "No."

18(A) Did you initiate a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes
___X___No

18(B) Did you complete a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes
__X____No

If "Yes" to either 18(A) or 18(B), items 18(C) – (F) must also be completed. (Do NOT complete 18(C-F) if 18(A) and 18(B) are both "No.")

18(C) How many hospital and health care professionals were involved in the research project?

_____Number of hospital and health care professionals involved in the research project

18(D) How many subjects were included in the study compared to targeted goals?

_____Number of subjects originally targeted to be included in the study
_____Number of subjects enrolled in the study

Note: Studies that fall dramatically short on recruitment are encouraged to provide the details of their recruitment efforts in Item 17, Progress in Achieving Research Goals, Objectives and Aims. For example, the number of eligible subjects approached, the number that refused to participate and the reasons for refusal. Without this information it is difficult to discern whether eligibility criteria were too restrictive or the study simply did not appeal to subjects.

18(E) How many subjects were enrolled in the study by gender, ethnicity and race?

Gender:
_____Males
_____Females
_____Unknown

Ethnicity:
_____Latinos or Hispanics
_____Not Latinos or Hispanics
_____Unknown

Race:
_____American Indian or Alaska Native
_____Asian
_____Blacks or African American
_____Native Hawaiian or Other Pacific Islander
_____White
_____Other, specify:_____
_____Unknown

18(F) Where was the research study conducted? (List the county where the research study was conducted. If the treatment, prevention and diagnostic tests were offered in more than one county, list all of the counties where the research study was conducted.)

19. Human Embryonic Stem Cell Research. Item 19(A) should be completed for all research projects. If the research project involved human embryonic stem cells, items 19(B) and 19(C) must also be completed.

19(A) Did this project involve, in any capacity, human embryonic stem cells?
_____ Yes
___X__ No

19(B) Were these stem cell lines NIH-approved lines that were derived outside of Pennsylvania?
_____Yes
_____ No

19(C) Please describe how this project involved human embryonic stem cells:

20. Articles Submitted to Peer-Reviewed Publications.

20(A) Identify all publications that resulted from the research performed during the funding period and that have been submitted to peer-reviewed publications. Do not list journal abstracts or presentations at professional meetings; abstract and meeting presentations should be listed at the end of item 17. **Include only those publications that acknowledge the Pennsylvania Department of Health as a funding source** (as required in the grant agreement). List the title of the journal article, the authors, the name of the peer-reviewed publication, the month and year when it was submitted, and the status of publication (submitted for publication, accepted for publication or published.). Submit an electronic copy of each publication or paper submitted for publication, listed in the table, in a PDF version 5.0.5 (or greater) format, 1,200 dpi. Filenames for each publication should include the number of the research project, the last name of the PI, the number of the publication and an abbreviated research project title. For example, if you submit two publications for PI Smith for the "Cognition and MRI in Older Adults" research project (Project 1), and two

publications for PI Zhang for the "Lung Cancer" research project (Project 3), the filenames should be:

Project 1 – Smith – Publication 1 – Cognition and MRI
Project 1 – Smith – Publication 2 – Cognition and MRI
Project 3 – Zhang – Publication 1 – Lung Cancer
Project 3 – Zhang – Publication 2 – Lung Cancer

If the publication is not available electronically, provide 5 paper copies of the publication.

Note: The grant agreement requires that recipients acknowledge the Pennsylvania Department of Health funding in all publications. Please ensure that all publications listed acknowledge the Department of Health funding. If a publication does not acknowledge the funding from the Commonwealth, do not list the publication.

Title of Journal Article:	Authors:	Name of Peer-reviewed Publication:	Month and Year Submitted:	Publication Status (check appropriate box below):
1. Competition and the Impact of Online Hospital Report Cards	Shin-Yi Chou, Mary E Deily, Suhui Li, Yi Lu	Journal of Health Economics	December 2012	☒Submitted ☐Accepted ☐Published
2. Travel Distance and Health Outcomes for Scheduled Surgery	Shin-Yi Chou, Mary E Deily, Suhui Li	Social Sciences & Medicine	November 2012	☒Submitted ☐Accepted ☐Published

20(B) Based on this project, are you planning to submit articles to peer-reviewed publications in the future?

