CLINICAL ENGINEERING BENCHMARKING: A Preliminary Analysis of Clinical Engineering Data in American General Acute-Care Hospitals

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INTRODUCTION

Almost since the creation of clinical engineering (CE), professionals in this field have been struggling to find suitable metrics to measure their performance, as well as for benchmarking their performance against others. Several reports were published in the late 1980's discussing suitable metrics for benchmarking productivity and cost effectiveness across North America and elsewhere (see, e.g., David & Rohe, 1986; Furst, 1986; Bauld, 1987; Johnston, 1987; Frize, 1990a and 1990b). These studies laid the foundations for the formation of a Benchmarking Validation subcommittee within the Association for the Advancement of Medical Instrumentation. This subcommittee collected data from 13 hospitals in two consecutive years and concluded the only consistent and reliable metric is the "service costs/acquisition cost" ratio (Cohen, 1997; Cohen, 1998).

In the meanwhile, financial and operational benchmarking in general has advanced considerably in healthcare organizations. It is rare today to find a healthcare executive who does not base his/her decisions on some benchmarking data, even though the CE community continues to question the validity of the metrics chosen or the notion of benchmarking itself (Mahachek, 1996; Stiefel, 1997).

This article reports an attempt to analyze data collected from a large number of American general, acute-care hospitals with the goal of detecting metrics that could serve as reasonable benchmarking indicators across institutions. It must be stressed that the results presented here should not be considered benchmarks against which individual CE departments can compare themselves. As described in the materials and methods section below, the data are not as accurate and consistent as one would desire, and no data validation was performed. The basic objective here is only to find promising paths to be followed with better controlled studies.

MATERIALS AND METHODS

The data analyzed were obtained from Solucient LLC, an information products company that provides tools for healthcare managers to improve their organizations' performance. The product used was the Action O-I® database which has approximately 850 subscribers. This is the result of a merger of two databases: MECON developed by the University Hospital Consortium and HBSI. The data extracted was for the fiscal year that ended by the second quarter of 2005.

In this query period, only 187 Action O-I® subscribers provided CE data. Of these, 13 were excluded because they are not general, acute-care hospitals. Therefore, only 174 sets of CE data were analyzed. Forty-six hospitals identified themselves as "major teaching" (typically >400 beds), 8 as "minor teaching," 36 as "non-teaching," while 84 did not indicate their teaching profile.

Each data set consists of dozens of "measures." These "measures" can be divided into three groups: (i) primary data provided by the hospitals, e.g., numbers of capital devices maintained, scheduled and unscheduled maintenance orders completed; (ii) secondary data calculated from the primary data, e.g., expense/100 devices maintained, expense/bed served; and (iii) operational characteristics, e.g., maintain CT scanners, perform capital equipment procurement, and responsible for radiation safety. Furthermore, each hospital provided data for its entire facility (e.g., patient discharges, operating costs, beds licensed, etc.). All these data were provided anonymously (i.e., the name and address of the hospitals are not known to the authors).

Because it was impossible to analyze the large amount of data in detail, a decision was made to analyze only the primary data and focus on the indicators previous publications suggested, as well as some others the authors believed to be potentially useful based on their personal experiences. Some of the traditional metrics used in most CE programs (e.g., PM completion rate, repair turnaround time, and a clinical user satisfaction survey) are not available from Action O-I®, thus not analyzed.

This study considered but did not limit itself to the indicators analyzed by Cohen et. al (1995). On the other hand, the five characteristics of a good indicator proposed in that study (i.e., well defined, objective, measurable, based on current knowledge and experience, and valid) were adopted. In particular, the "validity" was measured by calculating the statistical correlation coefficient (CC) between the two sets of data in question. CC was calculated using Microsoft Excel®. Only certain indicators that yielded CC above 0.65 are presented here.

The main reason for accepting such a low correlation coefficient is that the data contain numerous obvious errors and inconsistencies. Some of those errors could be simply typos, while others could be misinterpretation of the instructions or terminology (Solucient, 2005). Due to the anonymous nature of the data, it was not possible to validate the data or make corrections. So a decision was made to keep all data, even when there were questions to their validity. The only data editing made was the replacement of zeros with blank space within Microsoft Excel® spreadsheets. This was required because it was necessary to use logarithmic scales in the figures to allow visibility of the wide range of data (several orders of magnitude). A distinct disadvantage of using a logarithmic scale is the visual compression of the data, often making the data appear more compact than when plotted on a linear scale. Because of data impurities, no further statistical calculations were made; instead, arbitrary straight lines were drawn to assist visual interpretation.

RESULTS

Technology Adoption Indicators

Hospital administrators often use beds and patient discharges as the yardsticks for a hospital's capacity and output. Using these as "denominators," two indicators emerged as promising. Figure 1 shows the number of capital devices (defined as devices with purchasing cost >$500) as a function of staffed beds (not licensed beds). With the exception of the largest major teaching hospitals, most have approximately 13 capital devices/bed. Figure 2 shows the total cost of capital devices (at acquisition time) as a function of total patient discharge. Each patient discharge apparently requires hospitals to invest about $3,000 in capital equipment.

