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Do hospitals cross-subsidize?

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Abstract

Despite its salience as a regulatory tool to ensure the delivery of unprofitable medical services, cross-subsidization of services within hospital systems has been notoriously difficult to detect and quantify. We use repeated shocks to a profitable service in the market for hospital-based medical care to test for cross-subsidization of unprofitable services. Using patient-level data from general short-term hospitals in Arizona and Colorado before and after entry by cardiac specialty hospitals, we study how incumbent hospitals adjusted their provision of three uncontested services that are widely considered to be unprofitable. We estimate that the hospitals most exposed to entry reduced their provision of psychiatric, substance-abuse, and trauma care services at a rate of about one uncontested-service admission for every four cardiac admissions they stood to lose. Although entry by single-specialty hospitals may adversely affect the provision of unprofitable uncontested services, these findings warrant further evaluation of service-line cross-subsidization as a means to finance them.

Keywords

Hospital markets; Cross-subsidies; Specialty hospitals

JEL classification

I11; L1; L33

1. Introduction

Mechanisms internal to the firm are often promoted to achieve social goals. In health care markets, cross-subsidies are often considered the principal mechanism[1] through which hospitals provide otherwise unprofitable care (Phelps, 1986; Norton and Staiger, 1994; Banks et al., 1997, 1999; Horwitz, 2005; David and Helmchen, 2006; Vladeck, 2006; Chen et al., 2009). While there is evidence of regulation-driven cross-subsidization of otherwise unprofitable services in the transportation and telecommunications industries (Brennan,

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[1]Other mechanisms include DSH payments, bailouts, uncompensated care pools, tax exemptions, and donations. We examine each of these in the Discussion section.

1990; Banks et al., 1999; Nicolas, 1991; Chevalier, 2004), evidence of cross-subsidization in the hospital industry remains largely anecdotal and its extent is not well documented.

Cross-subsidization of individually unprofitable service lines within hospitals is not transparent from an accounting perspective, and therefore direct observation of this practice and its extent is not possible. In this paper, we explore a novel approach to test empirically whether hospitals cross-subsidize purportedly unprofitable services. Specifically, we study shocks that affected only hospitals' profitable services and identify the presence and magnitude of cross-subsidization through their effect on unprofitable services.[2] We use single-specialty hospitals' entry in the market for select procedures as a shock that affects incumbent hospitals' profits[3],[4] and argue that unprofitable services offered by incumbent hospitals will be affected if they rely financially on the profitable services contested by the entrant. In fact, the potentially adverse effects on general hospitals' ability to cross-subsidize unprofitable care led Congress to institute a moratorium in November 2003 that halted the construction of new single-specialty hospitals.[5]

The success of single-specialty entrants relies on their ability to attract the most profitable components of the demand for the services they offer. To do so, single-specialty entrants carefully consider their potential competitors' provision of the contested services before entry. At the same time, these entrants are unlikely to consider explicitly the incumbents' provision of uncontested unprofitable services, as there is no evidence that these services help predict how an incumbent might respond to entry (Burns et al., 2011). Therefore, we posit that entry into a specific set of profitable services directly affects incumbents' profits but does not affect the incumbents' provision of unprofitable services except through the shock to profits.

Although the possibility of entry by specialty hospitals can challenge the financial resilience and mission-fulfillment capability of incumbent general hospitals, it is not clear if and how general hospitals reconfigure the scope, quantity, and quality of their uncontested service lines in response to entry.

The conditions for cross-subsidization across different service lines arise in part because reimbursement for Medicare fee-for-service and Medicaid admissions is based on administered prices set by the Federal and state governments. While private payers continuously adjust their reimbursement levels to changing supply and demand conditions, public payers seek to mimic these adjustments periodically. As a result, cross-subsidization is more likely to emerge in markets where public payers are the dominant form of insurance and price distortions may persist longer, allowing service lines to remain profitable or

[2]Unprofitable care, also referred to as *under*- and *uncompensated care*, includes free or discounted care, care that hospitals charge for but do not realistically expect to be reimbursed for (expected bad debt), as well as shortfalls from Medicare, Medicaid and other insurance. While U.S. hospitals provide approximately $30 billion in unpaid care annually, the practice of financing unprofitable care is not well understood (Nicholson et al., 2000; Vladeck, 2006).

[3]The federal law defines a specialty hospital as one that is "primarily engaged in the care and treatment of cardiac, orthopedic, or surgical patients" (MedPAC, 2005), omitting from this definition psychiatric, and long-term acute hospitals that also are all single-specialty hospitals.

[4]Reports by the Medicare Payment Advisory Committee (MedPAC) and the Government Accountability Office (GAO) found conflicting results on the effect of entry by specialty hospitals on community hospitals' revenues (MedPAC, 2005; GAO, 2003).

[5]While the moratorium ended in August 2006, no specialty hospitals entered the markets we study after this date.

unprofitable before reimbursement levels are corrected. Variability in the generosity of reimbursement across service lines also exists in the private market because prices are a function of the ex-ante demand for services by the members of private health plans (Capps et al., 2003). To make their health plans more attractive to firms and their employees, insurers will pay a premium to ensure broad access for the treatment of common and predictable conditions.

Federal regulations also play a role in the persistence of profitable and unprofitable service lines. The Emergency Medical Treatment and Active Labor Act (EMTALA) limits hospitals' ability to discriminate among patients admitted via the Emergency Department based on patients' ability to pay. These patients must be stabilized before discharge regardless of payer. Thus, service lines that tend to attract a large number of underinsured or uninsured patients admitted via the Emergency Department tend to be less profitable. No such restrictions are placed on elective or urgent care if the patient is otherwise stable.

Hospitals (and their admitting physicians) may give preferential treatment to patients based on expected reimbursement, which could lead to higher average reimbursement for scheduled patients, as these patients are more likely to carry generous insurance coverage than emergently admitted patients. In addition, scheduled admissions may be less severe than emergent admissions, for which waiting was not a viable option. Moreover, hospitals that offer only scheduled services do not need to maintain costly surge capacity, which by definition is used only rarely. Finally, patients who can afford to schedule their surgery in advance are typically healthier and not as acutely ill as emergently admitted patients. Thus, hospitals offering only scheduled services will tend to attract patients with fewer comorbidities and a lower risk of complications, which are costly to manage during hospitalization. For these reasons, providers specializing in procedures that are scheduled in advance may realize cost savings that are not available to providers allowing emergent admissions.

We study the effect of entry by specialty cardiac hospitals in Arizona on the provision of psychiatric, trauma, and substance-abuse care by incumbent general hospitals.[6] These uncontested services are considered to be unprofitable (Horwitz, 2005; Vladeck, 2006; Chen et al., 2009; Huckman and Kolstad, 2011). We also test the effect of entry on incumbents' provision of neurosurgery, an uncontested but profitable service (Resnick et al., 2005; Lindrooth et al., 2013). The response by incumbent hospitals to a negative profitability shock allows us to study the reliance of select uncontested services on cross-subsidization. We study Arizona because entry occurred in two markets that are geographically well-delineated. In addition, entry was limited to cardiac specialty hospitals over a relatively short period of time, allowing us to use longer time series for the pre- and post-entry periods.

We find evidence that is broadly consistent with system-level cross-subsidization of services considered unprofitable. The evidence is robust to different specification and samples. In Section 2, we discuss our strategy for identifying cross-subsidization. Section 3 presents the

[6]Tucson Heart Hospital entered Tucson in 1998 and was fully operational in 1999, Arizona Heart Hospital entered Phoenix in 1999, and Banner Baywood Heart Hospital entered Mesa in 2001.

methodology used for measuring hospitals' exposure to entry and its effect on the provision of unprofitable services. Section 4 describes the data. The results are discussed in Section 5. Section 6 concludes.

2. Entry by single-specialty hospitals

2.1. The entry decision by a single-specialty competitor

Most stand-alone specialty hospitals are for-profit entities (Hadley and Zuckerman, 2005; Guterman, 2006)[7] and many are at least partially owned by physicians (Cromwell et al., 2005; McClellan, 2005).[8] They enter when they expect to make a profit and aim to attract patients suited for standard, low-risk procedures that can be delivered profitably, leaving incumbent hospitals to treat disproportionately many high-risk patients with complex care requirements.[9] Consistent with this prediction, specialty hospitals have been found to be more profitable than general community hospitals when all payer types are considered (GAO, 2003; Iglehart, 2005), in part because specialty hospitals treat a lower percentage of severely ill patients than community hospitals (GAO, 2003; MedPAC, 2005; Barro et al., 2006; Mitchell, 2005; Cromwell et al., 2005; Greenwald et al., 2006; Cram et al., 2005).

Forward-looking potential entrants evaluate very carefully and strategically their prospects of success before they decide to offer services in a given location. A potential entrant will consider the likely demand for its services in the context of the competitiveness of hospitals that supply contested services near its preferred location. This decision is based on characteristics of the suppliers of contested services but unlikely to be influenced by the market for uncontested services. Markets will not be selected for entry if incumbent hospitals are expected to succeed in deterring entry, for instance by allocating more resources to retain physicians attractive to single-specialty competitors (Dafny, 2005; Dobson and Haught, 2005; Berenson et al., 2007; Burns et al., 2011).

2.2. The response to entry by incumbents

Entry of specialty hospitals into a profitable service line will reduce incumbents' profits and thereby may compromise the ability of incumbent general hospitals to cross-subsidize unprofitable services (Shactman, 2005; Berenson et al., 2006; Schneider et al., 2007, 2008; Tynan et al., 2009; Al-Amin et al., 2010; Burns et al., 2011; Steinbuch, 2010). For instance, entry by single-specialty competitors will raise the bargaining power of physicians who

[7]The Centers for Medicare and Medicaid Services define a specialty hospital as either: (1) a hospital where more than two-thirds of Medicare inpatients fall into no more than two Major Diagnostic Categories, which encompass a range of similar Diagnosis-Related Groups (DRGs), or (2) a hospital where two thirds or more of Medicare claims are from surgical DRGs (McClellan, 2005). The Government Accountability Office (GAO, 2003) identified nearly 100 stand-alone specialty hospitals in three major categories: cardiac (17 hospitals), orthopedic (36), surgical (22). Women's hospitals and other types of specialty hospitals made up the remainder.

[8]Physician ownership of specialty hospitals poses a particular organizational and financial challenge for general hospitals that compete in the same market. Physician-owners have a stake in the clinical and financial performance of the hospital and are a major source of patient referrals. Cardiac specialty hospitals in particular have a higher percentage of physician ownership on average than other types of specialty hospitals.

[9]Specialty hospitals tend to be concentrated in states that lack certificate-of-need (CON) laws; all specialty hospitals are located in 28 states, with two-thirds located in just 7 states (GAO, 2003). In addition, specialty hospitals tend to be located in high-growth metropolitan areas that lack a dominant community hospital, and that have a large, single-specialty physician practice group (Casalino et al., 2003).

provide the contested services if they can credibly threaten the incumbent hospitals with defecting to the entering specialty facilities.

To the extent that entry raises the number of competing providers in a market, it will tend to lower the time price of reaching the nearest provider and possibly lower fees and health insurance premia. For this reason, entry may adversely affect the provision of uncontested services if it constrains incumbent hospitals' ability to cross-subsidize less profitable or unprofitable services. For instance, cardiology and cardiovascular surgery diagnosis-related groups (DRGs) account for 25–40 percent of the average community hospital's net revenue (Casalino et al., 2003); entry by an aggressive competitor will put this revenue, and thus the incumbent's overall financial viability, at risk.

The incumbent's response to entry will depend on whether the fixed cost of changing its policies and service offerings is offset by improved future cash flows. Thus the effect of the shock on incumbents' uncontested services will be nonlinear in that only the hospitals and systems most affected will pursue the discrete changes necessary to scale back unprofitable admissions. Potential changes include reducing the admitting privileges of specialists in uncontested and unprofitable services; reducing the number of beds available for specific service lines; or even closing a service line altogether (Horwitz, 2005).

3. Methods

The econometric approach consists of two stages. First, we estimate the exposure of incumbent hospitals to single-specialty hospital entry into contested services. This variable, *exposure*, is calculated in three steps:

1. estimate a model of patient choice of hospital for an admission,
2. predict the annual number of admissions with and without the specialty hospital as an option, and
3. calculate *exposure* using the difference in predicted annual admissions with and without specialty hospital entry. If multiple hospitals within a market were owned by the same hospital system, then *exposure* is aggregated to the system level by calculating the sum of each individual hospital's exposure within each system.

The specification of patient choice of hospital is based on a random-utility model and implemented using McFadden's conditional logit specification (McFadden, 1974). Our measure of exposure is an application of techniques originally developed to measure changes in admissions related to hospital closure in Capps et al. (2010).

The effect of *exposure* on utilization of uncontested services is estimated in the second stage. Utilization is modeled as a function of exposure using two dependent variables:

1. the patient's choice of hospital for an admission requiring an uncontested service and
2. the number of admissions for uncontested services.