Yes_____ No____x_____

If yes, please describe your plans:

21. Changes in Outcome, Impact and Effectiveness Attributable to the Research Project. Describe the outcome, impact, and effectiveness of the research project by summarizing its impact on the incidence of disease, death from disease, stage of disease at time of diagnosis, or other relevant measures of outcome, impact or effectiveness of the research project. If there were no changes, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

22. Major Discoveries, New Drugs, and New Approaches for Prevention Diagnosis and Treatment. Describe major discoveries, new drugs, and new approaches for prevention, diagnosis and treatment that are attributable to the completed research project. If there were no major discoveries, drugs or approaches, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

23. Inventions, Patents and Commercial Development Opportunities.

23(A) Were any inventions, which may be patentable or otherwise protectable under Title 35 of the United States Code, conceived or first actually reduced to practice in the performance of work under this health research grant? Yes_____ No___X_____

If "Yes" to 23(A), complete items a – g below for each invention. (Do NOT complete items a - g if 23(A) is "No.")

a. Title of Invention:

b. Name of Inventor(s):

c. Technical Description of Invention (describe nature, purpose, operation and physical, chemical, biological or electrical characteristics of the invention):

d. Was a patent filed for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No____

If yes, indicate date patent was filed:

e. Was a patent issued for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No____
If yes, indicate number of patent, title and date issued:
Patent number:
Title of patent:
Date issued:

f. Were any licenses granted for the patent obtained as a result of work performed under this health research grant? Yes_____ No____

If yes, how many licenses were granted?_____

g. Were any commercial development activities taken to develop the invention into a commercial product or service for manufacture or sale? Yes___ No____

If yes, describe the commercial development activities:

23(B) Based on the results of this project, are you planning to file for any licenses or patents, or undertake any commercial development opportunities in the future?

Yes_____ No____X_____

If yes, please describe your plans:

24. Key Investigator Qualifications. Briefly describe the education, research interests and experience and professional commitments of the Principal Investigator and all other key investigators. In place of narrative you may insert the NIH biosketch form here; however, please limit each biosketch to 1-2 pages. *For Nonformula grants only – include information for only those key investigators whose biosketches were not included in the original grant application.*

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME Shin-Yi Chou	POSITION TITLE Frank Magee Professor of Economics, Lehigh University and Research Associate, NBER
eRA COMMONS USER NAME SHINYICHOU	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
National Taiwan University, Taiwan	BA	1994	Economics
Duke University, Durham, NC	Ph.D.	1999	Economics

A. Personal Statement. My role in the project includes the following tasks: (1) develop the analytical models and direct analytical implementations and (2) contribute to manuscripts and presentations emanating from the project. I have been engaged in research in health economics using advanced econometrics methods for a decade and have published twenty-seven peer-reviewed journal articles.

B. Positions and Honors.

Positions

Assistant Professor, New Jersey Institute of Technology, Dep. of Humanities and Social Sciences, 1999-2003.
Faculty Research Fellow, National Bureau of Economic Research, 2000-2006.
Assistant Professor, Lehigh University, Department of Economics, 2003-2006.
Research Associate, National Bureau of Economic Research, 2006-present.
Associate Professor (with Tenure), Lehigh University, Department of Economics, 2006-2010.
Professor, Lehigh University, Department of Economics, 2010-Present.

Honors

Kane Faculty Fellow, Lehigh University, 2004-2005.
Frank L. Magee Fellow, Lehigh University, 2006-present.
Carl R. and Ingeborg Beidleman Research Award, Lehigh University, 2006
Hillman Award for Graduate Advising, Lehigh University, 2009.

C. Referred Journal Articles (Selected).

1. Lea Gimenezduarte, Shin-Yi Chou, Jin-Tan Liu and Jin-Long Liu, "Parental Loss and Children's Wellbeing", *Journal of Human Resources*, forthcoming.
2. Mary E. Deily, Tianyan Hu, Sabrina Terrizzi, Shin-Yi Chou and Chad D. Meyerhoefer "The Impact of Health Information Technology Adoption by Outpatient Facilities on Pregnancy Outcomes", *Health Services Research*, 48(February 2013, 1): 70-94.
3. Juan Du, Justin Wang, Yao Chen, Shin-Yi Chou and Joe Zhu, "Incorporating Health Outcomes in Pennsylvania Hospital Efficiency: An Additive Super-efficiency DEA

