Original Article

Does the provision of high-technology health services change after the privatization of public hospitals?

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Background: Public hospitals hold a key role in providing health care services especially to individuals without health insurance, those who are partially covered by health insurance, and low income population. However, some of these hospitals have converted to private status. The objective of this study was to assess the effect of the ownership conversion of public hospitals into private status on the provision of high-technology health services.

Methods: This study used a non-experimental longitudinal design based on merged secondary data from the American Hospital Association annual survey, the Area Health Resources File, and the Local Area Unemployment Statistics [1997–2013]. The dependent variable "high-technology health services" was measured using Saidin index. There were 492 non-federal acute care public hospitals (n=8,335 hospital-year observations) in our sample, of which 104 (21%) converted to private status (75 converted to private not-for-profit and 29 converted to for-profit hospitals). The independent variable "privatization" referred to ownership conversion from public to either private not-for-profit or private for-profit status. We ran two fixed-effects linear regressions to measure the impact of privatization on high-technology services offering.

Results: Our key findings suggested that privatization was associated with a decrease in Saidin index (β=–0.74; P=0.016; 95% CI: –1.34 to –1.38). For-profit privatization was associated with a greater decrease in Saidin index (β=–1.29; P=0.024; 95% CI: –2.41 to –0.17), compared with an insignificant decrease for not-for-profit privatization (β=–0.56; P=0.106; 95% CI: –1.25 to 0.12).

Conclusions: Given the excessive cost of high-technology health services and the change in the hospitals' mission after privatization, privatized hospitals tend to reduce the number of high-technology health services they provide.

Keywords: Public hospitals' privatization; Saidin index

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Introduction

Public hospitals are the main responsible for the delivery of health care services to everyone, regardless of ability to pay or health insurance status (1). In addition, public hospitals are expected to provide medical and allied health educations, engage in research, and administer highly specialized services regardless of profitability (2-4). However, the number of public hospitals in the United States has declined from 1,778 hospitals in 1980 to 956 hospitals in 2018 (46% decline) (5,6). One underlying cause of this decline is financial crisis, which can result in closures or privatizations of public hospitals (1,7). For instance, roughly 147 public hospitals converted to private status between 1997 and 2009; 80% (117 hospitals) became private not-for profit (NFP) and 20% [30] became private for-profit (FP) hospitals (7).

For the purpose of this study, privatization indicates hospital change of ownership from public to either NFP or FP status. It has been one of the strategic moves chosen by government entities that own public hospitals experiencing financial difficulties or in need of some financial stability (7,8). Previous research has demonstrated that privatization may result in improved financial performance (2,9-12), efficiency (2,13,14), and productivity (14). However, other studies have indicated that privatization may lead to a decline in health care quality (10,15,16) and a reduction in access to care (2,16). The improvement in financial performance and efficiency, after privatization, may adversely impact health care quality (10) as well as the provision of uncompensated care (11,17).

Changes in management and hospital mission, after privatization, may also offer an opportunity to overhaul service provision. This may include the provision of high-technology health services or clinical services that are "designed to solve certain human health problems, to improve human health conditions, or to improve the precision of diagnosis" [p13 in (18)]. These services may include specialized services, such as organ transplantation, burn care, fertility, medical/surgical/neonatal intensive care, cardiac, emergency department, cancer, neurological, and HIV-AIDS services. They also include services that require a certain level of technological innovation, such as virtual colonoscopy, shaped beam radiation system, and extracorporeal shock wave lithotripsy. Both the initial capital investment and operational cost for high-technology services can be very high and have been identified as major contributors to the escalating health care costs (19,20). However, high-technology services can also contribute to health care improvement, such as more accurate diagnostics, minimally invasive procedures, increased use of outpatient services versus inpatient hospital stay, shorter hospital stay, better health outcomes, and increased longevity (20).

Relatively few studies have explored the impact that privatization may have on the provision of high-tech services. Prior studies have found that privatized hospitals tended to terminate services that are essential but deemed unlucrative, such as trauma center (2,9), alcoholism and drug abuse therapeutic services, and HIV-AIDS services (2). However, these studies tended to explore the impact of privatization on a limited number of high-tech services. Furthermore, one study focused on privatization of public hospitals to NFP status in only three states (2) and the other study was limited to privatization data through 1998 (9).

The purpose of this study is to build on prior studies by assessing the change in the overall provision of high-technology medical services following privatization using longitudinal data from 1997–2013. Furthermore, the study uses the Saidin-index, which is a comprehensive measure of the high-technology services provided by each hospital. The measures of high-technology services included in the Saidin-index are based on previous literature that has identified these services as indicators of hospitals' high-technology capability (21-23). Finally, the study examines whether the provision of high-technology medical services differs between NFP and FP privatizations.