The patient's choice of hospital is modeled using a conditional logit specification and the number of admissions is modeled using a generalized negative binomial count data model. The coefficients of the conditional logit specification are identified based on alternative-specific variation, in other words variation across hospitals within the patient's choice set. Patients value alternative-specific characteristics more or less depending on their location and diagnosis. In contrast the generalized negative binomial count data model uses within market variation between hospitals and over time. The unit of observation is the hospital and it collapses to a hospital choice model if one assumes that patients within each market are identical.[10]

The estimated coefficients of *exposure* measure how the utilization of uncontested services changed with the loss of profits on the part of the incumbent hospital, expressed as the estimated annual number of cardiac admissions that the incumbent would have lost to the entrant had it remained passive in the face of entry. *Exposure* can be interpreted as the degree of overlap between the incumbent and specialty hospital's service offerings and location in each time period. *Exposure* equals zero prior to entry and increases with the overlap between a specialty hospital's and the incumbent hospital's service offerings and catchment area. *Exposure* is lower for hospitals that did not offer the same services as specialty hospitals, even if their locations were proximate to one another. It also declines as the geographic distance between the incumbent hospital and the specialty hospital increases. The analysis also includes a control group that consists of hospitals that were not exposed because of their location, because they did not offer enough contested services, or both.[11]

3.1. Provision of contested services

A patient's choice of hospital for an admission is based on a random utility model of the utility of an admission to hospital *h* in year *t*:

$$U_{hit}(H_{h,pre}, T_{hi}, X_{it}, D_{it}, S_{h,pre}, \gamma_h)=\beta_1 H_{h,pre}+\tau_1 T_{hi}+\tau_2 T_{hi}\cdot X_{it}+\beta_2 D_{it}\cdot H_{h,pre}+\beta_3 D_{it}\cdot S_{h,pre}+\tau_3 T_{hi}\cdot\gamma_h+\varepsilon_{hit} \quad (1)$$

where U_{hit} is patient *i*'s utility of receiving care at hospital *h* in year *t*, $H_{h,pre}$ is a vector of cardiac service offerings at hospital *h* prior to entry or in the case of single-specialty hospitals upon entry; T_{hi} is the approximate travel time from the zip code of patient *i*'s residence to hospital *h;* X_{it} is a column vector reflecting patient characteristics and clinical attributes that affect hospital choice; D_{it} is a column vector reflecting the patient's diagnosis related group (DRG); $S_{h,pre}$ is a vector of cardiac service offerings at the system that owns hospital *h*, and γ_h is a hospital fixed effect.[12] The interactions between $H_{h,pre}$ and D_{it} control

[10]Guimarães and Lindrooth (2007) describe the link between individual choices based on a random utility model and a (conditional) fixed effect negative binomial count data model when patient can be grouped by common characteristics. In the current paper, the negative binomial count data model is estimated at the hospital level and thus ignores all within-market variation in patient characteristics including location and diagnosis group.

[11]All hospitals admitted cardiac patients. However several hospitals did not offer cardiac surgery which significantly lowered their degree of exposure, as admissions to specialty hospitals are predominantly surgical.

for access to surgical services relative to the patient's diagnosis and $S_{h,pre}$ and D_{it} control for access to surgical services at other locations within the hospital's system. This is necessary because within-system transfers and referrals will influence where a patient is admitted.

We deliberately hold general hospital and system-wide service offerings fixed over the entire sample period because our objective is to estimate the effect of entry by comparing estimates of the number of admissions with and without specialty hospital entry. We posit that, after adjusting for changes in patient characteristics, hospitals that dropped cardiac services did so in response to entry; therefore, we hold their service offerings constant at their pre-entry level. If we included contemporaneous service offerings, our estimate of the effect of entry would be biased substantially downward for hospitals that dropped services.

Under the logit demand assumption, the predicted probability s of a patient with characteristics (T_{hi}, X_{it}, D_{it}) of choosing a given hospital h from a set of G hospitals available at time t, is

$$s(G_t, X_{it}, D_{it}, T_{hi}) = \frac{\exp[U(H_{h,pre}, T_{hi}, X_{it}, D_{it}, S_{h,pre}, \gamma_h)]}{\sum_{g \in G_t} \exp[U(H_{g,pre}, T_{gi}, X_{it}, D_{it}, S_{g,pre}, \gamma_g)]} \quad (2)$$

The parameter estimates from Eq. (2) are used to calculate the expected number of cardiac admissions in each year over the entire sample period at the system and individual hospital levels, denoted $E(Admissions_{st}^{entry})$ and $E(Admissions_{hr}^{entry})$ respectively. This is done by summing the predicted probabilities over all the hospitals in a system or individual hospitals, respectively. We follow Capps et al. (2010) and simulate the number of system and individual hospital cardiac admissions had entry not occurred, denoted $E(Admissions_{st}^{no\ entry})$ and $E(Admissions_{ht}^{no\ entry})$. This is done by eliminating the single-specialty hospital from the choice set G and re-normalizing the predicted probabilities in Eq. (2) so that they sum to one. For each provider p (individual hospital or system), the estimated change in admissions resulting from entry is[13]:

$$\Delta Admissions_{pt} = Exposure_{pt} = Admissions_{pt}^{Entry} - Admissions_{pt}^{No\ entry} \quad (3)$$

Eq. (3) is the estimated change in incumbents' admissions for the contested service that is attributable to entry. Under this definition, the more closely prospective patients view the entering competitor's services as substitutes for the incumbent's, the more exposed the incumbent will be to entry. Accordingly, we model the response to entry such that an

[12]A patient/admission fixed effect could be included to represent an idiosyncratic error related to the patient's utility. However, a patient-specific idiosyncratic error does not vary by hospital in the choice set and is irrelevant to the predicted probability of admission (see McFadden, 1974 or Train, 2003). Empirically, a patient/admission fixed effect is included in the conditional logit specification of a McFadden choice model. The dataset used to estimate a conditional logit model is organized such that one observation reflects the characteristics of a hospital in the patient's choice set. As a result, there are H observations related to each admission, where H denotes the number of hospitals in the patient's choice set. The patient/admission fixed effect represents the node for each decision.

[13]For the single-specialty entrant $E(Admissions^{no\ entry})$ will equal zero.

incumbent hospital will respond to entry only when $\Delta Admissions_{pt}$ is large enough to warrant the fixed costs of changing service offerings. We set $Exposure_{pt}$ equal to one if the absolute value of the estimated change in admissions is greater than a response threshold and zero otherwise[14]:

$$Exposure_{pt}^{Threshold\%} = \begin{cases} 1 & \text{if } |\Delta Admissions_{pt}| > \Delta Admissions^{Threshold\%} \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

The estimate of *Exposure* is related to the well-known independence of irrelevant alternatives (IIA) assumption that underlies logit demand models in that a patient's ranking of two incumbent hospitals is unchanged by the addition or removal of a third hospital, including a single-specialty entrant.[15] The simulation without specialty hospitals allocates all specialty-hospital admissions to the incumbent hospitals. As a result, exposure reflects a decline in market share due to entry. If incumbents and specialty hospitals have similar propensities to admit and perform procedures on patients, as found by Stensland and Winter (2006), then this assumption is reasonable. However, if specialty hospitals perform surgeries and admit patients that would not have occurred in absence of the specialty hospital then we would over-estimate exposure. Even so, the ordering of hospitals would be unlikely to change because an increase in the total number of admissions related to entry will affect both $\Delta Admissions^{Threshold}$ and $\Delta Admissions_{ht}$ leaving the providers satisfying the threshold unchanged. For hospitals in systems, $\Delta Admissions^{Threshold}$ is based on the system-level exposure whereas the exposure of independent hospitals is measured using a threshold based on hospital-level exposure.

Entry will also affect the prices that hospitals charge private payers for the contested service. While we do not observe these prices, the effect of entry on private prices could be estimated by calculating the value of a given hospital to an insurance network with and without entry following the approach used by Capps et al. (2003) to measure the effect of hospital mergers on prices. This measure is highly correlated with estimates of the change in admissions due to entry, as both are based on the same parameters from a logit demand model. For this reason, it is not possible to identify price and quantity effects of entry separately. Thus, we make the simplifying assumption that the effect of entry on incumbent hospitals is proportional to the change in the number of admissions. This approach is bolstered by the fact that entry will have no direct or immediate effect on the reimbursement rates for services provided to Medicare and Medicaid beneficiaries.

We estimate Eq. (2) separately for the Denver, Phoenix, and Tucson markets using five years of admissions that span the pre- and post-entry periods. We also report results that use all

[14]We used three response thresholds which correspond to the top 25th, 50th, and 75th percent of exposure.

[15]This assumption is reasonable in our specification because, as is described below, we stratified the sample by diagnosis and estimated the model for medical and for surgical admissions separately. Furthermore, within these diagnosis and procedure categories we interacted the clinical supply characteristics of each hospital with the clinical diagnosis characteristics of each patient and also control for travel time from the patient's zip code to each hospital in the choice set. Patients reach each diagnosis node, not by choice, but by nature of their illness. Clearly if specialty hospitals induce demand for more intensive services then our specification that limits the IIA assumption to within diagnosis cells would lead to higher estimates of exposure. However, it would not affect our analysis of uncontested services because the system ranking of exposure would be unchanged.

years of data. We split the sample into surgical and medical admissions. Patients' choice sets are smaller for surgical admissions because surgeries are more invasive and require specialized skills and equipment. Thus fewer hospitals invest in the capability to perform cardiac surgeries than minimally invasive medical admissions. Another reason why we stratify between surgical and medical admissions is that surgical admissions constitute a relatively large share of admissions at specialty hospitals and thus the degree of service overlap is greater for hospitals that offer cardiac surgery. If we pooled each type of admission then we would underestimate the exposure of hospitals that offer cardiac surgery and overestimate it at hospitals that only offer medical services.

We control for the hospital and system supply of cardiac catheterizations and open-heart surgery interacted with a patient's diagnosis in the choice model. Thus, if a patient has a diagnosis that requires heart surgery the interaction will control for hospitals that offer heart surgery and zero otherwise. We also control for whether the patient had HMO coverage because this may affect travel patterns and other patient characteristics. All patient characteristics are interacted with the natural log of drive time which serves to incorporate variation in patients' preferences across hospitals in the choice set. Variation in the estimate of *exposure* is in large part due to overlap in services offerings with the new entrant as well as proximity to the new entrant. Eq. (2) is estimated using a grouped conditional logit model in which the data are aggregated to groups of patients that share zip codes and the other patient characteristics in order to speed computation (Guimarães et al., 2003).

3.2. Provision of uncontested services

Utilization of uncontested services is also based on a random utility model where the utility patient i receives from an admission to hospital h in time t is:

$$U_{hit}(Exposure_{ht}, \gamma_h, X_i, T_{hi}) = \beta_1 Exposure_{ht} + \tau_1 T_{hi} + \tau_2 T_{hi} \cdot X_i + \tau_3 T_{hi} \cdot \gamma_h + \varepsilon_{hit} \quad (5)$$

where $Exposure_{ht}$ is a dichotomous variable that measures whether incumbent hospital h is exposed to entry at time t calculated using Eqs. (3) and (4); T_{hi} is the approximate travel time from patient i's residence's zip code to hospital h. X_i is a vector of patient characteristics and clinical attributes that affect demand for inpatient services and γ_h is a hospital fixed effect. The final term in (4), ε_{hit}, represents the personal and idiosyncratic component of patient i's utility of admission to hospital h at time t.

There are a number of ways exposed hospitals can reduce the supply of unprofitable uncontested services. They could reduce the number of beds available for those services, limit admitting privileges of physicians in uncontested specialties, or completely close the service line. Each of these will decrease the attractiveness of a hospital relative to its competitors and thus reduce the expected utility and likelihood of an admission to the exposed hospital. An additional mechanism lies in patients' idiosyncratic valuation of a hospital. As is common in hospital choice models, we treat a patient's choice of a physician as occurring in tandem with the choice of a hospital. Put differently, we assume that the attractiveness of individual physicians to the patient is encompassed in the patient's valuation of a hospital's idiosyncratic attributes. Thus if exposed hospitals reduce the supply of uncontested services by limiting the admitting privileges of specialists, the expected utility of an admission to an exposed hospital will also be lowered relative to its competitors.

Under the logit demand assumption, the predicted probability of a patient with characteristics (X_i, T_{hi}) of choosing a given hospital h from a set of G hospitals available at time t, is

$$\tilde{s}(G_t, X_i, T_{hi}, Exposure_{ht}, \gamma_h) = \frac{\exp[U(Exposure_{ht}, \gamma_h, X_i, T_{hi})]}{\sum_{g \in G_t} \exp[U(Exposure_{gt}, \gamma_g, X_i, T_{gi})]} \quad (6)$$

The parameter associated with $Exposure_{ht}$ measures the effect of entry in contested services on the probability a patient will be admitted to hospital h for an uncontested service. As we described above, $Exposure_{ht}$ equals one if hospital h is above the exposure threshold described in Eq. (3) in year t and zero otherwise.

Recall that the estimate of latent exposure to entry is a function of a hospital or system's exogenous supply of cardiac catheterizations and open-heart surgery. The provision of cardiac services prior to entry is unlikely to independently affect the provision of uncontested services, except through incumbent hospitals' exposure to entry and thus specialty service offerings function as an instrument for our estimate of the true, unmeasured effect of entry. Thus the coefficient on $Exposure_{ht}$ reflects variation in exposure due to overlap in services offerings with the new entrant as well as proximity to the new entrant within the market. To minimize any potential omitted-variable bias, we also instrument for the proximity of the incumbent hospital to the new entrant with measures of the demand for cardiac services in each hospital's catchment area in addition to service offerings as instruments. The results are similar to those presented here and are reported in David et al. (2011).

The specification in Eq. (6) is more parsimonious than the one used for cardiac services. We do not control for specialty service offerings that vary over time because hospital administrators may add or drop these services in response to entry and the inclusion of these changes over time would yield inconsistent estimates of the effect of exposure on the provision of uncontested services. As a result, our estimates capture all changes in specialty services offerings at more exposed hospitals relative to less exposed ones.

