Estimating Lives and Dollars Saved from Universal Adoption of the Leapfrog Safety and Quality Standards:

2008 Update

By

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Prepared for The Leapfrog Group, Washington, DC

Sept. 23, 2008

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Introduction

This report reviews recent evidence around lives and dollars saved from the first three Leaps, i.e., evidence-based advancements in hospital care initiated by The Leapfrog Group. Previous studies commissioned by The Leapfrog Group have estimated numbers of lives and dollars saved based on literature as of 2005 regarding the first three recommended safety and quality practices or Leaps: computerized physician order entry (CPOE), ICU (intensive care unit) physician staffing (IPS), and evidence-based hospital referral (EBHR). Research by Birkmeyer and Dimick (2004) showed that up to 65,400 lives could be saved and as many as 907,600 serious medication errors could be prevented each year if these three original Leaps were implemented in every non-rural hospital in the U.S. Conrad and Gardner (2005) estimated that $41.5 billion could be saved annually from implementing these practices universally. This report uses major updates the literature from key journals and data bases through mid 2008 regarding the efficacy of these Leaps to update the estimates of lives saved and dollars saved.

The Leapfrog Group defines these Leaps as follows:

Computerized Prescriber Order Eentry (CPOE): CPOE systems are electronic prescribing systems that intercept errors when they most commonly occur — at the time medications are ordered. With CPOE, physicians (prescribers) enter orders into a computer rather than on paper. Orders are integrated with patient information, including laboratory, patient demographics, and prescription data. The order is then automatically checked for potential errors or problems.

ICU Physician Staffing (IPS): A growing body of scientific evidence suggests that quality of care in hospital ICUs is strongly influenced by (i) whether "intensivists" are managing care, and (ii) how the rest of the staff is organized in the ICU. Intensivists are familiar with the complications that can occur in the ICU and, thus, are better equipped to minimize errors. Leapfrog defines intensivists as either:
1. Board-certified physicians who are additionally certified in the subspecialty of critical care medicine, or
2. Physicians board-certified in emergency medicine who have completed a critical care fellowship in an ACEP accredited program, or
3. Physicians board-certified in Medicine, Anesthesiology, Pediatrics or Surgery who completed training prior to the availability of subspecialty certification in critical care and who have provided at least six weeks of full-time ICU care annually since 1987.
Neurointensivists are an approved alternative to intensivists in providing care in neuro ICUs.

Evidence-Based Hospital Referral (EBHR): Hospitals fulfilling the EBHR Safety Standard will meet the hospital volume criteria, and those performing bariatric surgeries will also meet surgeon volume criteria for bariatric surgeries as shown in Table 1 below. Hospitals that do not meet these criteria but adhere to the Leapfrog endorsed process measures for coronary artery bypass graft surgery, percutaneous coronary intervention, abdominal aortic aneurysm repair, and care for high-risk neonates, will receive partial credit toward fulfilling the EBHR Safety Standard.

Table 1: Leapfrog recommended annual hospital volumes and recommended annual surgeon volume

Procedure	Hospital volume / surgeon volume (where applicable)
1. Coronary artery bypass graft	≥ 450
2. Percutaneous coronary intervention	≥ 400
3. Abdominal aortic aneurysm repair	≥ 50
4. Aortic valve replacement	≥ 120
5. Pancreatic resection	≥ 11
6. Esophagectomy	≥ 13
7. Bariatric surgery	>125 / 50
High-risk delivery: - Expected birth weight < 1500 grams, - Gestational age < 32 weeks, or - Pre-natal diagnosis of major congenital anomaly	Neonatal ICU with annual count of very-low-birth-weight babies ≥50

Methods

Literature review

Our approach entailed identifying relevant articles published since the previous Leapfrog reports, and conferring with experts in the field. To identify key relevant literature, we first adapted the search algorithms from previous systematic reviews. The key words of the search algorithms were based on Eslami et al.,(2007) for CPOE, and Halm et al.(2002) for EBHR.

For the IPS leap , we mainly used the "related article" feature of Pubmed to find new articles related to Pronovost's financial modeling (Pronovost et al., 2004), and Young's estimate of potential reductions in mortality rates (Young et al., 2000). We used "related articles" again to find publications concerning these newly identified articles. We identified additional articles through key words from these publications such as "cost and lives saved" and "intensivist to patient ratio."

For these searches, we accessed ten databases related to fields in health and medicine, including Pubmed, BioMed Central Journals, and JSTOR Health Policy. In accordance with our objectives, we limited the review to original studies. We further limited the search to articles written in English. To work within the time constraints of this project, we used the feature of "sort by relevance" to make the most relevant articles appear first in the output of the search results. For all Leaps, we also identified articles from the bibliographies of key articles.