Conceptual framework

This study applied the agency and property rights theories. Both theories have been used to examine hospital performance after privatization (14,24). These theories explain managerial behavior based on the organization's ownership type. Public hospitals in the United States (U.S.) are the possessions of the citizens of a state, county, or city, who are represented by the federal, state, or local government and as such they directly or indirectly operate under the control of elected officials (25). Public hospitals generate financial capital from public funding in the form of tax revenues as well as tax-exempt bonds (26). Given that public hospitals receive funding from the public, their principal purpose is to meet the needs of the public by providing health care and delivering specialized services to all patients regardless of financial or health insurance status. For instance, 108 public hospitals members

of America's Essential Hospitals, which account for roughly 2% of all US community hospitals, provided 18% of all uncompensated care of the nation ($7.8 billion) in 2014 (27). While all hospital types are expected to maintain a viable financial profile, public hospitals tend not to focus on making profit only and are more likely to provide specialized services, regardless of profitability, compared with private hospitals (3). In addition, profits gained by public hospitals are usually deposited in the public treasury and not distributed among the owners and managers (25).

Private not-for-profit (NFP) hospitals are tax-exempt charities as determined by section 501 (c) (3) of the U.S. Internal Revenue Code. They are owned by faith-based or other secular organizations. Given their tax-exempt status, the NFP hospitals' mission is to provide high-quality health care, medical education, and research with a non-profit seeking motive (28). These hospitals are required to provide both compensated and uncompensated care on condition that it does not jeopardize their financial stability (29). NFP hospitals raise their capital from philanthropists' donations and tax-exempt bonds. Yet, giving donations does not guarantee the donors the right to receive excess revenues over costs, which are required to be reinvested in the hospital. In addition, the funds from the sale of the hospital cannot be given to philanthropists; they are invested in a foundation for the good of the community (28,30,31).

In contrast to NFP, for-profit (FP) hospitals are owned by investors and their primary goal is to grow investors' wealth. Taking into consideration their profit-seeking motive, FP hospitals are not exempt from property, sales, and income tax, and they are not required by law to deliver uncompensated care. Not like public and NFP hospitals, FP hospitals' shareholders are legally entitled to receive dividend and financial gain on hospital sale among themselves (28,30,31).

Agency theory explains the conflict regarding the relationship between the principal (the owner of the organization) and the agent (the manager or management team), who is hired by the principal to manage the organization. Agency theory suggests that the principal and the agent have diverging plans and objectives. The inability to converge the plans and objectives of the agent with those of the principal may result in poor organizational performance. The agent's major agenda is to achieve his or her own objectives even at the expense of the principal's objectives (24,32), and it can be challenging and pricey for the principal to oversee the agent's behavior (33). According to agency theory, and in the case of private firms, the principal can offer some financial incentives to the agent for his or her commitment to the principal's agenda. Managers of profit maximizing private firms are rewarded in term of co-ownership through stock options as they engage in strategies that improve financial performance. Managers of private not-for-profit organizations may receive some financial incentives at the discretion of the Board of Directors or "Compensation Committee", in terms of bonus, increase in annual compensation, and threat of executive turnover (34,35). Public organizations, in contrast, are constrained in their ability to use financial incentives to reward management performance. Decisions regarding compensations of public hospitals' managers are made at public meetings (36). The citizens, who are the major stakeholders of public hospitals, may be reluctant to offer generous financial compensation to managers (36). Furthermore, the relationship between the principal and the agent of public organizations is mediated by politicians, resulting in two principal-agency relationships: the relationship between the public, who is the owner (as principal) and the politicians (as agents) and the relationship between the politicians (representing the public) and the managers (as agents) (32). Politicians are powerful entities who can impose their agenda, which might facilitate their re-election, but might negatively impact performance (13,24,32). Politicians, on the other hand, do not have power to directly interfere in management practices of privately-owned organizations. Thus, the principals of private organizations are better able to align their interests and objectives with those of the agent than the principals of public organizations. Since privatization is a turn-around strategy, privatized hospitals can freely implement drastic cost reduction strategies, which may include the cessation of some high-technology services. Therefore, based on agency theory, we hypothesize that:

Hypothesis 1: *Public hospitals reduce the number of high-technology health services following privatization*.

Property rights theory (PRT) suggests that giving managers the right to make decisions regarding the use of an asset as well as ownership of the residual income is the most effective incentive for managers to make profit-maximizing decisions, which consequently increases managers' financial compensation (37,38). Private FP hospitals are profit maximizers; their primary goal is to satisfy their shareholders. Shareholders are allowed to distribute residual income among themselves and managers, as well as sell their shares to other investors if they do not get the highest rate of return on their investments (24,38). Therefore, managers

will do their best to satisfy investors by maximizing their wealth. Managers may implement cost reduction strategies such as discontinuing expensive and/or unprofitable high-technology services to increase profit. Unlike private FP hospitals, private NFP hospitals are utility maximizers. Given their tax-exempt status, private NFP hospitals are expected to meet the needs of the community. A study of the Congressional Budget Office found that NFP hospitals are more likely to provide unprofitable specialized services such as emergency room care and labor and delivery services compared with FP hospitals (29). Also, NFP hospitals are not permitted to allocate residual income among the donors, the board of directors, or the managers (24). Therefore, the managers of NFP hospitals are not as motivated as the managers of FP hospitals with respect to profit maximization. While the Chief Executive Officers of NFP hospitals are not given ownership right to the hospitals, based on financial performance, they may receive compensation based on the levels of high-technology services provided by the hospital (39). Consequently, the managers of NFP hospitals may not be as motivated as the managers of FP hospitals to aggressively cut costs by closing expensive and/or unprofitable high-technology services. Thus, according to PRT, we hypothesize that:

Hypothesis 2: *Public hospitals privatized to FP status will have a larger decrease in high-technology health services level compared with hospitals privatized to NFP status*.

Methods

Data

Our study combined three publicly available secondary data from: (I) the American Hospital Association (AHA) Annual Survey, (II) the Area Health Resources File (AHRF), and (III) the Local Area Unemployment Statistics (LAUS) from the Bureau of Labor Statistics. The AHA data file contains hospital profile variables such as ownership status, the number of hospital beds, teaching status, multihospital system affiliation, the size of the health care workforce, and the list of services provided by each hospital. The AHRF data file contains county-level demographic, health care workforce, and economic data. The LAUS data file provides unemployment rates for metropolitan areas, cities, and counties (monthly and annual estimates). The AHA data are the mostly used data for studies of US hospitals and the AHRF data are the mostly used data with respect to county-level variables. The LAUS has the complete unemployment rate data at the county level.

Sample

Our sample was comprised of all publicly owned, non-federal, community hospitals in the U.S. These hospitals were tracked each year from 1997 to 2013. Data after 2013 were not included in our study years due to the major changes in the US healthcare system after 2013. The full implementation of the Affordable Care Act (ACA), signed into law 2010, was in 2014. Some provisions of the ACA to improve access and quality of care while enhancing efficiency (as seen in Hospital value-based purchasing programs) may affect the provision of high-technology health care services. In the same vein, the Medicare Access and CHIP Reauthorization Act (MACRA), signed into law in 2015 and implemented in 2017, which involves some fundamental changes in physician reimbursement from treating Medicare patients may also affect the provision of high-technology services. Also adding more years to our study period of 17 years will lead to additional attrition of hospitals and result in smaller sample size. As we add more years to the data, the number of hospitals that have missing data, with respect to the dependent variable, increases and they need to be dropped from the sample. Our initial sample contained 1,247 public hospitals. To build our study sample, we excluded the following hospital types: hospitals that converted to a skilled nursing (n=4) or an ambulatory care organization (n=1); critical access hospitals (n=578) because they have a special Medicare reimbursement rate at 101% of reasonable costs and they are not subject to both Inpatient and Outpatient Prospective Payment Systems (40); hospitals that experienced a merger or an acquisition (n=8); hospitals with incomplete data, with respect to the dependent variable, throughout the study period (n=85); hospitals that underwent several changes in ownership status (n=32); and hospitals that closed (n=47). The final study sample included 492 public hospitals (8,335 hospital-year observations).

Measures

Dependent variable

The number of high-technology services owned by a hospital was measured using a high-technology index "the Saidin index", which was a continuous variable and consisted of the sum of the weighted binary variables from the AHA survey on facilities and services that indicated the presence

or absence of a particular high-technology service in a particular hospital (23,41). In the Saidin index, the number of services increased as new technologies become available and as these technologies were added to the AHA survey. For instance, the number of high-technology services increased from 53 in 2005 to 68 in 2010 as new technologies such as simulated rehabilitation environment, endoscopic retrograde cholangiopancreatography, and assistive technology centers were added (see Table S1). The weights indicated the rareness of a particular high-technology service and were calculated by finding the proportion of hospitals that did not possess the high-technology service (42). For instance, a weight of 0.97 in 2010 for a robot-assisted walking therapy indicates that 97 percent of the U.S. hospitals did not have this particular high-technology service in 2010; only 3% of all US hospitals provided robot-assisted walking therapy. In the denominator of the Saidin index weight calculations, all US hospitals were included because a high-technology service was rare if only a few hospitals provided that service. Thus, higher Saidin index scores indicated the use of high-tech services with a higher degree of rareness (23).

Variable "count index" was used as the dependent variable in a sensitivity analysis. Count index consisted of the total number of all high-tech services provided by a hospital in a particular year. It was a binary variable coded as "1" if the hospital provided the service in a particular year and coded as "0" if the hospital did not.

Independent variables.