Approach", *Annals of Operations Research*, forthcoming.
4. Justin Wang, Jason Hockenberry, Shin-Yi Chou and Muzhe Yang, "Do Bad Report Cards Have Consequences? How Publicly Reported Provider Quality Information Impacts the CABG Market in Pennsylvania", *Journal of Health Economics*, 30(2), 392-407, 2011.
5. Jason Hockenberry, Hsien-Ming Lien and Shin-Yi Chou, "Surgeon and Hospital Volume as a Quality Indicators for CABG in Taiwan: Examining Hazard to Mortality and Accounting for Unobserved Heterogeneity", *Health Services Research*, 45(5p1), 1168-1187, 2010.
6. Hsien-Ming Lien, Shin-Yi Chou and Jin-Tan Liu, "The Role of Hospital Competition on Treatment Cost and Outcome: Evidence from Stroke Treatment in Taiwan", *Economic Inquiry*, 48(3), 668-689, 2010.
7. Shin-Yi Chou, Jin-Tan Liu, Michael Grossman and Ted Joyce, "Parental Education and Child Health: Evidence from a Natural Experiment in Taiwan", *American Economic Journal: Applied Economics*, 2(1), 33-61, 2010.
8. Wehn-Jyuan Tsai, Jin-Tan Liu, Shin-Yi Chou and Robert Thornton, "Does Educational Expansion Encourage Female Workforce Participation? A Study of the 1968 Reform in Taiwan", *Economics of Education Review*, 28(6), 750-758, 2009.
9. Echu Liu, Cheng Hsiao, Tomoya Matusmoto and Shin-Yi Chou, "Maternal Full-Time Employment and Overweight Children: Parametric, Semi-Parametric, and Non-Parametric Assessment". *Journal of Econometrics*, 152(1), 61-69, 2009.
10. Jason Hockenberry, Hsien-Ming Lien and Shin-Yi Chou, "The Impact of Task Repetition and Temporal Breaks in Production on Human Capital and Productivity", *Journal of Human Capital*, 2(3), 303-335, 2008.
11. Shin-Yi Chou, Inas Rashad and Michael Grossman, "Fast Food Restaurant Advertising on Television and Its Influence on Childhood Obesity", *Journal of Law and Economics*, 51(4), 599-618, 2008.
12. Hsien-Ming Lien, Shin-Yi Chou and Jin-Tan Liu, "Hospital Ownership and Performance: Evidence from Stroke and Cardiac Treatment in Taiwan,"' *Journal of Health Economics*, 27(5), 1208-1223, 2008.
13. Ming-Jen Lin, Jin-Tan Liu and Shin-Yi Chou, "As Low Birth Weight Babies Grow, Can 'Good' Parents Buffer this Adverse Factor? A Research Note, *Demography*, 44(2), 335-343, 2007.

D. Research Support

Ongoing Research Support

AHRQ (1R18HS018649-01A1) Donald Levick (PI) 2012-2014
Data Flow & Clinical Outcomes in a Perinatal Continuum of Care System
We are studying the implementation by the Lehigh Valley Health Network (LVHN) of an integrated electronic medical record (EMR) system at its OB-GYN practice groups and the Labor and Delivery (L&D) Unit at the network's main hospital.
Role: Senior Investigator

NIA (1R21 AG033876-01A2) M. Grossman (PI) 2010-2012
Moral Hazard in Less Invasive Surgical Technology for Coronary Artery Disease
This study seeks to address the extent to which differences in the invasiveness of treatment impact post operative behavior of patients and what impacts this has on health outcomes observed between treatment approaches.
Role: Co-Principal Investigator

BIOGRAPHICAL SKETCH

NAME Mary E. Deily	POSITION TITLE Professor
eRA COMMONS USER NAME	

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	YEAR(s)	FIELD OF STUDY
University of Maryland, College Park, MD	BA	1979	Economics
Harvard University, Cambridge, MA	MA	1982	Economics
Harvard University, Cambridge, MA	PhD	1985	Economics

A. Personal Statement.

My roles in the project are to: (1) work with ShinYi Chou to develop the quantitative models, (2) help direct empirical analyses and interpret results, and (3) write manuscripts and presentations to disseminate our findings. I am an applied microeconomist currently focused on topics in health economics and health services research, primarily the relationships between competition, information, and the cost and quality of health outcomes.

B. Positions and Honors.

Positions

1984-1991 Assistant Professor, Department of Economics, Texas A&M University.
1987-1988 Visiting Scholar, Federal Reserve Bank of Cleveland
1991-1995 Assistant Professor, Lehigh University, Department of Economics.
1995-2007 Associate Professor, Lehigh University, Department of Economics.
1998-2000 Program Director, Economics, National Science Foundation
2007-present Professor, Lehigh University, Department of Economics.