We estimate Eq. (6) using a conditional logit model and calculate standard errors with patient/admission-level clustering. The observations in the conditional logit model are nested around each admission (or choice) such that there is an observation for each hospital in the choice set for each admission but only one hospital is selected. The standard errors within each nest (i.e. admission) are naturally clustered because they reflect the same decision and if one hospital is selected than the other hospitals are not selected by definition. Our specification is analogous to a difference-indifferences approach where the sample consists of admissions pre-and post-entry, the treatment is exposure to entry if the hospital is exposed in the post-entry period, and the outcome is the probability of an admission. The control group consists of hospitals located in Arizona (Phoenix or Tucson) that were least exposed to entry, i.e. whose predicted change in admissions for the contested service did not cross the threshold, as well as hospitals located in Colorado, which did not experience entry during the study period.[16]

While the patient-level specification takes advantage of information about the location of each patient's residence and condition in relation to each hospital in the market, it does not allow us to examine whether the absolute number of admissions declined at specific exposed hospitals or in the market as a whole. In other words, the specification does not measure the effect of exposure on the probability of admission to *any* hospital and does not yield insight into whether access to uncontested services was reduced and fewer patients were admitted in the market. To examine whether the absolute number of admissions was affected we estimate a hospital-level specification in which the annual number of admissions for each uncontested service is modeled as a function of the degree of exposure after entry using generalized negative binomial regression with market and year fixed effects and other control variables.[17] This model is estimated using the measure of exposure described above. The hospital-level analysis also enables us to model alternative specifications for contemporaneous trends that are not feasible in the admission-level analysis. We estimate a variety of specifications of market-specific trends in the annual number of admissions including: market-year dummy variables; market-specific linear trends; market-specific linear trends plus a separate trend for exposed hospitals; and market-specific quadratic trends. We treat the specification with market-year dummy variables as the primary specification because it is most consistent with the patient-level choice model. Alternative specifications of trend are not possible in the conditional logit model because the formulation of the random utility model relies solely on alternative-specific variation at the time of the admission and thus controls for all characteristics that do not vary across hospitals in a patient's choice set.

We also estimate models that control for consolidations that occurred during the sample period. There were several changes in system ownership between the pre and post periods of our sample. These changes occurred in both Arizona and Colorado and affected both exposed and unexposed hospitals. It is not clear whether the system acquisitions during the time period were related to entry of the specialty hospitals. For example, Banner Health System acquired hospitals in other markets in both Arizona and Colorado that were not exposed to entry, possibly implying that it was system-wide decision. The system itself was formed by combining Lutheran and Samaritan Health Systems. It is not possible to conclusively determine whether Banner Health System's acquisitions or any of the other system acquisitions were due to specialty hospital entry. On the one hand, exposed hospitals may be candidates for an acquisition if the acquirer feels it can increase efficiency by realigning service lines and increasing value by reducing unprofitable services. On the other hand, increased market power through consolidation may reduce the strain of entry on profits through increased private prices. Thus it may either facilitate the reduction of

[16]Overall the results are robust to excluding Colorado and thus do not reflect unusual trends in Colorado. The inclusion of Colorado does increase efficiency.

[17]Specification tests revealed that the data exhibited over-dispersion and that the degree of over-dispersion was a function of the market and a fixed indicator of whether the hospital was ever exposed to entry. Therefore we use a generalized version of the negative binomial regression and explicitly model the degree of over-dispersion.

uncontested service volume or, in the case of higher prices, lessen the need to reduce volume in uncontested services. Thus we control for system consolidations and test whether there was a differential response among exposed and unexposed systems that acquired new hospitals.

To provide context and an understanding of the contemporaneous trends we also estimate a linear model of hospital admissions with hospital fixed effects. The results of this specification provide the adjusted mean number admissions and trends. Finally, we estimate the model of hospital admissions using a coarse market-level measure of exposure that equals one if the market experienced entry and zero otherwise. The market-level measure compares the difference in admissions pre and post entry in markets with entry to markets that did not experience entry.

4. Data

Our primary dataset is the Healthcare Cost and Utilization Project (HCUP) State Inpatient Database (SID) compiled by the Agency for Healthcare Research and Quality (2006). The HCUP-SID includes the inpatient discharge abstracts from virtually all non-federal general and all specialty cardiac hospitals in Arizona and Colorado of all patients discharged between 1997 and 2007. The patient's choice set of hospitals was defined in the Phoenix, Tucson, and Colorado's front range (including Boulder, Colorado Springs, and Denver) markets based on hospitals that provided contested and uncontested services. Colorado borders Arizona to the northeast, and the front range of Colorado is similar to the Phoenix and Tucson markets in a number of ways. Both states have major population centers that are well delineated by geography from surrounding areas. The front range of Colorado is bordered by the Rocky Mountains to the west and semi-arid grasslands to the east. Similarly, Phoenix and Tucson are surrounded by the Sonoran Desert to the south and west and mountains to the north. These markets have a comparable presence of large local and national systems, reflecting similar regulatory environments. In addition, and perhaps most importantly, there was no specialty cardiac hospital entry in Colorado during the time period we study.

In our preferred specification, we limit the sample to a pre-period 1997–1998 and a three-year post-period 2005–2007 in order to allow for an adjustment period related to the shock. We exclude the adjustment period in 1999–2004 because specialty hospitals gradually increased their admissions and market share over time and because the adjustment process at incumbent hospitals is also likely to be slow. We also estimate the models using the entire 1997–2007 sample and include the results for comparison. However, we treat the pre–post sample as our primary specification because it allows for a lag between entry and the subsequent effect on hospitals' profits and thereby decisions regarding service offerings.

In addition, it took several years before the growth in specialty hospital admissions leveled off. Out of the three entrants, Tucson Heart Hospital opened in Tucson in 1998 and Arizona Heart Hospital opened in Phoenix in 1999. Both experienced rapid growth in 1999–2000 that leveled off after 2000. Banner Baywood Heart Hospital (originally known as Lutheran Heart Hospital) opened in the Phoenix suburb of Mesa in 2001. Banner Baywood Heart's admissions stabilized in 2003 after two years of rapid growth. Tucson and Arizona Heart Hospitals were opened by Medcath, Inc., a national specialty hospital chain. Tucson Heart Hospital was purchased by Carondelet Health System in 2006. In addition, several hospitals were purchased by systems between 1999 and 2003, possibly reflecting realignment to adapt to the new market structure.[18]

Our exposure measure is based on actual system ownership during the 2005–2007 period, since by construction the exposure measures for the pre-entry years 1997–1998 were zero. We use ownership in 2005–2007 because it corresponds to the time period when the adjustment to entry into cardiac services was complete. The estimate of exposure is stable for 2005–2007 such that the group of hospitals and systems in the top 25, 50, and 75 percent of exposure is stable. This may lead to an overestimate of exposure at hospital systems that acquired hospitals with cardiac units after cardiac admissions were reduced. Such acquisitions may also further reduce the impact through increased prices. Both of these will bias our estimates toward zero. As mentioned, we also estimate the models using data from the entire sample period and report these coefficients for comparison. However, the preferred specification excludes 1999–2004 because hospital ownership, and also the estimated level of exposure, was relatively stable during the 2005–2007 period.

Admissions for a contested service are defined as an admission in the Circulatory System Major Diagnostic Category (MDC 5). We examine the following uncontested services: psychiatry (MDC 19); substance abuse treatment (MDC 20); and trauma (MDC 24), all commonly considered to be unprofitable services (Horwitz, 2005; Vladeck, 2006; Chen et al., 2009). We also estimate the models for neurosurgery admissions (defined using surgical diagnosis-related groups [DRGs]).[19] In contrast to psychiatric, substance-abuse, and trauma services, neurosurgery has been shown to be profitable throughout the time period (Lindrooth et al., 2013). As neither market in Arizona experienced entry into neurosurgery, we predict that those incumbents most exposed to entry raised, rather than reduced, the number of neurosurgery discharges.[20] We restricted the sample to persons who were admitted within their state of residence to a hospital with at least 36 admissions for diagnoses in the respective service line in at least one of the sample years. Thus admissions at hospitals with relatively few admissions in all sample years were excluded but admissions at hospitals that grew or reduced service line admissions are included in the sample. As would be expected, the results using a more inclusive restriction of at least 24 admissions are

[18] Several health systems in Arizona are affected by using 2005–2007 ownership for the entire time period: Banner Baywood Health System; Carondelet; Triad; Tucson Medical Center Healthcare and Vanguard Health System. Banner Baywood Health System was created through the merger of Lutheran Health Systems and Samaritan Health System. Thus Lutheran and Samaritan Health System hospitals are treated as though they were both owned by Banner Baywood during the entire time period. Tucson Medical Center purchased El Dorado Hospital in 2003 and closed the hospital in 2005. Finally, Vanguard Health System, a for-profit hospital chain, entered the Phoenix market through the purchase of the nonprofit Baptist Health System; a former Samaritan hospital; a for-profit hospital previously owned by Triad; and the for-profit Phoenix Memorial Hospital between 1999 and 2001. These hospitals are treated as though they were owned by Vanguard Health System throughout the time period.

[19] Neurosurgery admissions are defined as admissions with surgical DRGs that are part of the Nervous System Major Diagnostic Category. The category includes Craniotomy (DRG 1–3; 484, 543); Carpal Tunnel Release (DRG 6); Peripheral and Cranial Nerve and other Nervous System Procedures (DRG 7–8); Intracranial Vascular Procedure (DRG 528); Ventricular Shunt Procedures (DRG 529–530); Spinal Procedures (DRG 4; 531–532); and Extracranial Vascular Procedures (DRG 5, 533–534).

[20] This prediction relies on the assumption that hospitals chose their pre-entry mix of profitable services optimally and were operating at capacity. If entry by specialty cardiac hospitals reduced cardiac admissions, space and time would be freed up to provide other services that require similar facilities and personnel.

quantitatively smaller than the results presented here but are of similar statistical significance.

Emergency admissions are identified using the admission type associated with the discharge. We do not distinguish between admissions from each payer because several hospitals, and importantly one cardiac specialty hospital, did not consistently report payer type in the HCUP-SID data during the sample period. However, the potential bias from excluding payer type is minimized because the majority of admissions for cardiac care are either Medicare or private and Medicaid and self-pay admissions for cardiac care are relatively rare. We did, however, include a dummy variable that indicates if the payer was in a Medicare, Medicaid or private health maintenance organization (HMO) to control for the fact that HMOs use selective contracting which could result in idiosyncratic differences in travel patterns for these patients.

Travel times from the centroid of each patient zip code to the address of the closest hospital-based service are calculated using data from Mapquest, Inc. (Mapquest, 2010). In the psychiatry sample we included the drive time to closest private specialty psychiatric hospital as a covariate to control for secular variation in access to substitutes to general hospital psychiatric admissions because the HCUP does not include discharges from specialty psychiatric hospitals. Three private psychiatric specialty hospitals closed during the sample period due largely to the bankruptcy of Charter Corporation, a national psychiatric-care chain.[21] By including drive times to psychiatric specialty hospitals, we control for the exit of these hospitals. As a result, our estimates reflect the adjustments in admissions for psychiatric care by incumbent hospitals once the profit-increasing impact of exit by psychiatric specialty hospitals is accounted for.

We link the SID files to data from the American Hospital Association (AHA) Annual Survey of Hospitals and the Centers for Medicare and Medicaid Services (CMS) Hospital Cost Report and Information Reporting System (HCRIS) to include additional hospital covariates. System membership, the existence of a cardiac catheterization lab, and open-heart surgery capability are also drawn from the AHA data. Net revenue per discharge and operating margins are from the HCRIS data. We also add median income at the ZIP-code level from the U.S. Census Bureau Population Estimates. Summary statistics for the patient and hospital covariates included in each uncontested service specification and the specification of neurosurgery falsification test are shown in Table 1. The top 25th percent of exposure corresponds to an estimated reduction of more than 786 system-wide admissions for hospitals in systems or 393 hospital admissions for independent hospitals. Similarly, the top 50 and 75 percent of exposure correspond to a reduction of more than 665 and 236 system-wide admissions for system hospitals, respectively and a reduction of 210 and 87 hospital admissions for independent hospitals, respectively. The average number of cardiac admissions of systems (hospitals) in the top 25 percent of exposure was 4530 (2427); systems (hospitals) in the top 50 percent of exposure averaged 3821 (1719) cardiac

[21]The exit of these hospitals occurred prior to entry of the cardiac specialty hospitals. The bankruptcy of Charter was unrelated to market-specific trends and likely reflective of national trends in psychiatric care. Nevertheless, the fact that these hospitals were closed rather than acquired could be reflective of local market conditions.

admissions and systems (hospitals) in the top 75 percent of exposure average 4041 (1703) cardiac admissions. Thus the percent of the potential reduction in cardiac admissions ranged from about 20 percent in the top 25 percent of exposure to about 5 percent in the top 75 percent of exposure. The percent thresholds were calculated using system and hospital as the respective unit of observation.

5. Results

Table 2 shows the pre–post admission-weighted mean of net income from services to patients; net revenue per hospital discharge; operating margin and the number of admissions for hospitals in our sample by the estimated degree of exposure to specialty hospital entry. The table shows that the mean net income of hospitals that were not exposed increased between the pre and post periods whereas it decreased at hospitals that were exposed. The pre and post values of net revenue per hospital discharge and operating margin exhibit trends where the values are consistent with improved financial condition at unexposed hospital versus a worsening financial condition at exposed hospitals. The pre–post trend of net revenue per discharge is similar to the change in the share of cardiac patients. The exposure thresholds capture all hospitals above each threshold and thus the samples are not mutually exclusive. There was a larger pre–post difference in the average number of admissions for psychiatric, substance abuse, and trauma services at hospitals that were not exposed compared to hospitals in the top 25 and 50 percent of exposure. There was a pre–post increase in neurosurgery admissions at exposed hospitals and a decrease at hospitals that were not exposed.