For Hypothesis 1, *privatization* was a binary variable recoded as "1" if the hospital converted to private status (the year of privatization and following years were recoded as 1) and "0" if the hospital remained public (12,14). For Hypothesis 2, privatization had two dummy variables. The dummy variable "privatization to for-profit status" was recoded as "1" if the hospital converted to private for-profit (the year of privatization and following years were recoded as "1") and "0" if the hospital stayed public. The other dummy variable "privatization to not-for-profit status" was recoded as "1" if the hospital converted to private not-for-profit (the year of privatization and subsequent years were coded as "1") and "0" if the hospital stayed public (12,14,43).

Control variables

This study included organizational and environmental variables that may influence the use of high-technology medical services as control variables (44,45). Organizational variables included: hospital size, teaching status, outpatient mix, occupancy rate, Medicare mix, Medicaid mix, multihospital system membership, participation in a health network, and contract management (12,14).

Environmental variables (county level) included the following: per capita income, unemployment rate, percentage of people who were ≥65-year-old, number of active physicians per 1,000 population, yearly change in the unemployment rate, Medicare Advantage penetration, excess capacity. In addition, Herfindahl-Hirschman Index measured at the Health Service Area (HSA) level was included as a control variable (12,14). *Table 1* summarizes the operational definitions of the variables (14).

Statistical analysis

Our study used a non-experimental longitudinal design using 1997–2013 data. Cross-tabulations and ANOVAs were used to describe the data, followed by hospital and year fixed-effects linear regression models. A fixed-effects (FE) model controlled for unobservable variables that remain unchanged over time but may be associated with the independent variables and may contribute to between-hospitals variations. As such, a FE model measures within-hospital variations regarding the provision of high-technology medical services. Failing to do so may bias the results due to omitted variables (12,14,46,47). We modeled the FE linear regressions as follow (14):

(I) Hypothesis 1:

$Y_{it}= \beta_0+ \beta_{1*} Private_{it} + \beta_{2*}Control_{it} + \beta_{3*}Yeardummy + \mu_{it}$

(II) Hypothesis 2:

$Y_{it}= \beta_0 + \beta_{1*} Privateprofit_{it} + \beta_{2*} Privatenoprofit_{it} + \beta_{3*}Control_{it} + \beta_{4*}Yeardummy + \mu_{it}$ (Hypothesis 2)

Where:

- Y: dependent variable;
- β_0: intercept;
- Private: conversion from public to private status;
- Privateprofit: conversion from public to for-profit status;
- Privatenoprofit: conversion from public to not-for-profit status;
- Control: control variables (organizational and market characteristics);
- Yeardummy: year dummy variables;
- i: individual hospital;
- t: each individual year;
- μ: error term.

Our dependent variables Saidin index and count index (for sensitivity analysis) were both approximately normal,

Table 1 List of variables and operational definitions (14)

Measures	Operational definition	Data source
Dependent variable		
High-technology health services	Saidin index (index of all the high-technology services provided by the hospital)	AHA
Independent Variables		
Privatization from public to private status	Hypothesis 1—dichotomous: privatization =1, no privatization =0	
Privatization from public to either private for-profit or private not-for-profit status	Hypothesis 2—dichotomous: privatization to FP =1, no privatization to FP =0; dichotomous: privatization to NFP =1, no privatization to NFP =0	AHA
Control variables: organizational factors		
Hospital beds	Total number of beds in the hospital	AHA
Teaching status	Dichotomous: having teaching activities =1, no teaching activities =0	AHA
Outpatient mix	1 – (total inpatient days/adjusted inpatient days)	AHA
Occupancy rate	Total inpatient days/(# beds ×365 days)	AHA
Percent Medicare inpatient days	Medicare inpatient days/total inpatient days	AHA
Percent Medicaid inpatient days	Medicaid inpatient days/total inpatient days	AHA
System membership	Dichotomous: system member hospital =1, stand-alone hospital =0	AHA
Health network	Dichotomous: health network membership =1, not health network membership =0	AHA
Contract management	Dichotomous: under contract management =1, not under contract management =0	AHA
Control variables: market factors		
Per capita income	Total income in county/total number of residents	AHRF
Unemployment rate	Total number of unemployed/total number of people in the labor force	LAUS
Total physicians per 1,000 population	(Total number of active physicians/total population) ×1,000	AHRF
Yearly change in unemployment rate	Change in unemployment rate from previous year to current year	LAUS
Percent population ≥65	Total number of people ≥65/total population in the county	AHRF
Medicare managed care penetration	(Medicare managed care enrollees/total Medicare eligible) ×100	AHRF
Excess capacity	Total number of unoccupied beds in the county/total number of hospitals in the county	AHRF
Herfindahl Hirschman index (HHI)	Herfindahl index = Σ squared market share of all the hospitals in the health service area. Market share for each hospital is measured in term of total acute-care patient days for individual hospitals/the total acute-care patient days in the health service area	AHRF/AHA

Table adapted from ref (14). AHA, American Hospital Association Annual Survey; AHRF, Area Health Resources Files; LAUS, Local Area Unemployment Statistic.

based on skewness and kurtosis (48-50). None of our independent variables had multicollinearity issues. To test Hypothesis 2, the "lincom" command in STATA was used after the regression analysis on the impact of privatization to either NFP or FP status on high-technology services level. "Lincom" stands for linear combination, this command

asks STATA to compute the difference between the beta coefficients of NP and NFP privatizations and assess whether that difference is statistically significant. Software SAS 9.2. and STATA 14 were used to clean and analyze the data, respectively.

