Journal of Clinical Anesthesia 46 (2018) 67–73

Contents lists available at ScienceDirect

Journal of Clinical Anesthesia

Original Contribution

Hospitals with greater diversities of physiologically complex procedures do not achieve greater surgical growth in a market with stable numbers of such procedures

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ARTICLE INFO

Article history:
Received 14 November 2017
Received in revised form 22 December 2017
Accepted 4 January 2018
Available online xxxx

ABSTRACT

Study objective: Although having a large diversity of types of procedures has a substantial operational impact on the surgical suites of hospitals, the strategic importance is unknown. In the current study, we used longitudinal data for all hospitals and patient ages in the State of Florida to evaluate whether hospitals with greater diversity of types of physiologically complex major therapeutic procedures (PCMTP) also had greater rates of surgical growth.
Design: Observational cohort study.
Setting: 1479 combinations of hospitals in the State of Florida and fiscal years, 2008–2015.
Measurements: The types of International Classification of Diseases, Ninth revision, Clinical Modification (ICD-9-CM) procedures studied were PCMT, defined as: a) major therapeutic procedure; b) >7 American Society of Anesthesiologists base units; and c) performed during a hospitalization with a Diagnosis Related Group with a mean length of stay ≥4.0 days. The number of procedures of each type of PCMTP commonly performed at each hospital was calculated by taking 1/Herfindahl index (i.e., sum of the squares of the proportions of all procedures of each type of PCMTP).
Main results: Over the 8 successive years studied, there was no change in the number of PCMTP being performed (Kendall's $\tau_b = -0.014 \pm 0.017$ [standard error], $P = 0.44$; $N = 1479$ hospital × years). Busier and larger hospitals commonly performed more types of PCMTP, respectively categorized based on performed PCMTP ($\tau = 0.606 \pm 0.017$, $P < 0.0001$) or hospital beds ($\tau = 0.524 \pm 0.017$, $P < 0.0001$). There was no association between greater diversity of types of PCMTP commonly performed and greater annual growth in numbers of PCMTP ($\tau = 0.002 \pm 0.019$, $P = 0.91$; $N = 1295$ hospital × years). Conclusions were the same with multiple sensitivity analyses. Post hoc, it was recognized that hospitals performing a greater diversity of PCMTP were *more* similar to the aggregate of other hospitals within the same health district ($\tau = 0.550 \pm 0.017$, $P < 0.0001$).
Conclusions: During a period with no overall growth in PCMTP, hospitals with greater diversities of types of PCMTP had growth that was, at most, minimally larger than that of the smaller hospitals, and vice-versa. Diversity is important operationally. From the perspective of delivering surgical care within a market, the unique contributions of each large teaching hospital performing many different types of PCMTP needs to be considered relative to the combined capabilities of other hospitals in its region.

1. Introduction

Having a large diversity of types of procedures has a substantial operational impact on hospitals' surgical suites [1,2,3,4,5,6,7,8,9,10,11,12]. At hospitals with substantial diversity, unless validated statistical methods suitable for rare events are used, anesthesiologists work with inaccurate predictions of surgical blood usage, case durations, cost accounting and price transparency, times remaining in late running cases, and use of intraoperative equipment [1,2,3,4,5,6,7,8,9,10,11,12].

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https://doi.org/10.1016/j.jclinane.2018.01.005
0952-8180/

The impact of diversity of types of procedures on growth rates of procedures is unknown.

Recently, we performed studies of the diversity of surgical procedures; one using data from the United States (US) and the other from Ontario, Canada [13,14]. In each, we relied on the definition of a *physiologically complex* procedure as having >7 American Society of Anesthesiologists base units [15,16,17,18]. For example, the partition between 7 and 8 base units excludes International Classification of Diseases, Ninth revision, Clinical Modification [ICD-9-CM] code 51.23 "laparoscopic cholecystectomy," but includes 57.71 "radical cystectomy" and 52.7 "radical pancreaticoduodenectomy" ("Whipple procedure"). The partition was done similarly using the Ontario Health Insurance Plan (OHIP) Schedule of Benefits' basic units [14,19]. The diversity of types of physiologically complex procedures performed at the hospitals was quantified using the relative proportions of such procedures of each code at each hospital [20]. The sum of the squares of the proportions was each hospital's Herfindahl index [20]. The Herfindahl index equals the probability that any two procedures selected at random, with replacement, from a list of all procedures performed at the hospital were of the same type (i.e., same ICD-9-CM code). The inverse of the Herfindahl is the *"number of procedures of each type of procedure performed commonly"* at a hospital [20]. The types of physiologically complex procedures commonly performed differed among hospitals [21]. Each increase in the number of different types of procedures commonly performed can be associated, in a monotonic fashion, with an increase in the inverse of the Herfindahl [20,22,23,24]. For example, a large teaching [25] hospital performed 4584 physiologically complex procedures in a year, of 274 different types of procedures; 78.1 ± 1.8 (standard error) types were performed commonly [13]. A small non-teaching [25] hospital performed 97 physiologically complex procedures that year, of 5 different types of procedures; 2.0 ± 0.2 types were performed commonly [13]. There are several tutorials online that explain further this measure of diversity [26,27,28,29].