Fig. 1 displays trends in median net revenue per discharge and operating profits between 1997 and 2007. For comparison over time the sample is limited to the subset of hospitals that report data in every year. The unadjusted trends are consistent with a revenue and profit shock at exposed hospitals and a subsequent adjustment period within which exposed hospitals shifted away from uncontested and relatively unprofitable services. Both exposed and unexposed hospitals experienced declining net revenue per discharge and operating margins between 1997 and 2000. This contemporaneous negative trend at unexposed hospitals is consistent with the reductions in Medicare reimbursement related to the Balanced Budget Amendment (BBA) of 1997. The reductions in net revenue per discharge and operating margins leveled off by 2000 at unexposed hospitals consistent as would be expected given that the BBA-related cuts were subsequently lessened by the Balanced Budget Refinement Act of 1999 and the Benefits Improvement and Protection Act of 2000 (Bazzoli et al., 2004). Despites these revisions to the BBA-related cuts, net revenue per discharge continued its downward trajectory at exposed hospitals, not leveling until 2002–2003. Operating margins recovered sooner and mirror the trends at the control hospitals more closely.

Covariate-adjusted admissions for uncontested services are shown in Table 3, which includes the parameter estimates of an ordinary least squares regression of admissions on exposure as well as year and hospital fixed effects. Admissions increased between 1997 and 2007 with the exception of neurosurgery in 2007. The constant reflects the adjusted average number of admissions for each service line in 1997. Relative to the controls, psychiatric admissions at exposed hospitals declined by an additional 84–96 admissions (33–38 percent). Admissions for substance abuse declined by 84–101 admissions (68–82 percent). Trauma admissions were not significantly affected. Admissions for neurology increased at exposed hospitals but the coefficient estimate is not statistically significant.

The results of a specification that uses a market-level measure of exposure where all hospitals in Tucson and Phoenix are treated as exposed in the post period are reported in Table A1 of the Appendix. The estimates based on the market level are not statistically significant and smaller in magnitude than the results based on the hospital-specific measures of exposure. This result is consistent with uncontested admissions being shifted from exposed to unexposed hospitals and demonstrates the importance of the within market variation used to identify the effect of exposure.

The coefficients of the generalized negative binomial count data model of the number of hospital admissions for each of the three uncontested services: inpatient psychiatric services, substance-abuse treatment, and trauma care are reported in Table 4. The models were estimated using the pre–post sample and the sample that includes the entire period. The thresholds are the same in each specification. The estimates using the entire sample are consistently smaller when the top 25 and 50 percent of exposure threshold is used, regardless of the service. However, the coefficient estimates are larger for trauma services using the top 75 percent exposure threshold. Overall the results are consistent with cross-subsidization of psychiatric and substance abuse services, regardless of the sample and specification of time and market fixed effects.

Table 5 reports the marginal effects from the analysis of the number of hospital admissions. For each service and level of exposure, the results are based on three separate specifications that differ only in the way system consolidations are modeled. The first specification is based on the market-year fixed effect parameters reported in Table 4. For inpatient psychiatric services, hospitals in more exposed systems had fewer yearly admissions post entry, even after we control for hospital consolidations. The magnitude of the decrease ranges between 100 and 200 fewer psychiatric admissions, depending on the level of exposure. The hospitals that were exposed and were involved in system consolidation experienced the largest reduction. There were also statistically significant decreases in substance abuse admissions at exposed hospitals, ranging from 52 to 61 admissions. However, the reduction in admissions at exposed hospitals undergoing system consolidations was smaller, although the coefficient estimate for the interaction of the post-entry indicator, system-consolidation indicator, and exposure measure was not statistically significant. Similar results are obtained for trauma care, although the results are not statistically significant. The underlying coefficient estimates including the market-year fixed effects of selected specifications are reported in Table A2 of the Appendix.

Table 6 reports the coefficient estimates from the conditional logit model of the probability of being admitted to each hospital within the market. As in Table 4 the models were estimated using the pre–post sample and the full sample. The probability of an admission at hospitals in the top 25 and 50 percent of exposed for psychiatric, substance abuse, and to a lesser extent trauma services declined significantly, regardless of the sample. The results are largely consistent with those presented in Table 4 for psychiatric and substance abuse services. The effect of exposure on trauma admission market share is negative and significant in the conditional logit specification. Overall, the likelihood of receiving care (for any of the three uncontested services) in hospitals that were in the top 25 and 50 percent of exposure was significantly lower and there was not a meaningful difference in the estimates if drive-time hospital fixed effects were included in the model. For substance abuse and trauma, as the definition of exposure is expanded to include all hospitals in the top 50 and 75 percent of exposure, the estimates become smaller in magnitude. For psychiatric services, attenuation is seen between the top 50 and 75 percent of exposure. The results with hospital fixed effect and drive time interactions were consistently smaller when analyzing the full sample.

The specification used to estimate the parameters reported in Table 7 includes controls for system consolidation interacted with the pre and post dummy variable. The reduction in the probability of admissions to an exposed hospital tends to be larger after we control for system consolidation.

Table 8 shows the results of a falsification test in which we model admissions for neurosurgery, an uncontested service generally considered to be highly profitable. The top set of results shows the marginal effects from the hospital-level generalized negative binomial regression model (analogous to Table 5) and the bottom set of results shows the coefficient estimates from the conditional logit model without drive time and hospital fixed effect interactions (analogous to those reported in Table 6 column 2 and Table 7 column 2). The change in admissions of neurosurgery patients to hospitals exposed to entry is statistically indistinguishable from zero, regardless of the level of exposure. The estimate becomes positive and larger in magnitude but remains statistically indistinguishable from zero when the bottom-quartile cutoff is used. This result is identical in direction but weaker in magnitude and statistical robustness than the result we obtain from the conditional logit analysis, where the probability of a neurosurgery admission to hospitals in the top 75 percent of exposure increased significantly.

Appendix Table A5 reports the results of the alternative specification of the contemporaneous trends in the hospital level models of the number of admissions, for the pre–post sample and the full sample. The magnitude of the coefficients is similar across specifications, although the statistical significance varies. The largest difference in the coefficients and statistical significance occurs in specification that includes both market- and exposure-specific trends and the pre–post sample because the effect of exposure is likely picked up by the trend variables. When the full sample is used the results with market- and exposure-specific trends are closer to the baseline estimates. The results using the 1997–2007 time period mirror the results reported in Table 4 closely. The results are generally robust to alternative specifications of contemporaneous trends lending credence to a causal interpretation.

We also report the results of a continuous measure of exposure which is the change in cardiac admissions denominated in 1000s. Note that a decline cardiac admissions (i.e. increase in exposure) is negative. The specifications are otherwise equivalent to the first column of the psychiatric, substance abuse, and trauma results reported in Table 6 and the first column of the neurosurgery results reported in Table 8. The estimates are the partial derivatives of the number of admissions with respect to a change in cardiac admissions denominated in 1000s at the average hospital. Generally the magnitude is within the range of the results reported using the thresholds. Fig. 2 includes the predicted change in admissions from the conditional logit model of patient's choice of hospital. We first predict the number of admissions using the observed exposure level and then use the coefficients to predict the number of admissions after setting the level of exposure equal to zero. The graphs report this measure plotted against the actual level of exposure using the pre–post sample. The results echo those presented in previous tables. We do not estimate consistently significant declines for psychiatric admissions until exposure declines below −600. The decline trauma admissions and the increase in neurosurgery admissions are smaller in magnitude than the declines in psychiatric and substance abuse admissions. Note that the measure of exposure does not differentiate between hospital and system exposure.

We also test whether the reaction to exposure differed by ownership status. These results should be interpreted with caution and should not be interpreted as representative of for-profit ownership as a whole. While all of the markets include both for-profit and non-profit hospitals, the system consolidations that occurred among exposed hospitals all involved for-profit systems. In addition, the only hospitals that changed from not-for-profit to for-profit status were part of a consolidation with an exposed system. As a result, we are unable to separately identify the effects of exposure on consolidated entities versus for-profit entities. The table reveals a number of anomalies captured by the for-profit interactions. Non-profit entities in the top 25 percent of exposure decrease psychiatric admissions relative to unexposed non-profit hospitals, whereas for-profits increase admissions relative to unexposed for-profits. However, at the top 50 percent and 75 percent exposed for-profits decrease admissions relative to unexposed for-profits as well as exposed non-profits. This difference is due to the fact that the only one for-profit entity is included in the top 25 percent threshold. The results for substance abuse reveal consistent reductions at exposed non-profits and to a greater extent at for-profits. In contrast, the results for trauma reveal an increase at admissions at exposed for-profits relative to non-profits. Finally, neurosurgery admissions increased at exposed non-profits whereas they decreased at exposed for-profits. The results are suggestive of a differential response by ownership but should be treated with caution because they reflect the response of only a few entities depending upon the level of exposure and are not generalizable (Appendix Tables A6 and A7).

6. Discussion

Despite its salience as a regulatory tool to ensure the delivery of unprofitable services, cross-subsidization of services within firms has been notoriously difficult to detect and quantify. We use repeated shocks to a profitable service in the market for hospital-based medical care to uncover evidence of cross-subsidization of unprofitable services. We find that hospital systems adjusted their uncontested service offerings in the face of entry by single-specialty competitors. Consistent with cross-subsidization, reductions in the volume of psychiatric, substance abuse, and to a lesser extent trauma care were greatest among the hospital systems most exposed to a potential loss in volume of their cardiac services.

Hospitals can react to an erosion of profits on a large number of margins (Bazzoli et al., 2007). For example they could lower discretionary quality (Dor and Farley, 1996), although it is unclear why under prospective payment they would not have reduced the discretionary quality of uncontested services already to a minimum even before single-specialty hospitals began contesting profitable service lines (Lindrooth et al., 2007). They could also increase efficiency by realigning services within a system or by offering new, profitable services such as ambulatory surgery. To the extent that hospitals responded to an erosion of profits in ways other than reducing admissions for unprofitable uncontested service lines, our results understate the extent to which hospitals adjusted their operations.

We focus on cross-subsidization across service lines, but there are several other mechanisms to support the provision of unprofitable care, regardless of a patient's diagnosis. Traditionally, governments have provided additional funding to hospitals treating a disproportionate number of low-income and uninsured patients through the Disproportionate Share Hospital (DSH) programs at the federal level and direct transfers at the state and local levels (Duggan, 2000). The United States Affordable Care Act includes a provision to phase out DSH payments because the offset was deemed unnecessary as the number of patients without health insurance is expected to decline. Another approach used in several states is to cross-subsidize unprofitable care across hospital systems using uncompensated care pools (Anderson et al., 2009; Bovbjerg et al., 2000). The transfers related to DSH payments and uncompensated care pools lessen the cost of cross-subsidizing the care of those without insurance or Medicaid regardless of their condition. Even in the presence of these indirect subsidies we find evidence of cross-subsidization of services that are less generously reimbursed overall. As specialty hospitals aim to treat generously covered patients for conditions that are generously reimbursed, they are unlikely to affect either the DSH payments received by incumbent hospitals or the size of the uncompensated care pool. Furthermore, it is not uncommon for communities to bail out hospitals at risk of bankruptcy and closure that are considered to provide community benefits (Capps et al., 2010). Such subsidies are more likely if a hospital provides unprofitable services that are in short supply. Sole providers of unprofitable services in a community may be in a position to extract a subsidy from local governments in order to keep a service line open.[22]

While we find evidence that the incumbent hospitals most exposed to a loss in profits from contested service lines modified their offerings of uncontested services in the expected direction, the estimates vary in magnitude and in some instances statistically indistinguishable from zero. There are a number of potential reasons why our estimates should be interpreted as conservative. First, as discussed above, hospitals could have lessened the adverse impact on profits by adopting other responses unrelated to the provision of psychiatric or substance abuse care. Second, there were contemporaneous closures of specialty psychiatric hospitals that were unrelated to cardiac hospital entry but could have led to an increase in demand for general hospital beds for psychiatric care. Third, because

[22]Similarly, nonprofit hospitals receive tax exemptions and can use the retained tax payments for this purpose, and a number of states have introduced explicit charity care mandates (Ginn and Moseley, 2006; Noble et al., 1998). Additionally, nonprofit hospitals may rely on unrelated business activity (Riley, 2007) and donations (Okten and Weisbrod, 2000; Leone and Van Horn, 2005) to finance care. Incumbent hospitals might also react to entry by declaring bankruptcy or merging.

the moratorium on specialty hospitals was lifted in 2006, the post-entry period of our data (2005–2007) spans two regulatory regimes. Thus, while it is certain that in 2005–2006 no incumbent hospitals were exposed to the threat of entry by specialty hospitals, it is possible that in 2007 some incumbent hospitals were exposed to the threat of entry but successfully deterred actual entry. Any resources that exposed incumbent hospitals expended to deter entry would have reduced their profits and thus raised their likelihood of reducing the provision of unprofitable services. For these reasons, our estimates may understate the impact of specialty entry on the provision of uncontested unprofitable services.

On balance, our results might prompt a reassessment of the prevalence and practical importance of cross-subsidization as a means to finance unprofitable services. In this sense, our results call into question to what extent regulators should continue to rely on hospitals' assumed ability to cross-subsidize unprofitable, yet socially desirable services.

Cross-subsidization of unprofitable services by general hospitals is not necessarily an efficient way to achieve social goals such as supporting access to services or serving indigent patients. Others have shown that direct lump-sum transfers to maintain access to unprofitable hospitals likely decrease welfare (David and Helmchen, 2006; Capps et al., 2010, 2011; Lindrooth et al., 2003). Rather, because reimbursement for a large share of unprofitable patients is set by fiat it would seem advisable to set reimbursement at a level that preserves access to services deemed socially vital. Our findings support the conjecture that hospitals adjust downward their offerings of unprofitable services in response to an adverse shock to services that were profitable enough to encourage entry by single-specialty hospitals. In light of these findings, a comprehensive welfare analysis of entry by single-specialty hospitals should include their market-wide effects, however slight and uneven, not only on contested services but also on uncontested services that are cross-subsidized by incumbent hospitals.