Results

One hundred and four hospitals (21%) privatized among the 492 hospitals in our study sample. Seventy five hospitals (72%) converted to NFP and 29 hospitals (28%) converted to FP status among the 104 hospitals that privatized. With regards to the 85 hospitals that did not have complete data throughout the study period and were removed from our study sample, 33% were affiliated with multihospital systems, 14% were under contract management, 17% were health network participants, and 19% were teaching hospitals. On average, the number of beds was 166, occupancy rate was 56%, and the Saidin index was 5.43.

Table 2 summarizes the descriptive statistics of our study sample by type of privatization. The Saidin index before FP privatization was the lowest (4.72) and the Saidin index after NFP privatization was the highest (11.30). Hospitals privatizing to NFP had the highest average number of beds (199). They were also more likely to be built in counties with the highest per capita income ($33,446) as well as highest Medicare Advantage penetration (16%). Hospitals privatizing to FP status had the highest percentage of hospitals affiliated with multihospital systems (71%) and highest Medicare mix (56%), but the lowest percentage of teaching hospitals (13%), the lowest Medicaid mix (18%), and the lowest occupancy rate (49%).

The results of the fixed-effects linear regressions are summarized in *Table 3*. After controlling for organizational and environmental factors, privatization was associated with a decrease in Saidin index (β=–0.74; P=0.016; 95% CI: –1.34 to –1.38). Therefore, hypothesis 1 was supported. Hypothesis 2 was partially supported; privatization to FP was associated with a greater decrease in Saidin index (β=–1.29, P=0.024; 95% CI: –2.41 to –0.17) compared with a non-significant decrease for privatization to NFP (β=–0.56; P=0.106; 95% CI: –1.25 to 0.12). However, the results from the lincom command showed that the difference in the levels of high-technology services between FP and NFP privatizations was not statistically significant (coefficient = 0.73; P=0.252; 95% CI: –0.52 to 1.99).

The results of the sensitivity analysis using count index as the dependent variable were similar to the results using Saidin index. Privatization was associated with a significant decrease in count index (β=–1.03; P=0.007; 95% CI: –1.78 to –0.285), but the effect size was greater with count index than Saidin index. In the same vein, FP conversion was associated with a larger reduction in count index (β=–1.72; P=0.015; 95% CI: –3.11 to –0.34), compared with a smaller and marginally significant decrease for NFP privatization (β=–0.80; P=0.061; 95% CI: –1.64 to 0.04). However, the results from the lincom command indicated that the difference in the levels of high-technology services for FP and NFP privatizations was not statistically significant (coefficient =0.92; P=0.245; 95% CI: –0.63 to 2.47) (Table not shown).

With respect to the control variables, the results of privatization from public to private status as well as privatizations from public to NFP and from public to FP status (*Table 3*) were quite similar. Thus, we report the results of privatizations from public to NFP and from public to FP status (hypothesis 2). Several organizational variables were positively associated with Saidin index: hospital beds (β=0.01; P≤0.001; 95% CI: 0.01 to 0.02), occupancy rate (β=4.76; P≤0.001; 95% CI: 3.68 to 5.84), percent Medicare inpatient days (β=2.94; P≤0.001; 95% CI: 1.77 to 4.107), and contract management (β=0.51; P=0.026; 95% CI: 0.06 to 0.96). The variables outpatient mix (β=–4.00; P≤0.001; 95% CI: –5.79 to –2.21) and multihospital system membership (β=–1.38; P≤0.001; 95% CI: –1.73 to –1.02) were negatively associated with Saidin index.

With respect to market variables, per capita income (β=0.11; P≤0.001; 95% CI: 0.08 to 0.15) and unemployment rate (β=0.33; P≤0.001; 95% CI: 0.25 to 0.40) were positively associated with Saidin index. The variables number of physicians per 1,000 population (β=–0.55; P≤0.001; 95% CI: –0.86 to –0.24) , yearly change in unemployment rate (β=–1.47; P≤0.001; 95% CI: –2.13 to –0.82), excess capacity (β=–0.008; P=0.006; 95% CI: –0.01 to –0.002), and HHI (β=–3.27; P≤0.001; 95% CI: –4.64 to –1.90) were negatively associated with Saidin index.