Financial Indicators

As mentioned before, Cohen (1997 & 1998) concluded that the "only published cost metric that statistically yields high correlation" is the "service costs/acquisition cost" ratio. Figure 3 shows Action O-I® data fall close to the Cohen data and the 4% line but the scatter is much greater. Attempts were also made to correlate total CE expense with the number of staffed beds and capital devices. Both yielded CC around 0.65. Similar CC values were also obtained when relating total CE expense to patient discharges adjusted for outpatient care and case-mix index.

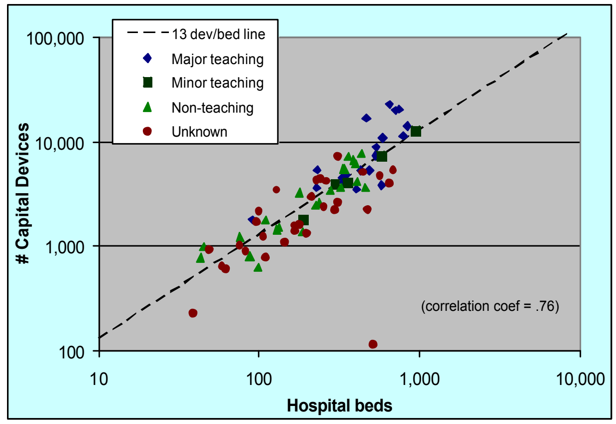

Figure 1 - Number of capital devices versus staffed beds. CC = 0.76.

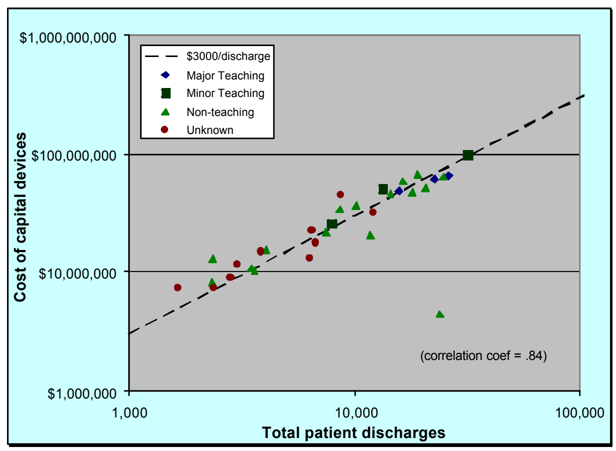

Figure 2 - Total cost of capital devices (at acquisition time) versus total patient discharge. CC = 0.84.

A seldom-studied indicator is the relation between total CE expense and the hospital's total operating expense. Figure 4 shows most hospitals spend about 1% or less of their operating budget on CE.

Operational Indicators

Figure 5 shows the amount of unplanned repairs is approximately once per year for most hospitals. Obviously, this "global failure rate" masks significant variability amount different types, brands and models of equipment. Some devices may have failed multiple times, while others never failed in a single year.

Figure 6 shows that typically about 2.6 FTEs are being utilized by hospitals for every 100 staffed beds. It should be clarified that FTE is not a head count, as it is calculated from the amount of paid work hours. In other words, FTE includes overtime and disregards unpaid sick leave. As figure 1 shows each bed is normally indicative of 13 capital devices, each CE FTE is, therefore, typically responsible for about 520 pieces of equipment.

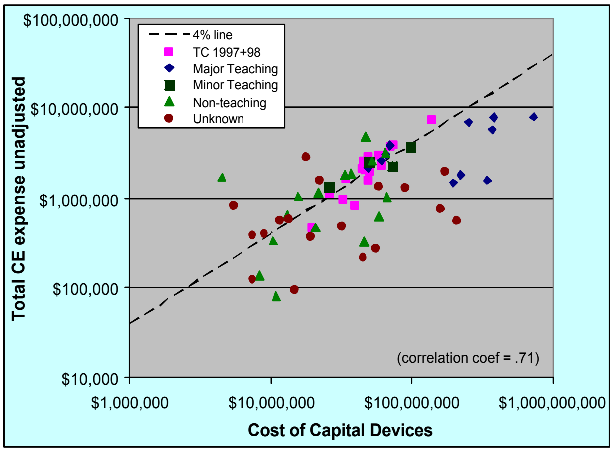

Figure 3 - Total CE expense versus total cost of capital devices (at acquisition time). CC = 0.71.

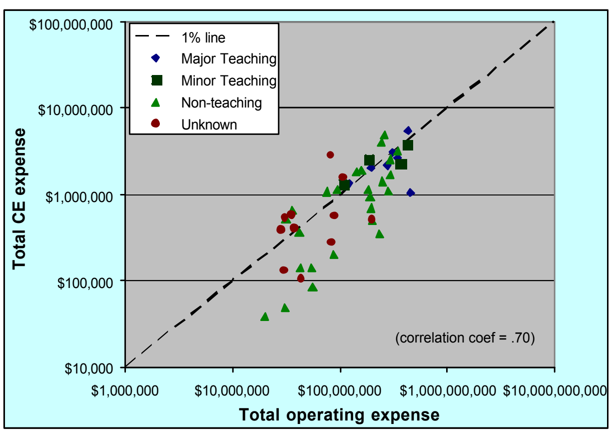

Figure 4 – Total CE expense versus total hospital operating expense. CC = 0.70.