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Appendix

See Tables A1–A7.

Table A1

Generalized negative binomial regression estimates of the market-level effect of entry on admissions, by diagnosis.

	Psychiatric	Substance abuse	Trauma	Neurosurgery
Post-entry	77.20*	46.68**	85.85***	28.92
	(41.73)	(18.19)	(16.37)	(26.67)
Arizona*post-entry	−62.70	−37.73	33.58	5.866
	(63.97)	(35.70)	(27.75)	(25.84)
Constant	323.3***	155.1*	129.4***	156.4***
	(103.9)	(79.37)	(32.90)	(22.30)
Observations	190	170	265	190

Robust standard errors with hospital level clustering in parentheses. Separate models were estimated for each diagnosis. Controls for percent emergency admissions and partial year reporting by one hospital. Psychiatric specification controls for system-level agreements with psychiatric specialty hospital (Banner in 2007 and Tucson Medical Center after 2005), Sample 1997–1998 and 2005–2007.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

Table A2

Selected coefficient estimates of the effect of exposure with market * year fixed effects, generalized negative binomial count data model.

	Psychiatry			Substance abuse			Trauma			Neurosurgery		
	25th percentile	50th percentile	75th percentile	25th percentile	50th percentile	75th percentile	25th percentile	50th percentile	75th percentile	25th percentile	50th percentile	75th percentile
Exposure	−0.660**	−0.377	−0.672**	0.378	0.440	−0.0209	0.117	0.198	0.0257	0.248	0.133	−0.0435
	(0.274)	(0.266)	(0.283)	(0.392)	(0.466)	(0.326)	(0.369)	(0.374)	(0.433)	(0.405)	(0.378)	(0.351)
Exposure * post	−0.758	−0.951**	−0.778*	−0.833**	−0.738**	−0.687***	−0.215	−0.216	−0.0302	−0.00893	−0.0112	0.234
	(0.480)	(0.447)	(0.428)	(0.406)	(0.374)	(0.264)	(0.349)	(0.400)	(0.563)	(0.438)	(0.348)	(0.425)
Phoenix *1998	−0.0898	−0.0751	−0.0778	0.131	0.133	0.120	0.0214	0.0216	0.0215	0.127***	0.128***	0.127***
	(0.102)	(0.0983)	(0.0989)	(0.134)	(0.141)	(0.131)	(0.0446)	(0.0456)	(0.0452)	(0.0403)	(0.0405)	(0.0403)
Phoenix *2005	1.028**	1.177***	1.152***	1.329***	1.333***	1.302***	0.354***	0.353***	0.354***	0.259*	0.263*	0.258*
	(0.404)	(0.422)	(0.417)	(0.438)	(0.459)	(0.414)	(0.107)	(0.107)	(0.107)	(0.142)	(0.144)	(0.143)
Phoenix *2006	0.599	0.664	0.652	0.977***	0.980***	0.956***	0.383***	0.383***	0.383***	0.212*	0.212*	0.211*
	(0.386)	(0.415)	(0.410)	(0.365)	(0.376)	(0.351)	(0.0908)	(0.0910)	(0.0910)	(0.109)	(0.111)	(0.108)
Phoenix *2007	0.828**	0.973**	0.947**	1.102***	1.108***	1.068***	0.354***	0.350***	0.352***	0.0835	0.0895	0.0826
	(0.359)	(0.379)	(0.373)	(0.353)	(0.376)	(0.346)	(0.118)	(0.118)	(0.116)	(0.136)	(0.141)	(0.139)
Tucson *1997	−0.262	−0.380	−0.0461	−0.0234	−0.103	0.142	0.138	0.0943	0.179	0.0346	0.0896	0.189
	(0.516)	(0.527)	(0.508)	(0.411)	(0.431)	(0.440)	(0.415)	(0.423)	(0.487)	(0.262)	(0.253)	(0.238)
Tucson *1998	−0.132	−0.0846	0.169	0.0815	0.000496	0.257	0.145	0.100	0.182	0.0465	0.114	0.219
	(0.508)	(0.505)	(0.495)	(0.400)	(0.415)	(0.429)	(0.431)	(0.446)	(0.506)	(0.272)	(0.251)	(0.255)
Tucson *2005	0.905	1.106*	1.410**	1.162***	1.155***	1.472***	0.767*	0.749*	0.741	0.335	0.399	0.314
	(0.620)	(0.597)	(0.574)	(0.420)	(0.421)	(0.421)	(0.429)	(0.420)	(0.517)	(0.284)	(0.278)	(0.391)
Tucson *2006	0.833	1.011*	1.309**	1.206***	1.197***	1.476***	0.777*	0.762*	0.754	0.272	0.336	0.228
	(0.632)	(0.609)	(0.580)	(0.428)	(0.441)	(0.406)	(0.408)	(0.395)	(0.495)	(0.289)	(0.293)	(0.374)
Tucson *2007	0.493	0.970	1.168*	0.903**	0.922**	1.213***	0.571	0.553	0.548	0.00508	0.0725	−0.0188
	(0.653)	(0.663)	(0.617)	(0.448)	(0.455)	(0.409)	(0.414)	(0.399)	(0.499)	(0.280)	(0.285)	(0.388)
Colorado *1997	1.285***	1.259***	1.216**	0.721*	0.700	0.758*	0.274	0.164	0.253	0.468	0.489	0.528*
	(0.482)	(0.479)	(0.509)	(0.432)	(0.504)	(0.405)	(0.398)	(0.390)	(0.453)	(0.305)	(0.298)	(0.277)
Colorado *1998	1.328***	1.301***	1.242**	0.698*	0.662	0.733*	0.270	0.163	0.243	0.486	0.503*	0.552**
	(0.492)	(0.475)	(0.506)	(0.423)	(0.454)	(0.380)	(0.393)	(0.391)	(0.450)	(0.309)	(0.303)	(0.260)
Colorado *2005	2.527***	2.362***	2.507***	1.331***	1.310***	1.510***	0.581	0.492	0.516	0.599***	0.614***	0.504*
	(0.663)	(0.701)	(0.659)	(0.435)	(0.469)	(0.383)	(0.482)	(0.459)	(0.544)	(0.218)	(0.228)	(0.288)
Colorado *2006	2.737***	2.661***	2.693***	1.558***	1.533***	1.689***	0.675	0.583	0.598	0.520**	0.541**	0.458
	(0.619)	(0.654)	(0.627)	(0.474)	(0.526)	(0.409)	(0.509)	(0.481)	(0.550)	(0.247)	(0.252)	(0.348)
Colorado *2007	2.527***	2.407***	2.334***	1.316***	1.311**	1.472***	0.475	0.384	0.393	0.234	0.258	0.148
	(0.638)	(0.678)	(0.653)	(0.464)	(0.521)	(0.393)	(0.491)	(0.465)	(0.530)	(0.237)	(0.242)	(0.298)
Constant	5.801***	5.958***	5.931***	4.654***	4.658***	4.630***	4.576***	4.561***	4.567***	4.680***	4.693***	4.678***
	(0.435)	(0.453)	(0.448)	(0.348)	(0.367)	(0.343)	(0.275)	(0.272)	(0.265)	(0.219)	(0.227)	(0.229)

Robust standard errors with System/Hospital clustering in parentheses. Coefficients are the basis for the marginal effects in Table 4, columns 2, 5 and 8 for psychiatric, substance abuse and trauma admissions, respectively and Table 6, columns 2, 4, and 6 for neurology admissions.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

Table A3

Estimates of the effect of exposure on the probability of uncontested admission.

	Psychiatric	Substance abuse	Trauma	Neurosurgery
Exposure	0.408 ***	0.818 ***	0.127 ***	−0.207 ***
	(0.0304)	(0.0311)	(0.0294)	(0.0415)
Exposure-squared	−0.246 ***	−0.659 ***	−0.0123	0.0541
	(0.0284)	(0.0298)	(0.0240)	(0.0347)
Exposure-cubed	−0.113 ***		−0.0214	0.0705 **
	(0.0225)		(0.0212)	(0.0307)

Conditional logit specification includes drive time interacted with the patient characteristics listed in Table 1 and a dummy variable indicating a partial year report of one hospital. Psychiatric specification controls for system-level agreements with psychiatric specialty hospital (Banner in 2007 and Tucson Medical Center after 2005). Robust standard errors with patient/admission clustering in parentheses. Separate models were estimated for each diagnosis. Sample 1997–1998 and 2005–2007.

*** $p < 0.01$.

** $p < 0.05$.

Table A4

Results of conditional logit analysis cardiac admissions.

Market:	Phoenix		Tucson		Denver	
Service:	Surgical	Medical	Surgical	Medical	Surgical	Medical
Teaching hospital	0.483 ***	1.101 ***	−1.298 ***	−1.038 ***	0.557 **	−0.0962
	(0.0334)	(0.0293)	(0.0548)	(0.0447)	(0.268)	(0.283)
Cardiac catheterization	0.488 ***	−0.483 ***	0.468 *	0.118 **	−1.774 ***	−0.325 ***
	(0.0367)	(0.0216)	(0.263)	(0.0574)	(0.0921)	(0.0497)
Open-heart surgery	0.839 ***	0.823 ***	1.097 ***	1.080 ***	1.890 ***	0.572 ***
	(0.0250)	(0.0170)	(0.0940)	(0.0503)	(0.0869)	(0.0476)
ln(drive time)	−1.063 ***	−1.500 ***	−0.0256	−0.504 ***	−1.121 ***	−0.997 ***
	(0.0331)	(0.0231)	(0.0788)	(0.0441)	(0.0993)	(0.0762)
ln(drive time) interacted with						
Emergency admission	−0.941 ***	−0.824 ***	−0.875 ***	−0.517 ***	−0.425 ***	0.0167
	(0.0125)	(0.00946)	(0.0295)	(0.0178)	(0.0420)	(0.0299)
Median income	−1.14e–05 ***	−9.68e–06 ***	−2.34e–05 ***	−2.70e–05 ***	−2.31e–05 ***	−3.21e–05 ***
	(4.86e–07)	(3.74e–07)	(1.25e–06)	(8.50e–07)	(1.56e–06)	(1.31e–06)
Age 50–74	−0.184 ***	−0.166 ***	−0.0715	−0.0765 ***	−0.319 ***	−0.167 ***
	(0.0175)	(0.0131)	(0.0451)	(0.0263)	(0.0460)	(0.0388)
Age ≥75	−0.314 ***	−0.323 ***	−0.192 ***	−0.155 ***	−0.466 ***	−0.216 ***
	(0.0194)	(0.0137)	(0.0495)	(0.0268)	(0.0586)	(0.0435)
# Procedures	−0.0418 ***	0.0973 ***	−0.279 ***	−0.0632 ***	0.175 ***	0.494 ***
	(0.00322)	(0.00249)	(0.0340)	(0.0201)	(0.0396)	(0.0336)
# Diagnoses	0.0185 ***	0.0167 ***	0.0320 ***	0.162 ***	−0.0168 **	0.100 ***
	(0.00253)	(0.00191)	(0.00798)	(0.00461)	(0.00700)	(0.00585)
HMO payer	−0.0688 ***	0.00490	−0.0168 ***	0.0134 ***	0.00784	−0.0323 ***

Market:	Phoenix		Tucson		Denver	
Service:	Surgical	Medical	Surgical	Medical	Surgical	Medical
	(0.0122)	(0.00942)	(0.00636)	(0.00351)	(0.00806)	(0.00619)
Patient diagnosis–hospital service offerings interactions						
Cardiac catheterization	1.049***		3.343***		−0.127*	
	(0.0520)		(1.039)		(0.0749)	
Stent* open heart surgery	0.611***		0.884***		0.397***	
	(0.0240)		(0.0733)		(0.147)	
Open heart surgery	1.830***		0.961***		0.0753	
	(0.0336)		(0.0847)		(0.0613)	
Patient diagnosis–system service offerings interactions						
Cardiac catheterization	0.0265***		0.0225*		−0.0626***	
	(0.00457)		(0.0132)		(0.0104)	
Stent* open heart surgery	−0.0317***		0.0374**		−0.0838***	
	(0.00492)		(0.0154)		(0.0233)	
Open heart surgery	0.0141***		−0.341***		−0.00977	
	(0.00545)		(0.0191)		(0.0216)	
Hospital fixed effects ln(drive time)*						
Hospital 2	−0.0102*	−0.0646***	−0.0243***	−0.194***	−0.375***	−0.273***
	(0.00605)	(0.00554)	(0.00645)	(0.00553)	(0.0146)	(0.0117)
Hospital 3	−0.102***	−0.0529***	−0.0210	0.0254	−0.218***	−0.393***
	(0.00862)	(0.00691)	(0.0266)	(0.0161)	(0.0145)	(0.0164)
Hospital 4	0.221***	0.0211***	−1.625***	−1.462***	−0.0466***	−0.186***
	(0.00607)	(0.00543)	(0.0799)	(0.0830)	(0.0121)	(0.0120)
Hospital 5	−0.281***	0.103***	−0.240***	−0.431***	−0.193***	−0.254***
	(0.0193)	(0.00801)	(0.00788)	(0.0233)	(0.0138)	(0.0133)
Hospital 6	0.104***	0.0244***	−0.189***	−0.145***	0.0750***	−0.935***
	(0.00624)	(0.00621)	(0.00741)	(0.0158)	(0.00941)	(0.0301)
Hospital 7	−0.225***	−0.164***	−0.0919***	−0.192***	−0.338***	0.0215***
	(0.00956)	(0.00793)	(0.0307)	(0.0195)	(0.0152)	(0.00701)
Hospital fixed effects ln(drive time)*						
Hospital 8	−0.0756***	−0.116***	0.272***	−0.208***	−0.221***	−0.401***
	(0.00790)	(0.00658)	(0.0154)	(0.00555)	(0.0140)	(0.0151)
Hospital 9	−0.310***	−0.0319***	−0.112***	−0.00896**	−0.216***	−0.286***
	(0.0108)	(0.00676)	(0.00614)	(0.00454)	(0.0124)	(0.0128)
Hospital 10	−0.00463	0.0541***		−0.131***	−0.287***	−0.264***
	(0.00738)	(0.0116)		(0.0192)	(0.0139)	(0.0119)
Hospital 11	0.0363***	−0.206***		0.194***	−0.259***	−0.318***
	(0.00854)	(0.00727)		(0.0140)	(0.0619)	(0.0133)
Hospital 12	0.0687***	−0.181***		−0.0967***	−0.327***	−0.164**
	(0.0143)	(0.00730)		(0.00501)	(0.0167)	(0.0664)
Hospital 13	−0.261***	−0.295***		−0.308***	0.0866***	−0.346***
	(0.00820)	(0.0152)		(0.0220)	(0.0109)	(0.0144)