Discussion

This study assessed the effect of the privatization of public hospitals on the provision of high-technology health services. It further explored whether privatization to FP leads to a larger reduction in high-technology services delivery relative to privatization to NFP. Based on the agency theory and PRT theory and using the Saidin index to measure the overall level of high-technology services offered

Table 2 Cross-tabulations and analysis of variance (n=8,335)[a] (14)

Variable	Remained public	Public → FP	Public → NFP	P value
Dependent variable, mean/frequency (%)				
High-technology services index, Saidin index	9.58	Before FP privatization, 4.72; after FP privatization, 5.93	Before FP privatization, 6.36; after FP privatization, 11.30	<0.001[b]
Control variables: organizational Factors				
Hospital beds	197	107	199	<0.001[b]
Teaching status				
Yes	1,932 (25.94)	31 (12.55)	168 (26.21)	<0.001[b]
No	5,515 (74.06)	216 (87.45)	473 (73.79)	
Outpatient mix	0.50	0.46	0.52	<0.001[b]
Occupancy rate	0.57	0.49	0.56	<0.001[b]
Percent Medicare inpatient days	0.45	0.56	0.51	<0.001[b]
Percent Medicaid inpatient days	0.24	0.18	0.20	<0.001[b]
System membership				<0.001[b]
Yes	1,802 (24.20)	176 (71.26)	363 (56.63)	
No	5,645 (75.80)	71 (28.74)	278 (43.37)	
Health network				<0.001[b]
Yes	1,746 (29.69)	35 (25.74)	247 (47.41)	
No	4,139 (70.31)	101 (74.26)	274 (52.59)	
Contract management				0.042[b]
Yes	1.052 (16.88)	14 (9.52)	81 (15.25)	
No	5,181 (83.12)	133 (90.48)	450 (87.75)	
Control variables: market factors				
Per capita income	29,243	31,362	33,446	<0.001[b]
Unemployment rate (%)	6.41	7.67	6.52	<0.001[b]
Percent population ≥65	13.70	15.48	13.82	<0.001[b]
Total physicians per 1,000 population	2	1	2	<0.001[b]
Yearly change in unemployment rate	0.04	0.04	0.05	0.605
Medicare advantage penetration (%)	12.07	12.77	16.38	<0.001[b]
Excess capacity	60	54	59	0.047[b]
Herfindahl Hirschman index	0.79	0.82	0.80	0.309

[a], sample size and frequencies are expressed in hospital-year observations; [b], statistically significant at P≤0.05.

by each hospital, our key findings suggest that the level of high-technology services is reduced after privatization. This finding is supported by prior studies; privatized hospitals discontinue or terminate some high-technology services such as emergency rooms, trauma centers, intensive care units, and cardiac services (2,9,51). Considering the managerial flexibilities that private hospitals tend to have, it may be easier for privatized hospitals to discontinue

Table 3 Fixed effects linear regression models to test hypotheses 1a and 1b (n=8,335)[a] (14)

Variable	Saidin index from Public to Private: Hypothesis 1				Saidin index from Public to NFP, from Public to NP: Hypothesis 2			
	β	P value	95% CI	SE	β	P value	95% CI	SE
Independent variables								
Privatization from public to private	−0.74**	0.016	−1.34 to −1.38	0.31	–			-
Privatization from public to FP	–	–	–	–	−1.29**	0.024	−2.41 to −0.17	0.57
Privatization from public to NFP	–	–	–	–	−0.56	0.106	−1.25 to 0.12	0.35
Control variables: organization factors								
Hospital beds	0.01****	<0.001	0.01 to 0.02	0.001	0.01****	<0.001	0.01 to 0.02	0.001
Teaching status	0.19	0.504	−0.36 to 0.73	0.28	0.18	0.515	−0.36 to 0.73	0.28
Outpatient mix	−3.92****	<0.001	−5.71 to −2.14	0.91	−4.00****	<0.001	−5.79 to −2.21	0.91
Occupancy rate	4.79****	<0.001	3.72 to 5.82	0.55	4.76****	<0.001	3.68 to 5.84	0.55
Percent Medicare inpatient days	2.90****	<0.001	1.73 to 4.07	0.59	2.94****	<0.001	1.77 to 4.107	0.60
Percent Medicaid inpatient days	0.80	0.209	−0.45 to 2.06	0.64	0.78	0.222	−0.47 to 2.03	0.64
System membership	−1.39****	<0.001	−1.75 to −1.04	0.18	−1.38****	<0.001	−1.73 to −1.02	0.18
Health network	0.33*	0.059	−0.01 to 0.66	0.17	0.33	0.059	−0.01 to 0.66	0.17
Contract management	0.55**	0.016	0.10 to 0.99	0.23	0.51**	0.026	0.06 to 0.96	0.23
Control variables: environmental factors								
Per capita income	0.11****	<0.001	0.08 to 0.15	0.02	0.11****	<0.001	0.08 to 0.15	0.02
Unemployment rate	0.33****	<0.001	0.25 to 0.40	0.04	0.33****	<0.001	0.25 to 0.40	0.04
Percent population ≥65	−0.03	0.477	−0.13 to 0.06	0.05	−0.04	0.461	−0.13 to 0.06	0.05
Total physicians per 1,000 population	−0.55****	<0.001	−0.86 to −0.25	0.16	−0.55****	<0.001	−0.86 to −0.24	0.16
Yearly change in unemployment rate	−1.47****	<0.001	−2.13 to −0.82	0.33	−1.47****	<0.001	−2.13 to −0.82	0.33
Medicare managed care penetration	0.01	0.554	−0.01 to 0.03	0.01	0.01	0.569	−0.01 to 0.03	0.01
Excess capacity	−0.008***	0.005	−0.01 to −0.002	0.003	−0.008***	0.006	−0.01 to −0.002	0.003
Herfindahl-Hirschman index	−3.27****	<0.001	−4.64 to −1.90	0.70	−3.27****	<0.001	−4.64 to −1.90	0.70
Overall F-test	242.29****	<0.001			235.42****	<0.001		
Overall R-squared	0.57				0.57			