DISCUSSIONS

It is interesting to see hospitals of widely different capacities and outputs have similar technology incorporation patterns. It is unclear how much of this pattern is traceable to actual patient need and standard of care, as compared to financial constraints imposed by reimbursement models. Although major teaching hospitals have not deviated very significantly from others in most indicators, the former clearly tend to acquire some more devices and, more importantly, the most-sophisticated, higher-cost models of the same devices (e.g., 64 instead of 16-slice CT scanner). This fact accounts for the segregation seen on figures 1 and 3.

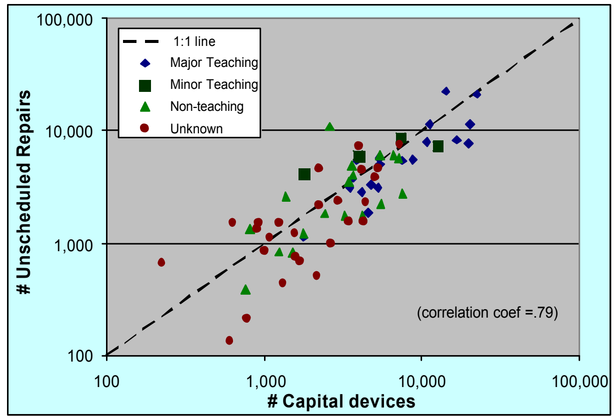

Figure 5 – Global failure rate, i.e., the total number of unscheduled repairs versus total number of capital devices. CC = 0.79.

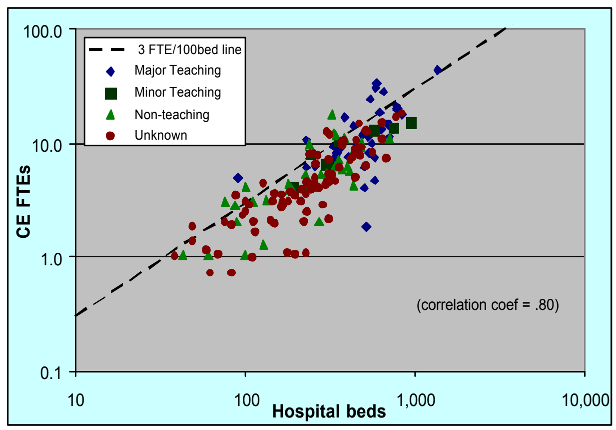

Figure 6 – Number of full-time-equivalent (FTE) CE employees versus the number of hospital beds. CC = 0.80.

Readers familiar with Cohen studies (1997 & 1998) may be disappointed to see here a much weaker correlation than what was reported (CC = 0.98), even considering their sample size was much smaller. Opponents of benchmarking probably feel vindicated by the data scatter caused by obvious errors and inconsistencies. Optimists, on the other hand, would conclude controlled studies could significantly increase the CC of promising indicators. Regardless, it is clear that no one should expect such broad based indicators to achieve precise benchmarks; only ballpark comparisons are meaningful.

More pertinent to CE professionals is the finding that their budget is ~1% or less of the hospital's total operating budget. This may help explain why financially pressed C-level executives seldom pay attention to this area. On the other hand, it also points out that CE's impact to the organization's revenue is actually 100 times its cost. This fact should be considered in all CE activity planning and execution, and could be a useful argument in budget discussions.

While the global failure rate of once per year confirms a previous report (Eliason et al., 2005), it should be noted that they also reported this indicator only applies to biomedical equipment, not to imaging or laboratory equipment. Likewise, other indicators should not be extended without proper caution, as they often agglutinate a large number of factors.

The relationship between FTE and measures such as beds or number of devices is likely to be very controversial. It is notorious that staff tended to "pad" their timesheets when they realize they are expected to account for a certain amount of worked hours. This suspicion was verified by our finding that the amount of hours worked is essentially independent of the number of work orders completed. It is clear that more objective indicators need to be developed for studying productivity.

Because of data quality issues, it is possible that some good indicators were missed in this study, just like global failure rate eluded Cohen in his studies (1997 & 1998). Furthermore, as pointed out earlier, many of the traditionally used CE indicators are not available from Action O-I®. Therefore, readers should not interpret the few indicators hereby reported as promising as the only ones that should be used for benchmarking. Actually, a much more diverse set of measures such as those advocated by Kaplan & Norton (1996) in their Balanced Scorecard model should be considered for a comprehensive assessment of the performance of a CE department.

As Cohen (1997 & 1998) reported, it is unlikely that it will be possible to congregate enough CE volunteers to contribute to a large-scale study. Perhaps an alternative approach would be for each CE department to work more closely with its respective organization's benchmarking liaison so more accurate and consistent data are provided to the benchmarking companies chosen by their organization. At the same time, CE professionals can assist benchmarking companies to collect meaningful data in a consistent manner. Ultimately, the CE community can have benchmarking that will benefit itself, as well as the healthcare industry.

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