Market:	**Phoenix**		**Tucson**		**Denver**	
Service:	**Surgical**	**Medical**	**Surgical**	**Medical**	**Surgical**	**Medical**
Hospital 14	0.222***	−0.0570***			−0.400***	0.0753***
	(0.00693)	(0.00813)			(0.0185)	(0.00965)
Hospital 15	0.117***	−0.153***			−0.830***	−0.267***
	(0.0103)	(0.0109)			(0.0434)	(0.0138)
Hospital 16	−0.122***	−0.315***				−0.544***
	(0.00747)	(0.00712)				(0.0203)
Hospital 17	−0.151***	0.0176**				
	(0.0160)	(0.00683)				
Hospital 18	−0.0162	−0.154***				
	(0.0121)	(0.00997)				
Hospital 19	0.125***	−0.115***				
	(0.00777)	(0.00609)				
Hospital 20	−0.243***	−0.328***				
	(0.0124)	(0.0128)				
Hospital fixed effects ln(drive time)*						
Hospital 21	0.0110	−0.00662				
	(0.00733)	(0.00880)				
Hospital 22	−0.287***	−0.350***				
	(0.0162)	(0.00853)				
Hospital 23	−0.307***	−0.438***				
	(0.0174)	(0.0111)				
Hospital 24	−0.256***	−0.224***				
	(0.00807)	(0.00731)				
Hospital 25	−0.0553***	−0.224***				
	(0.00707)	(0.0105)				
Hospital 26	0.0194***	−0.157***				
	(0.00667)	(0.0103)				
Hospital 27	−0.530***	−0.250***				
	(0.0324)	(0.00655)				
Hospital 28	−0.00371	−0.0398***				
	(0.00668)	(0.00573)				
Hospital 29	−0.309***	0.00656				
	(0.0180)	(0.00519)				
Hospital 30		−0.313***				
		(0.00990)				
Hospital 31		0.00817				
		(0.00548)				
Hospital 32		−0.112***				
		(0.0102)				
Observations	2,234,621	2,376,325	195,349	415,210	332,565	341,968

Standard errors in parentheses. Separate models were estimated for each market and diagnosis type.

$^{***}p < 0.01$.

$^{**}p < 0.05$.

$^{*}p < 0.1$.

Table A5

Parameter estimates using alternative specifications of trends by exposure level.

	Psychiatry				Substance abuse			
Top 25 percent								
Exposure	−0.502*	−0.659**	0.318	0.424	0.502	0.378	0.651**	0.553**
	(0.283)	(0.274)	(0.338)	(0.347)	(0.435)	(0.393)	(0.279)	(0.266)
Exposure*post	0.142	−0.764	−0.280	−0.333*	−0.136	−0.834**	−0.530**	−0.537**
	(0.782)	(0.477)	(0.210)	(0.183)	(0.752)	(0.410)	(0.249)	(0.257)
Top 50 percent								
Exposure	−0.448*	−0.365	0.394	0.446	0.507	0.439	0.876**	0.691***
	(0.240)	(0.275)	(0.365)	(0.421)	(0.561)	(0.468)	(0.363)	(0.227)
Exposure*post	−1.388	−0.979**	−0.554***	−0.547***	−0.335	−0.741**	−0.197	−0.209
	(1.175)	(0.446)	(0.162)	(0.170)	(0.756)	(0.376)	(0.173)	(0.206)
Top 75 percent								
Exposure	−0.576*	−0.661**	0.413	−0.261	0.0870	−0.0251	1.011***	0.768***
	(0.335)	(0.288)	(0.620)	(0.405)	(0.416)	(0.326)	(0.370)	(0.211)
Exposure*post	−0.302	−0.805*	−0.693***	−0.727***	−0.0778	−0.683***	−0.295***	−0.294**
	(1.220)	(0.424)	(0.200)	(0.213)	(0.694)	(0.262)	(0.111)	(0.119)
	Trauma				Neurosurgery			
Top 25 percent								
Exposure	0.145	0.111	0.639**	0.533*	0.267	0.237	0.336	0.0544
	(0.371)	(0.366)	(0.295)	(0.276)	(0.406)	(0.399)	(0.228)	(0.205)
Exposure*post	0.0214	−0.206	−0.0194	−0.0356	0.193	0.00923	0.146	0.114
	(0.250)	(0.345)	(0.130)	(0.131)	(0.347)	(0.432)	(0.107)	(0.140)
Top 50 percent								
Exposure	0.214	0.191	1.151***	0.955***	0.214	0.121	0.442	0.247
	(0.383)	(0.370)	(0.271)	(0.299)	(0.392)	(0.371)	(0.329)	(0.351)
Exposure*post	−0.0302	−0.207	−0.0614	−0.0850	0.523	0.00589	−0.0501	−0.0385
	(0.304)	(0.394)	(0.188)	(0.203)	(0.409)	(0.343)	(0.132)	(0.134)
Top 75 percent								
Exposure	0.0808	0.0144	2.077***	1.964***	0.0174	−0.0529	0.395	0.541
	(0.465)	(0.423)	(0.376)	(0.207)	(0.372)	(0.349)	(0.302)	(0.391)
Exposure*post	0.383	−0.0134	−0.261*	−0.283*	0.635*	0.249	−0.0118	0.0195
	(0.296)	(0.546)	(0.139)	(0.148)	(0.361)	(0.425)	(0.138)	(0.165)
Trend	Market and exposure-specific	Market-specific quadratic	Market and exposure-specific	Market-specific quadratic	Market and exposure-specific	Market-specific quadratic	Market and exposure-specific	Market-specific quadratic
Sample	1997–98 & 2005–07		1997–2007		1997–98 & 2005–07		1997–2007	

Estimated using a generalized negative binomial regression model, see Table 4 notes for details. All specifications include market and year fixed effects. Robust standard errors with system level clustering in parentheses.

$^{***}p < 0.01$.

$^{**}p < 0.05$.

$^{*}p < 0.1$.

Table A6

Analysis of number of admissions with continuous measure of exposure.

	Psychiatry		Substance abuse	
Exposure[a]	1.151***	0.670***	0.427***	0.243*
	(0.255)	(0.208)	(0.0826)	(0.125)
Marginal effect of exposure[b]	259.0***	168.6**	37.85***	24.71*
	(79.49)	(74.44)	(7.324)	(13.02)
	Trauma		Neurosurgery	
Exposure[a]	0.311*	0.116	−0.0699	−0.0567
	(0.173)	(0.181)	(0.151)	(0.122)
Marginal effect of exposure[b]	58.52*	22.85	−9.246	−7.882
	(31.39)	(36.45)	(21.14)	(17.52)
Sample	1997–98 & 2005–07	1997–2007	1997–98 & 2005–07	1997–2007

All specifications include market and year fixed effects.

[a]Robust standard errors with system level clustering in parentheses.

[b]Calculated at sample means, unconditional standard errors calculated for marginal effects.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

Table A7

Effect of entry and for-profit ownership on probability of admission, by exposure level and diagnosis.

Exposure level	Psychiatry			Substance abuse		
	25 percent	50 percent	75 percent	25 percent	50 percent	75 percent
Exposed*post	−0.323***	−0.0138	0.0661**	−0.305***	−0.350***	−0.232***
	(0.0469)	(0.0349)	(0.0322)	(0.0733)	(0.0657)	(0.0624)
Exposed*for-profit*post	0.963***	−0.293***	−0.190***	−1.789***	−1.486***	−0.350***
	(0.0813)	(0.0610)	(0.0568)	(0.140)	(0.121)	(0.0953)
For-profit*post	−0.979***	−0.597***	−0.696***	−0.473***	−0.598***	−1.350***
	(0.0366)	(0.0367)	(0.0347)	(0.0914)	(0.0911)	(0.0928)
Exposure level	Trauma			Neurosurgery		
	25 percent	50 percent	75 percent	25 percent	50 percent	75 percent
Exposed*post	−0.218***	−0.300***	−0.0482	0.140***	0.103***	0.418***
	(0.0304)	(0.0290)	(0.0299)	(0.0362)	(0.0363)	(0.0401)
Exposed*for-profit*post	0.197***	0.587***	0.147***	−0.662***	−0.262***	−0.350***
	(0.0664)	(0.0558)	(0.0529)	(0.0864)	(0.0697)	(0.0633)
For-profit*post	−0.401***	−0.662***	−0.417***	−0.256***	−0.428***	−0.328***
	(0.0443)	(0.0445)	(0.0465)	(0.0563)	(0.0534)	(0.0555)

Conditional logit specification includes drive time interacted with the patient characteristics listed in Table 1 and a dummy variable indicating a partial year report of one hospital. Also includes a dummy indicating any exposure; a dummy for for-profit ownership and an interaction between any exposure and for-profit ownership. Psychiatric specification controls for system-level agreements with psychiatric specialty hospital (Banner in 2007 and Tucson Medical Center after 2005). All specifications include hospital*drive time fixed effects. Sample: 1987–88 and 2005–07. Robust standard errors with patient/admission clustering in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

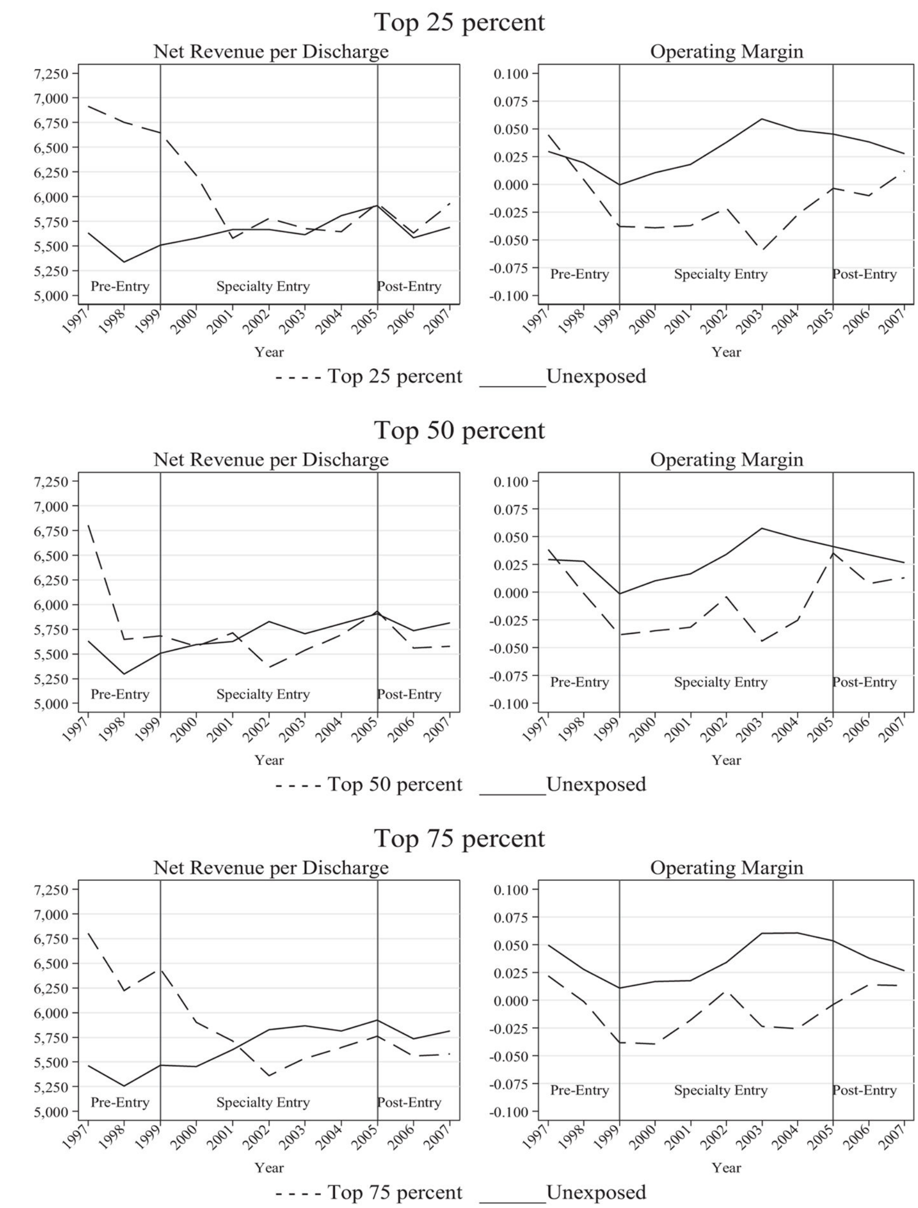

Fig. 1.