[a], sample size is expressed in hospital-year observations; [CI,] is confidence interval; [SE,] is standard error. *P≤0.10, **P≤0.05, ***P≤0.01, ****P≤0.001.

expensive and/or unprofitable high-technology services than for public hospitals. As providers of last resort, public hospitals are more likely to provide the services needed by the community including high-technology services. For instance, 131 public hospitals affiliated with America's Essential Hospitals own 42% of all the U.S. burn care beds, 34% of level one trauma centers, and 25% of pediatric intensive care beds (4). In addition, privatized hospitals may have a greater independence choosing the kind of high-technology services to provide than public hospitals.

Furthermore, our finding suggests that FP privatization is more likely to be associated with a greater reduction in high-technology services offering, compared with a non-significant reduction after NFP privatization. Since managers of FP hospitals face a greater pressure to maximize profit than NFP hospitals and are better compensated based on hospital's financial performance than managers of NFP hospitals, they may focus on closures of some high-technology services based on financial gain, patient mix, and physician staffing (51). Furthermore, NFP hospitals may have greater pressures from medical staff to keep high-technology services than FP hospitals. Therefore, managers of NFP hospitals may be reluctant to drastically reduce the high-technology services provided by the hospitals (39).

We also found some associations between the control variables and the Saidin index. Hospitals that increase in size and experience growth in occupancy rate and Medicare inpatient days are associated with increased provision of high-technology services. Large hospitals and those with higher occupancy rate may have excess resources to invest in high-technology services and the ability to generate economies of scale that allow them to provide high-technology services. Similarly, hospitals that experience growth in Medicare inpatient days are more likely to experience revenue growth, which will allow them to invest in high-tech services. Medicare patients tend to have multiple comorbidities and severe medical conditions. Therefore, hospitals may need to invest in high-technology services to meet the needs of Medicare patients.

Becoming affiliated with a multihospital system is associated with a reduction in high-technology services. Multihospital systems may have some restrictions in the provision of high-technology services to ensure the financial health of its members and the system. Multihospital systems may also coordinate the provision of these services to achieve economies of scale, especially if system hospitals are in the same market.

Managerial implications

While a reduction in high-technology services provision, after privatization may be a good strategy to reduce expenditures and improve the financial outlook of the hospital, a thorough assessment of the choice of high-technology services to discontinue is important. Such choice should be based on the needs of the population and the cost-effectiveness of the technologies to ensure that patients have adequate access to the needed services without causing financial stress to hospitals. Some technologies may be highly advanced and costly, and yet the marginal improvements in health care process and outcomes may be minimal. Conversely, privatized hospitals may assess the availability of high-technology services to the community and decide to close those services that are already provided by other facilities to avoid service duplication. This may contribute to overall efficiency at the community level (52). Also, involving physicians in decisions to cut high-technology services is important since they are the key providers. Outsourcing high-technology services to other nearby facilities may also be a better alternative to closing those services.

Policy implications

City, county, or state governments that plan to privatize their public hospitals may need to conduct some preliminary studies on provision of high-tech services, after privatization, to ensure continuity of needed services, without imposing a financial burden to the hospital. Community health needs assessment coupled with cost-benefit analysis and comparative effectiveness studies may help all parties involved in deciding which high-technology services to discontinue. A tight monitoring of public hospital privatization is important to ensure continuity of needed high-technology services.

Limitations

This study has some limitations with respect to the data. First, our Saidin index measure failed to include the availability of high-technology services in non-hospital settings (such as imaging centers and hemodialysis clinics) because the AHA data file only included high-technology data among all hospitals. The inclusion of high-technology

data from outpatient settings may improve Saidin index value (23). Second, we were not able to assess whether privatized hospitals referred their patients to other hospitals or stand-alone clinics after they discontinued the service. The elimination of some services may not dramatically impact access if privatized hospitals outsource those services to stand-alone specialty clinics or health centers. Third, the results from this study are not generalizable to critical access hospitals since they were excluded from this study. Given the different Medicare reimbursement policy for critical access hospitals, they need to be studied as separate entities from non-critical access hospitals.