Honors

1978 Phi Beta Kappa.
1979 Phi Kappa Phi, Omicron Delta Epsilon; National Science Foundation Fellowship.
2001-2003 Class of ’61 Chair, Lehigh University.
2006 Carl R. and Ingeborg Beidleman Research Award, Lehigh University.
2006-2009 Arthur F. Searing Professorship, Lehigh University.

C. Refereed Journal Articles

1. Deily ME, Hu T, Terrizzi S, Chou SY, Meyerhoefer CD. The Impact of Health Information Technology Adoption by Outpatient Facilities on Pregnancy Outcomes, *Health Services Research*, 48(February 2013, 1): 70-94.
2. McKay NL, Deily ME. Cost Inefficiency and Hospital Health Outcomes. *Health Economics* 17(July 2008, 7): 833-848.
3. Deily ME, Gray WB. Agency Structure and Firm Culture: OSHA, EPA, and the Steel Industry. *The Journal of Law, Economics, & Organization,* 23(October 2007, 3): 685-709.

4. Bergenstock DJ, Deily ME, Taylor, LW. A Cartel's Response to Cheating: An Empirical Investigation of the De Beers Diamond Empire. *Southern Economic Journal* 73(1): 173-189. July 2006.
5. Deily ME, McKay NL. Cost Inefficiency and Mortality Rates in Florida Hospitals. *Health Economics* 15(4): 419-431. April 2006.
6. McKay NL, Deily ME. Comparing High- and Low-Performing Hospitals Using Risk-Adjusted Excess Mortality and Cost Inefficiency. *Health Care Management Review* 30(4): 347-360. October-December 2005.
7. McKay NL, Deily ME, Dorner, FH. Ownership and Changes in Hospital Efficiency, 1986-1991. *Inquiry* 39(4): 388-399. Winter 2002/2003.
8. Deily ME, McKay NL, Dorner FH. Exit and Inefficiency: The Effects of Ownership Type. *Journal of Human Resources* 35(4): 734-747. Fall 2000.
9. Deily ME. Wages in the Steel Industry: Take the Money and Run? *Industrial Relations* 37(2): 153-177. April 1998.
10. Gray WB, Deily ME. Compliance and Enforcement Behavior: Air Pollution Regulation in the U.S. Steel Industry. *Journal of Environmental Economics and Management* 31: 96-111. 1996. Summary included in Compliance Information Project: Literature Summaries. Office of Planning and Policy Analysis, United States Environmental Protection Agency, EPA-3000-R-99-002, April 1999.
11. Deily ME, Reed, WR. Temptation, Willpower, and the Problem of Rational Self-Control. *Rationality and Society* 5(4): 455-472. October 1993.
12. Deily ME, Gray, WB. Enforcement of Pollution Regulations in a Declining Industry. *Journal of Environmental Economics and Management* 21: 260-274. 1991. Reprinted in Environmental Instruments and Institutions, Thomas Tietenberg, Kenneth J. Button, and Peter Nijkamp, eds., Edward Elgar, 1999. Reprinted in Economic Costs & Consequences of Environmental Regulation, Wayne B. Gray, ed., Ashgate Publishing Limited, 2002.
13. Baye MR, Deily, ME, Jansen, DW. Marginal and Total Cost-of-Production Indices: Theory and Applications to the Steel Industry. *Journal of Productivity Analysis* 2(2): 91-102. July 1991.
14. Deily, ME. Exit Strategies and Plant-Closing Decisions: The Case of Steel. *The Rand Journal of Economics* 22(2): 250-263. 1991.
15. Deily, ME. Investment Activity and the Exit Decision. *The Review of Economics and Statistics* 70(4): 595-602. November 1988.

D. Ongoing Research Support

1 R18 HS018649-01A1 (Levick) 9/2011- 9/2014
AHRQ

Data Flow & Clinical Outcomes in a Perinatal Continuum of Care System

This study seeks to use both qualitative and quantitative methods to evaluate the adoption of an integrated EMR in the outpatient OB-GYN practices and inpatient Triage unit at LVHN. In particular, we intend to assess the ability of an integrated EMR to address a recognized failure to deliver accurate, complete, and timely data to physicians and clinical staff at critical clinical points along the perinatal continuum of care.