Median net revenue and margin, by exposure level. *Notes*: Median-band plot using Stata 12.0. Sample limited to hospitals that report in every year.

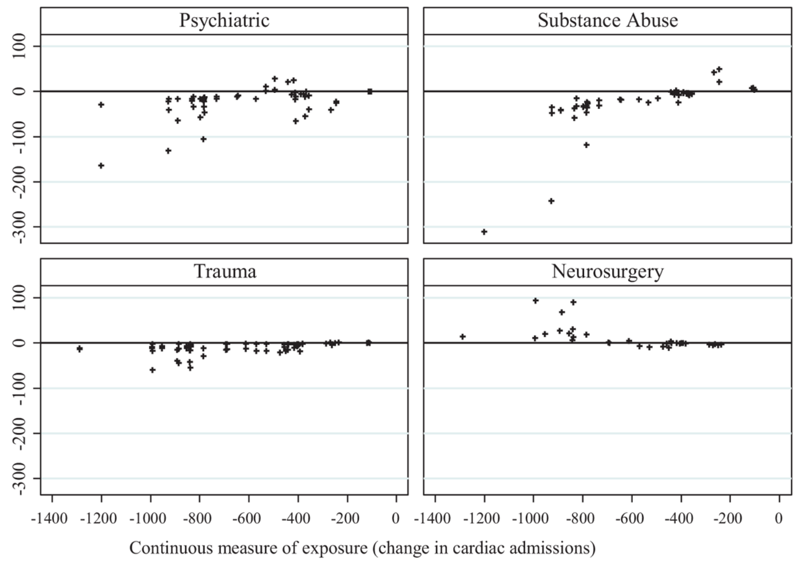

Fig. 2.

Predicted change in uncontested admissions due to exposure. *Notes*: Predictions of conditional logit model of patient's choice of hospital with hospital*drive time fixed effects; drive time interacted with the patient characteristics listed in Table 1 and a dummy variable indicating a partial year report of one hospital. Cubic specification of exposure in psychiatry, trauma, and neurosurgery samples and a quadratic specification is used for substance abuse. Parameter estimates in Table A3.

Table 1

Summary statistics by major diagnostic category.

Major Diagnostic Category:	**Psychiatric**	**Substance abuse**	**Trauma**	**Neurosurgery**
Patient characteristics				
Emergency admission	0.398	0.597	0.666	0.229
	(0.490)	(0.490)	(0.472)	(0.420)
HMO primary payer	0.174	0.206	0.221	0.308
	(0.379)	(0.404)	(0.415)	(0.462)
Age 50–74 years	0.221	0.283	0.287	0.482
	(0.415)	(0.451)	(0.452)	(0.500)
Age >74 years	0.129	0.0457	0.113	0.245
	(0.335)	(0.209)	(0.317)	(0.430)
Drive time (minutes)	21.08	19.27	28.14	35.88
	(29.08)	(27.67)	(46.67)	(50.28)
ICD9 procedures per admission	0.275	0.685	1.593	2.510
	(0.730)	(0.872)	(2.002)	(1.650)
ICD9 diagnoses per admission	4.998	5.681	6.130	5.426
	(2.327)	(2.133)	(2.098)	(2.387)
Admissions	51,489	16,875	50,249	26,035
Hospital characteristics[a]				
Phoenix market	0.402	0.476	0.642	0.595
	(0.490)	(0.499)	(0.479)	(0.491)
Tucson market	0.351	0.219	0.182	0.197
	(0.477)	(0.414)	(0.386)	(0.398)
System exposure level				
Top 25 percent[b]	0.0856	0.177	0.299	0.364
	(0.280)	(0.382)	(0.458)	(0.481)
Top 50 percent[c]	0.153	0.239	0.401	0.405
	(0.360)	(0.426)	(0.490)	(0.491)
Top 75 percent[d]	0.280	0.347	0.554	0.589
	(0.449)	(0.476)	(0.497)	(0.492)
Partial-year data	0.00171	0.00142	0.00203	0.000346
	(0.0413)	(0.0377)	(0.0450)	(0.0186)
Number of hospitals	38	34	53	38

Standard deviations in parentheses.

[a] Proportions weighted by admissions.

[b] System-wide reduction > 786 (system hospitals) or hospital reduction > 393 (independent hospitals).

[c] System-wide reduction > 665 (system hospitals) or hospital reduction > 210 (independent hospitals).

[d] System-wide reduction > 236 (system hospitals) or hospital reduction > 87 (independent hospitals).

Table 2

Hospital financial performance measures and admissions before and after entry, by exposure level, per hospital and year.

	No exposure		Exposure level					
	Pre	Post	Top 25 percent[a]		Top 50 percent[a]		Top 75 percent[a]	
			Pre	Post	Pre	Post	Pre	Post
Net income from service to patients (1000s)[b]	2087.92	7996.68	2077.44	921.56	253.49	−2818.06	−1604.14	−2260.07
	(16326.96)	(15599.34)	(10805.25)	(15053.50)	(12997.46)	(31021.47)	(12213.98)	(26105.65)
Net revenue per hospital discharge[b]	6395.00	6536.80	7773.52	6222.94**	7401.75	6118.30**	7000.00	5933.66
	(1654.80)	(1408.70)	(3134.81)	(1659.11)	(2981.93)	(1549.56)	(2703.32)	(1417.52)
Operating margin[b,c]	0.005	0.03	0.02	−0.002	0.01	−0.01	−0.005	−0.014
	(0.105)	(0.08)	(0.08)	(0.101)	(0.10)	(0.16)	(0.094)	(0.143)
Share of cardiac admissions[d]	0.146	0.144	0.151	0.138	0.152	0.134	0.168	0.146
	(0.029)	(0.035)	(0.023)	(0.051)	(0.038)	(0.050)	(0.051)	(0.055)
Psychiatric admissions	387.52	488.76	94.48	109.86	144.88	137.63	116.69	230.31
	(350.27)	(463.71)	(88.14)	(110.38)	(140.41)	(185.97)	(126.65)	(332.18)
Substance abuse admissions	96.33	195.52***	57.47	69.58	60.54	74.60	53.45	84.42
	(74.09)	(155.75)	(77.94)	(33.91)	(71.01)	(49.92)	(59.87)	(56.36)
Trauma admissions	233.50	359.73*	233.85	303.74	241.75	324.11	228.04	317.49
	(175.87)	(327.54)	(154.10)	(226.60)	(161.37)	(238.98)	(147.75)	(215.56)
Neurosurgery admissions	157.23	142.08	171.39	197.51	161.55	185.16	172.51	199.26
	(69.33)	(94.55)	(181.00)	(336.74)	(167.74)	(310.53)	(150.13)	(263.31)
Total admissions (1000s)	10.665	13.362	11.630	13.724	11.528	13.445	10.930	14.411
	(9.200)	(11.832)	(6.294)	(9.153)	(6.506)	(9.219)	(6.870)	(9.538)

*** $p < 0.01$ based on a hypothesis test that the pre and post difference in unweighted mean (or proportion) is zero.

** $p < 0.05$ based on a hypothesis test that the pre and post difference in unweighted mean (or proportion) is zero.

* $p < 0.1$ based on a hypothesis test that the pre and post difference in unweighted mean (or proportion) is zero.

[a] See Table 1 notes and text for definition. Mean with Standard Deviations in parentheses, weighted by total admissions.

[b] Healthcare Cost Report Information System (HCRIS), Centers for Medicare and Medicaid Services, March 2012 update. Sample limited to hospitals that reported net income from patient care to HCRIS. Converted to 1997 US$ using US hospital net revenue inflation rate.

[c] Operating margin calculated using net income from service to patients divided by net patient revenue.

[d] Share of cardiac admissions measured at hospital level for independent hospitals and the system level for system admissions.

Table 3

Fixed effect estimates of the effect of exposure and trends in admissions.

	Psychiatry	Substance abuse	Trauma	Neurosurgery
Top 25 percent[a]				
Exposure	−86.20*	−101.2*	−22.31	4.823
	(47.19)	(52.69)	(25.09)	(39.11)
1998	16.60	5.759	2.497	6.737
	(15.89)	(4.956)	(3.095)	(4.786)
2005	137.0***	94.63***	98.18***	48.20**
	(46.33)	(19.11)	(21.53)	(17.88)
2006	142.2***	89.55***	99.41***	39.44**
	(48.85)	(19.47)	(19.55)	(17.70)
2007	90.25*	64.25***	58.91***	1.969
	(49.43)	(17.79)	(15.51)	(12.84)
Constant	250.5***	112.1**	160.9***	161.3***
	(48.66)	(47.00)	(21.74)	(16.77)
Top 50 percent[a]				
Exposure	−96.39	−86.96*	−8.898	1.156
	(59.87)	(44.85)	(25.82)	(33.54)
1998	16.58	5.626	2.509	6.740
	(15.95)	(4.945)	(3.089)	(4.792)
2005	144.8***	95.89***	95.11***	49.38**
	(47.75)	(19.79)	(22.87)	(18.67)
2006	149.9***	90.71***	96.34***	40.63**
	(50.98)	(19.99)	(20.54)	(18.62)
2007	98.23*	65.30***	55.80***	3.143
	(48.94)	(18.06)	(16.81)	(13.55)
Constant	250.3***	109.7**	161.3***	161.5***
	(47.49)	(47.86)	(21.77)	(16.79)
Top 75 percent[a]				
Exposure	−84.50	−84.30**	12.76	16.08
	(62.45)	(40.89)	(27.18)	(23.08)
1998	16.85	6.311	2.506	6.706
	(15.85)	(5.063)	(3.104)	(4.753)
2005	152.3**	112.5***	85.40***	40.17*
	(56.84)	(27.51)	(26.61)	(23.13)
2006	157.6**	107.8***	86.63***	31.34
	(60.46)	(28.25)	(23.61)	(22.70)
2007	106.2*	83.34***	46.00**	−6.004

	Psychiatry	Substance abuse	Trauma	Neurosurgery
	(58.19)	(27.29)	(19.49)	(17.34)
Constant	253.5***	122.3**	161.2***	159.4***
	(47.17)	(52.53)	(20.98)	(16.86)
Hospital-years	190	170	265	190

Separate models were estimated for each level of exposure and major diagnostic category. Robust standard errors with hospital-level clustering in parentheses. Controls for hospital fixed effects; percent emergency admissions and partial year reporting by one hospital. Psychiatric specification controls for system-level agreements with psychiatric specialty hospital (Banner in 2007 and Tucson Medical Center after 2005). Sample years: 1997–1998 and 2005–2007.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

[a] See Table 1 notes or text for definition.

Table 4

Coefficient estimates from generalized negative binomial regression of number of admissions.

Service line	Psychiatric				Substance abuse				Trauma			
Exposure level: top 25 percent[a]												
Exposed	−0. 680 **	−0.660 **	0.377	0.468	0.325	0.378	0.549 **	0.554 **	0.0444	0.117	0.534 *	0.536 *
	(0.280)	(0.274)	(0.354)	(0.347)	(0.378)	(0.392)	(0.263)	(0.259)	(0.326)	(0.369)	(0.277)	(0.276)
Exposed * post	−0.723 **	−0.758	−0.259	−0.382 **	−0.770 *	−0.833 **	−0.534 **	−0.568 **	−0.104	−0.215	−0.0337	−0.0398
	(0.327)	(0.480)	(0.192)	(0.188)	(0.418)	(0.406)	(0.268)	(0.259)	(0.224)	(0.349)	(0.124)	(0.141)
Exposure level: top 50 percent[a]												
Exposed	−0.456 *	−0.377	0.418	0.479	0.376	0.440	0.700 ***	0.682 ***	0.110	0.198	0.947 ***	0.961 ***
	(0.268)	(0.266)	(0.426)	(0.415)	(0.462)	(0.466)	(0.231)	(0.229)	(0.294)	(0.374)	(0.302)	(0.300)
Exposed * post	−0.826 ***	−0.951 **	−0.536 ***	−0.585 ***	−0.650 *	−0.738 **	−0.226	−0.216	−0.0867	−0.216	−0.0771	−0.0879
	(0.312)	(0.447)	(0.161)	(0.189)	(0.368)	(0.374)	(0.215)	(0.219)	(0.215)	(0.400)	(0.196)	(0.215)
Exposure level: top 75 percent[a]												
Exposed	−0.780 ***	−0.672 **	−0.339	−0.200	−0.0811	−0.0209	0.777 ***	0.901 ***	−0.0288	0.0257	1.913 ***	1.979 ***
	(0.282)	(0.283)	(0.445)	(0.361)	(0.321)	(0.326)	(0.232)	(0.155)	(0.309)	(0.433)	(0.216)	(0.207)
Exposed * post	−0.609 **	−0.778 *	−0.712 ***	−0.815 ***	−0.602 **	−0.687 ***	−0.320 **	−0.255 **	0.0506	−0.0302	−0.234	−0.298 **
	(0.297)	(0.428)	(0.208)	(0.264)	(0.289)	(0.264)	(0.129)	(0.124)	(0.214)	(0.563)	(0.165)	(0.152)
Fixed effect	Year, market	Market * year	Year, market	Market * year	Year, market	Market * year	Year, market	Market * year	Year, market	Market * year	Year, market	Market * year
Sample	1997–98; 2005–07		1997–2007		1997–98; 2005–07		1997–2007		1997–98; 2005–07		1997–2007	
Sample size[b]	190		398		170		377		265		542	

Separate models were estimated for each level of exposure and diagnosis. All specifications include hospital percent emergency admissions; and a dummy variable indicating a partial year report of one hospital. Psychiatric specification controls for system-level agreements with psychiatric specialty hospitals (Banner in 2007 and Tucson Medical Center after 2005). Likelihood-ratio test for over dispersion parameter $a = 0$: probability $\geq x^2$ yielded $p < 0.001$ in all specifications. The natural log of the over-dispersion parameter is modeled as a function of market dummies and a constant dummy variable indicating that the hospital was exposed. The constant is significant with a $p < 0.001$ in all specifications.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

[a] See Table 1 notes or text for definition of thresholds. Robust standard errors with system/hospital clustering in parentheses.