In the recent US study, there were data from 1981 hospitals nationwide [13]. Approximately half the hospitals commonly performed fewer than 10 types of physiologically complex procedures (54%, lower 99% confidence limit 51%) [13]. However, there was a substantive percentage (14%) of hospitals with >3-fold larger diversity [13] including 80% of the country's large teaching hospitals (lower 99% CL 72%) [13]. The implication is that the usefulness of statistical methods for operating room management [1,2,3,4,5,6,7,8,9,10,11,12] should be expected to be heterogeneous among hospitals, and especially useful for large teaching hospitals. A subsequent question was whether large diversity makes hospitals indispensable to their health districts, resulting in faster growth. Because the study analyzed only 1 year of data, we could not add a longitudinal assessment [13].

In the other study, 8 years of longitudinal data from all hospitals in Ontario were used to quantify non-physiologically complex and physiologically complex pediatric procedures [14]. Whereas there was no substantive change in the annual numbers of non-physiologically complex procedures province wide (Kendall's $\tau_b = -0.071$, $P = 0.91$; $N = 8$ years), there were reductions in numbers of physiologically complex procedures ($\tau = -0.857$, $P = 0.0017$), necessarily affecting the 4 pediatric specialty hospitals [14]. However, those hospitals still grew their total annual numbers of procedures ($\tau = 1.000$, $P < 0.0001$) because they performed a progressively greater percentage share of the province's non-physiologically complex procedures ($\tau = 1.000$, $P < 0.0001$) [14]. What we could not learn from that study was what would have happened to the distribution of physiologically complex surgery among the pediatric hospitals if they had been close to one another (e.g., within same health district), because, whereas physiologically complex surgery is performed at many hospitals for adult patients, there are only a few such hospitals for children [18,30].

In the current study, we used longitudinal data for all hospitals and patient ages in the State of Florida to evaluate whether hospitals with greater diversity of types of physiologically complex procedures also have greater rates of growth in such types of surgery.

2. Methods

2.1. State of Florida data

This retrospective observational study cohort was performed using de-identified data licensed from the State of Florida. Work was performed following a data use agreement dated May 18, 2017 with the State of Florida, Agency for Health Care Administration, Florida Center for Health Information and Transparency.

The data used for each hospital discharge in the State of Florida were hospital, fiscal year, Medicare Severity Diagnosis Related Group, and all ICD-9-CM procedure codes (Table 1) [31,32,33,34,35,36]. The dates studied were fiscal years 2008 through 2015 (i.e., 4th quarter of 2007 through the 3rd quarter of 2015). The types of procedures each accounting for at least 1.00% of the physiologically complex major therapeutic procedures *(PCMTP)* are listed in Table A of the supplemental digital content.

From the State of Florida's Agency for Health Care Administration, we obtained for each hospital 3 independent variables as of 2013: health district, hospital beds, and statutory teaching status [37]. The districts are used for local health councils to assist in health care planning [38,39,40]. From the State of Florida's Department of Health's Office of Health Statistics and Assessment, we obtained the annual population for each county, and from that the population within each health district [41].

Calculation of these counts for each combination of hospital, fiscal year, and type of PCMTP were performed using SQL Server (Microsoft, Redmond, WA). The starting year was chosen based on availability as part of the data use agreement. The final fiscal year was chosen because the US changed the method of classifying surgical procedures effective the 1st day of the 2016 fiscal year.

2.2. Quantities calculated for each combination of hospital and fiscal year

Calculations were performed for each combination of hospital and fiscal year that had at least 7 PCMTP performed that year. The standard errors for the independent variable of diversity were impractically large otherwise (see below). We studied $N = 1479$ hospital years, where $1479 = 201$ hospitals × 8 years - (129 such combinations with fewer than 7 PCMTP performed during the year). The distributions of these variables are summarized in Table 2. Excel 2010 and Visual Basic for Applications were used to perform these calculations (Microsoft, Redmond, WA).

- For each hospital, the difference was taken between successive fiscal years in the total number of PCMTP. This was one of the two dependent variables for inferential analysis. The difference was attributed to the first of the two successive years, to be related in the analysis to the diversity of types of PCMTP during that first year.
- For each hospital, the difference was taken between successive fiscal years in the number of discharges with at least one PCMTP. This was the second of the two dependent variables.
- For each hospital and fiscal year, the increase in the population of the hospital's health district was calculated. Population statistics were based on calendar year, while Medicare severity diagnosis related groups were based on fiscal year. Because the 2009 fiscal year has 3 months in 2008 and 9 months in 2009, and so forth for other fiscal years, the population during calendar year "2009" was attributed to the fiscal year "2009."
- For each hospital and fiscal year, the Herfindahl-Hirschman index of the numbers of PCMTP was calculated for the district [42,43,44]. The Herfindahl-Hirschman index is calculated as the sum of the squares of the proportions of all PCMTP in a district accounted for by each