Fourth, we were not able to assess the availability of high-technology services at the population level, after privatization. Future studies are needed to investigate the effect of public hospital privatization on the level of high-technology services offered to the population. Finally, we were not able to compare our findings with the findings of comparable empirical studies using data from other countries. Since privatization of public hospitals is a global phenomenon, empirical studies assessing its impact on the provision of high-tech services in other countries are greatly encouraged.

Conclusions

The key findings from this study suggest that privatization is associated with decreased use of high-technology services, especially for FP conversion. Due to the prohibitive price of high-technology services and the change in hospital's mission after privatization, privatizing hospitals tend to cut the provision of high-technology health services.

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Footnote

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Supplementary

Table S1 High-tech services and Saidin index weights for select years

High-tech Services	1997	2000	2005	2010	2014
Lung transplant			99%	99%	99%
Proton beam therapy				98%	98%
Liver transplant			98%	98%	98%
Heart transplant			98%	98%	98%
Pediatric cardiac surgery -			97%	97%	97%
Burn care	97%	98%	97%	97%	97%
Pediatric diagnostic catheterization			96%	97%	97%
Robot-assisted walking therapy				97%	97%
Pediatric cardiac electrophysiology				97%	97%
Bone Marrow transplant services			97%	97%	97%
Kidney transplant			97%	96%	97%
Intraoperative magnetic resonance imaging				97%	96%
Fertility Clinic			95%	96%	96%
Other Transplant			97%	96%	96%
Blood Donor Center			94%	95%	95%
Freestanding/Satellite Emergency Department			98%	95%	95%
Electron Beam Computed Tomography (EBCT)			95%	95%	95%
Tissue transplant			97%	95%	94%
Pediatric intensive care	93%	93%	92%	93%	93%
Other intensive care		94%	92%	92%	91%
Neonatal intermediate care	90%	90%	89%	89%	89%
Computer assisted orthopedic surgery			94%	90%	88%
Genetic testing/counseling			93%	90%	88%
Other special care	88%	90%	89%	89%	88%
Virtual colonoscopy			92%	88%	87%
Positron emission tomography (PET)	97%	95%	89%	89%	87%
Stereotactic radiosurgery			90%	87%	86%
Shaped beam Radiation System			89%	87%	85%
Neonatal intensive care	87%	87%	85%	85%	84%
Positron emission tomography/CT (PET/CT)			92%	86%	84%
Assistive technology center				88%	83%
HIV-AIDS services	72%	75%	81%	82%	83%
Image-guided radiation therapy			94%	86%	83%
Esophageal impedance study				86%	82%
Adult cardiac surgery			83%	82%	82%
Intensity-Modulated Radiation Therapy (IMRT)			87%	83%	82%
Ablation of Barrett's esophagus				85%	81%
Electrodiagnostic services				84%	80%
Ambulatory surgery center				81%	80%
Simulated rehabilitation environment				83%	80%
Cardiac intensive care	71%	74%	76%	79%	80%
Extracorporeal shock waved lithotripter (ESWL)	90%	86%	83%	80%	80%
Robotic surgery			96%	87%	80%
Adult cardiac electrophysiology				81%	78%
Hemodialysis		83%	78%	77%	77%
Adult interventional cardiac catheterization			79%	77%	75%
Endoscopic ultrasound				78%	74%
Certified trauma center	84%	77%	77%	75%	73%
Single photon emission computerized tomography (SPECT)	75%	74%	73%	72%	72%
Adult diagnostic catheterization			73%	72%	71%
Endoscopic retrograde cholangiopancreatography (ERCP)				71%	69%
Multi-slice spiral computed tomography 64 + slice			91%	71%	64%
Neurological services			67%	64%	64%
Chemotherapy			62%	62%	62%
Adult cardiology services				66%	62%
Cardiac Rehabilitation			63%	62%	61%
Diagnostic radioisotope facility	56%	55%	58%	59%	59%
Full-field digital mammography			90%	67%	58%
Multislice spiral computed tomography < 64 slice			64%	57%	58%
Medical/surgical intensive care	47%	47%	52%	53%	54%
Optical Colonoscopy				58%	52%
Magnetic resonance imaging (MRI)	66%	61%	57%	52%	51%
Breast cancer screening/mammograms	43%	42%	47%	48%	48%
Airborne infection isolation room			51%	45%	41%
Outpatient surgery	33%	33%	38%	39%	41%
Ultrasound	37%	36%	39%	39%	40%
Emergency Department	32%	31%	36%	37%	39%
Computed-tomography (CT) scanner	40%	37%	39%	38%	38%
Radiology therapeutic	81%	80%			
Number of high-tech services	20	22	53	68	68
Number of hospitals used to calculate the weights	6299	6044	6349	6334	6239

The table was sorted by 2014 weights from highest to lowest.

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