Table 5

Marginal effects from generalized negative binomial regression of number of admissions.

	Psychiatric (*N* = 190)			Substance abuse (*N* = 170)			Trauma (*N* = 265)		
Exposure level: top 25 percent[a]									
Exposed	−121.9**	−114.1**	−136.7***	37.03	40.88	56.94	22.06	−0.813	26.39
	(55.11)	(49.85)	(48.59)	(42.49)	(39.72)	(55.89)	(70.90)	(62.78)	(99.55)
Consolidated		26.80	−18.37		7.991	21.86		−83.76	−52.34
		(38.76)	(100.5)		(25.10)	(36.23)		(70.72)	(99.41)
Exposed*consolidated			68.96			−38.01			−53.47
			(94.55)			(56.21)			(110.1)
Post interactions									
Exposed	−127.7*	−144.0**	−59.65	−55.95***	−55.84***	−61.16**	−36.82	−53.78	−36.07
	(74.60)	(66.65)	(50.05)	(21.11)	(18.11)	(26.08)	(55.06)	(48.41)	(38.82)
Consolidated		−56.62	123.2		0.677	−8.157		−32.26	−23.25
		(67.40)	(166.8)		(23.14)	(28.03)		(55.46)	(68.72)
Exposed*consolidated			−147.3**			30.47			−41.73
			(59.27)			(87.68)			(67.52)
Exposure level: top 50 percent[a]									
Exposed	−75.12	−72.62*	−97.85	42.89	51.55	99.17	37.32	1.378	96.44
	(52.24)	(43.23)	(65.76)	(50.80)	(55.86)	(63.73)	(73.31)	(71.27)	(115.5)
Consolidated		1.711	−35.05		12.25	53.64*		−96.52	−6.371
		(50.63)	(112.3)		(31.28)	(32.09)		(80.34)	(112.0)
Exposed*consolidated			57.34			−97.51**			−150.4
			(102.2)			(46.17)			(123.1)
Post interactions									
Exposed	−155.1**	−201.6***	−77.81	−52.50**	−53.09**	−56.68**	−37.19	−46.77	−50.10
	(67.47)	(71.33)	(71.03)	(21.19)	(22.35)	(26.34)	(64.64)	(62.17)	(39.70)
Consolidated		−130.9	112.1		−2.640	−7.075		−28.48	−38.32
		(90.05)	(171.7)		(31.46)	(27.14)		(56.22)	(62.61)
Exposed*consolidated			−173.7***			0.594			−1.287

	Psychiatric (N = 190)			Substance abuse (N = 170)			Trauma (N = 265)		
			(47.41)			(51.54)			(64.03)
Exposure level: top 75 percent[a]									
Exposed	−136.5**	−163.8***	−229.9	−1.841	−0.717	20.73	4.706	−49.61	−25.49
	(57.55)	(52.00)	(144.2)	(28.73)	(28.35)	(43.15)	(79.36)	(88.42)	(171.4)
Consolidated		−50.28	−113.9		0.803	21.03		−107.0	−78.44
		(53.56)	(126.0)		(21.51)	(37.15)		(72.71)	(157.8)
Exposed*consolidated			91.44			−29.03			−30.94
			(135.2)			(44.03)			(152.7)
Post interactions									
Exposed	−137.5*	−203.9***	−92.07	−53.18***	−57.41***	−65.47***	−5.512	−46.78	−18.74
	(72.85)	(72.15)	(104.6)	(19.03)	(19.91)	(24.02)	(102.0)	(85.69)	(99.82)
Consolidated		−106.9*	49.71		−11.22	−19.99		−38.52	−22.41
		(57.93)	(149.9)		(17.84)	(16.85)		(49.81)	(71.22)
Exposed*consolidated			−143.5**			15.59			−41.73
			(68.87)			(39.29)			(68.20)

Marginal effects evaluated at the mean values. Separate models were estimated for each level of exposure and diagnosis. Controls for year*market fixed effects; hospital percent emergency admissions; and a dummy variable indicating a partial year report of one hospital. Psychiatric specification controls for system-level agreements with psychiatric specialty hospitals (Banner in 2007 and Tucson Medical Center after 2005). Likelihood-ratio test of $a = 0$: probability $\geq x^2$ yielded $p < 0.001$ in all specifications. The natural log of the over-dispersion parameter is modeled as a function of market dummies and a constant dummy variable indicating that the hospital was exposed. The constant is significant with a $p < 0.001$ in all specifications. Sample years: 1997–1998 and 2005–2007. Standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

[a] See Table 1 notes or text for definition.

Table 6

Effect of entry on probability of admission, by exposure level and diagnosis, by sample.

Service line	Psychiatric				Substance abuse				Trauma			
Exposure level: top 25 percent[a]												
Exposed	−1.098***	−1.597***	0.282***	0.128***	0.451***	0.200*	0.866***	0.787***	0.0629***	0.277***	0.482***	0.572***
	(0.0287)	(0.0652)	(0.00851)	(0.0273)	(0.0389)	(0.107)	(0.0159)	(0.0523)	(0.0221)	(0.0415)	(0.00895)	(0.0270)
Exposed*post	−0.246***	−0.155***	−0.248***	−0.0362***	−1.338***	−1.298***	−0.644***	−0.526***	−0.278***	−0.190***	−0.0750***	−0.0478***
	(0.0362)	(0.0344)	(0.0108)	(0.0135)	(0.0515)	(0.0513)	(0.0185)	(0.0196)	(0.0266)	(0.0244)	(0.0108)	(0.0115)
Exposure level: top 50 percent												
Exposed	−0.669***	−1.158***	0.564***	−0.310***	0.402***	0.518***	1.278***	1.368***	0.280***	0.393***	1.032***	0.890***
	(0.0227)	(0.0572)	(0.00971)	(0.0341)	(0.0383)	(0.104)	(0.0203)	(0.0653)	(0.0205)	(0.0409)	(0.0111)	(0.0352)
Exposed*post	−0.307***	−0.262***	−0.453***	−0.0901***	−1.114***	−1.145***	−0.571***	−0.383***	−0.213***	−0.158***	−0.184***	−0.0681***
	(0.0283)	(0.0277)	(0.00995)	(0.0104)	(0.0475)	(0.0487)	(0.0162)	(0.0169)	(0.0247)	(0.0238)	(0.0100)	(0.0101)
Exposure level: top 75 percent												
Exposed	−1.189***	−2.057***	−0.136***	−1.467***	−0.0471	−0.233***	1.524***	1.059***	0.154***	0.103**	2.096***	2.277***
	(0.0209)	(0.0484)	(0.0144)	(0.0491)	(0.0403)	(0.0893)	(0.0309)	(0.100)	(0.0215)	(0.0423)	(0.0249)	(0.0603)
Exposed*post	0.00688	−0.0437	−0.381***	−0.00674	−0.840***	−0.731***	−0.858***	−0.373***	−0.077***	−0.0225	−0.0502***	−0.0268**
	(0.0265)	(0.0271)	(0.0105)	(0.0109)	(0.0490)	(0.0449)	(0.0183)	(0.0177)	(0.0258)	(0.0248)	(0.00928)	(0.0107)
Hospital FE & drive-time interactions?	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Sample	1997–98; 2005–07		1997–2007		1997–98; 2005–07		1997–2007		1997–98; 2005–07		1997–2007	
Sample size[b]	685,820		1,719,964		221,029		602,070		1,197,047		2,696,151	

Notes. Choice sets are defined for the Tucson, Phoenix & Colorado market areas. Separate models were estimated for each level of exposure and diagnosis. Conditional logit specification includes drive time interacted with the patient characteristics listed in Table 1 and a dummy variable indicating a partial year report of one hospital. Psychiatric specification controls for system-level agreements with psychiatric specialty hospital (Banner in 2007 and Tucson Medical Center after 2005).

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

[a] See Table 1 notes or text for definition. Robust standard errors with patient/admission clustering in parentheses.

[b] The sample size is the number of admissions times the number of hospitals in the patient's choice set.

Table 7

Effect of entry and consolidation on probability of admission, by exposure level and diagnosis.

Service line	Psychiatric		Substance abuse		Trauma	
Exposure level: top 25 percent[a]						
Exposed	−1.043***	−1.621***	0.517***	0.284**	0.0465**	0.241***
	(0.0286)	(0.0662)	(0.0380)	(0.120)	(0.0221)	(0.0440)
Consolidated	0.190***	−0.138***	0.171***	0.191*	−0.0823***	−0.148***
	(0.0195)	(0.0468)	(0.0344)	(0.100)	(0.0186)	(0.0430)
Exposed*post	−0.254***	−0.252***	−1.260***	−1.314***	−0.269***	−0.224***
	(0.0361)	(0.0358)	(0.0510)	(0.0594)	(0.0265)	(0.0266)
Consolidated*post	0.0103	−0.227***	0.294***	−0.0226	0.00461	−0.0887***
	(0.0240)	(0.0239)	(0.0419)	(0.0503)	(0.0223)	(0.0252)
Exposure level: top 50 percent						
Exposed	−0.606***	−1.253***	0.461***	0.710***	0.282***	0.368***
	(0.0225)	(0.0614)	(0.0363)	(0.124)	(0.0207)	(0.0453)
Consolidated	0.261***	−0.228***	0.162***	0.339***	−0.0777***	−0.0741*
	(0.0190)	(0.0483)	(0.0337)	(0.108)	(0.0187)	(0.0450)
Exposed*post	−0.319***	−0.402***	−1.007***	−1.209***	−0.217***	−0.204***
	(0.0279)	(0.0299)	(0.0454)	(0.0593)	(0.0248)	(0.0268)
Consolidated*post	−0.0104	−0.301***	0.304***	−0.102*	0.00312	−0.101***
	(0.0231)	(0.0247)	(0.0410)	(0.0532)	(0.0224)	(0.0261)
Exposure level: top 75 percent						
Exposed	−1.155***	−2.329***	−0.0499	−0.402***	0.147***	−0.0596
	(0.0210)	(0.0525)	(0.0446)	(0.111)	(0.0209)	(0.0544)
Consolidated	0.139***	−0.671***	−0.00485	−0.290***	−0.0637***	−0.258***
	(0.0184)	(0.0489)	(0.0399)	(0.112)	(0.0179)	(0.0517)
Exposed*post	−0.0306	−0.312***	−0.677***	−0.653***	−0.0842***	−0.0462
	(0.0263)	(0.0314)	(0.0549)	(0.0550)	(0.0247)	(0.0321)
Consolidated*post	−0.145***	−0.385***	0.269***	0.128**	−0.00149	−0.0368

Service line	Psychiatric		Substance abuse		Trauma	
	(0.0225)	(0.0264)	(0.0486)	(0.0524)	(0.0213)	(0.0298)
Hospital FE & drive-time interactions?	No	Yes	No	Yes	No	Yes
Sample size[b]	685,820 (discharges = 51,489)		221,029 (discharges = 16,875)		1,197,047 (discharges = 50,249)	

Notes. Choice sets are defined for the Tucson, Phoenix & Colorado markets. Separate models were estimated for each level of exposure and diagnosis. Conditional logit specification includes drive time interacted with the patient characteristics listed in Table 1 and a dummy variable indicating a partial year report of one hospital. Psychiatric specification controls for system-level agreements with psychiatric specialty hospital (Banner in 2007 and Tucson Medical Center after 2005). Sample years: 1997–1998 and 2005–2007. Robust standard errors with patient/admission clustering in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

[a] See Table 1 notes or text for definition.

[b] The sample size is the number of admissions times the number of hospitals in the patient's choice set.

Table 8

Analysis of neurosurgery utilization.

Exposure level	Top 25 percent		Top 50 percent		Top 75 percent	
Number of admissions[a]						
Exposed	34.56	−21.21	17.98	−31.97	−5.815	−69.34
	(62.97)	(45.20)	(54.30)	(34.66)	(46.33)	(47.83)
Consolidation		−98.89**		−105.0**		−105.9**
		(39.07)		(42.54)		(41.43)
Exposed*post	−1.184	−20.73	−1.481	−8.544	32.55	5.381
	(57.81)	(53.09)	(45.95)	(45.83)	(60.83)	(61.89)
Consolidation*post		−14.89		−11.33		−9.793
		(29.13)		(30.65)		(28.91)
Probability of admission[b]						
Exposed	0.269***	0.207***	0.157***	0.0911***	−0.0905***	−0.320***
	(0.0251)	(0.0233)	(0.0241)	(0.0229)	(0.0256)	(0.0266)
Consolidation		−0.349***		−0.366***		−0.503***
		(0.0218)		(0.0221)		(0.0244)
Exposed*post	0.0415	0.0249	0.0502	0.0303	0.291***	0.192***
	(0.0316)	(0.0292)	(0.0306)	(0.0290)	(0.0336)	(0.0336)
Consolidation*post		−0.295***		−0.291***		−0.217***
		(0.0277)		(0.0282)		(0.0300)

[a]Generalized negative binomial regression specification includes year*market fixed effects; hospital percent of emergency admissions; and a dummy variable indicating a partial year report of one hospital. Marginal Effects with unconditional standard errors.

[b]Conditional logit specification includes drive time interacted with the patient characteristics listed in Table 1 and a dummy variable indicating a partial year report of one hospital. Robust standard errors with patient/admission clustering in parentheses.

*** $p < 0.01$.

** $p < 0.05$.