The focus of our literature search was on articles published after those already reviewed by the Leapfrog Group. In addition to electronic literature searches, we conferred with members of the Leapfrog Group advisory group to ensure that we had all key articles, including ones not yet indexed in the electronic databases. [1]

Computerized prescriber order entry

Costs of CPOE are incurred at the start to install the system and train personnel, and annually for the time, training, and maintenance to use and update the system. Benefits occur because CPOE avoids treatment of adverse drug events and may avoid unnecessary expensive treatments. The cost attributed to adverse drug events are measured in terms of additional length of stay resulting from related injures.

To estimate the economic benefits to the US health care system in terms of dollars from implementation of CPOE, we began with the clinical baseline and financial impact study done for Massachusetts by a partnership among the Massachusetts Technology Collaborative, the New England Health Care Institute, David W. Bates, MD, MSc, and PricewaterhouseCoopers, LLP (Adams et al., 2008). We assumed that a CPOE system would have a useful life of 5 years, the period shown in the table by Adams et al. (2008). At the end of this period, the system was assumed to be obsolete and would require replacement. We annualized this study's potential costs and benefits for a typical hospital over the assumed five-year life cycle for CPOE, applying the recommended three-percent discount rate for estimating the potential costs and benefits at their present value[2] (Gold et. al, 1996). For national extrapolations, we used an estimate of the Agency for Health Care Research and Quality (AHRQ) for measuring the additional length of stay resulting from an adverse drug event. We calculated the national number of admissions based on the admission rate per population (using Table 166 of the Statistical Abstract, 2008), times the size of the US population (using Table 6 of the Statistical Abstract, 2008).

ICU physician staffing

The health benefits (lives saved) of staffing an ICU with intensivists are based on the number of admissions to ICUs where this standard could be added times the improvement in mortality per admission. We did not find any new evidence on this leap, so we decided to retain the same calculation from the previous report (Conrad et al., 2005). Thus we retained the shares of admissions going to an ICU (7.2% for adult ICUs

[1] We particularly wish to thank Dr David Bates regarding the CPOE Leap, and Dr John Birkmeyer regarding the EBHR Leap.

[2] This rate is based on the standard convention in economic analysis of excluding the effects of inflation for these analyses. Discounting reflects the fact that each dollar of savings in the future is less highly valued than a dollar of savings right now, because we must wait for the future savings. The three percent discount rate means roughly that a dollar saving a year in the future is worth three percent less to hospitals and payers than a dollar of savings right now because they need to wait. The calculations are based on the mathematics of compound interest.

and 2.7% for pediatric ICUs), the share of admissions to ICUs without IPS in each group for adults and children (79% of adult and 51% of pediatric ICU admissions), the mortality rates per ICU admission without IPS (12% for adults and 5% for pediatric), and the assumed reduction in ICU mortality (30%).

In accordance with the Leapfrog's survey for 2007, we updated the share of admissions to ICUs without IPS out of the total number of admissions. We utilized the annual number of admissions for adults and the annual number of admissions for children from national estimates from the Nationwide Inpatient Sample (2006).

The financial benefits (dollars saved) from IPS is calculated from the number of affected ICU admissions times the savings per affected admission. For estimating the national dollars saved, we used the financial model of Pronovost (2006) applied to an intermediate size ICU—12 beds. The projected number of annual admissions to an ICU (701) and annual savings ($1,909,512) implies savings per ICU admission of $2,724. By multiplying this saving by the number of annual urban admissions to ICUs without the IPS standards, we calculated the national estimate of savings from the full implementation of IPS standards in all urban hospitals.

Evidence-based hospital referral

The lives saved from evidence-based hospital referral are based on the number of procedures per year affected by this process, times the difference in mortality rates per procedure. We used the results of procedure-specific studies (Hannan et al., 2005, Marcin et al., 2008, Brooke et al., 2008, Nguyen et al., 2004, Dimick et al., 2005) to estimate the national total lives saved from evidence-based hospital referral. Only the studies done for the US population are included. Only statistically significant findings matched for the hospital volume criteria of Leapfrog's endorsed standards were adopted for extrapolating the national estimate. We also updated the annual number of cases, the proportion of procedures that were performed in urban hospitals, and the proportion of procedures in low-volume hospitals for each high-risk surgery in the evidence-based standards.

Results

Computerized physician order entry

The annualized costs and benefits per admission from implementation of CPOE are shown in Table 2.We estimate the annualized net benefit per preventable adverse drug event to be $1,223. Extrapolation from the MA pilot study suggests that the adverse events are substantial – 3.1 million adverse drug events prevented.

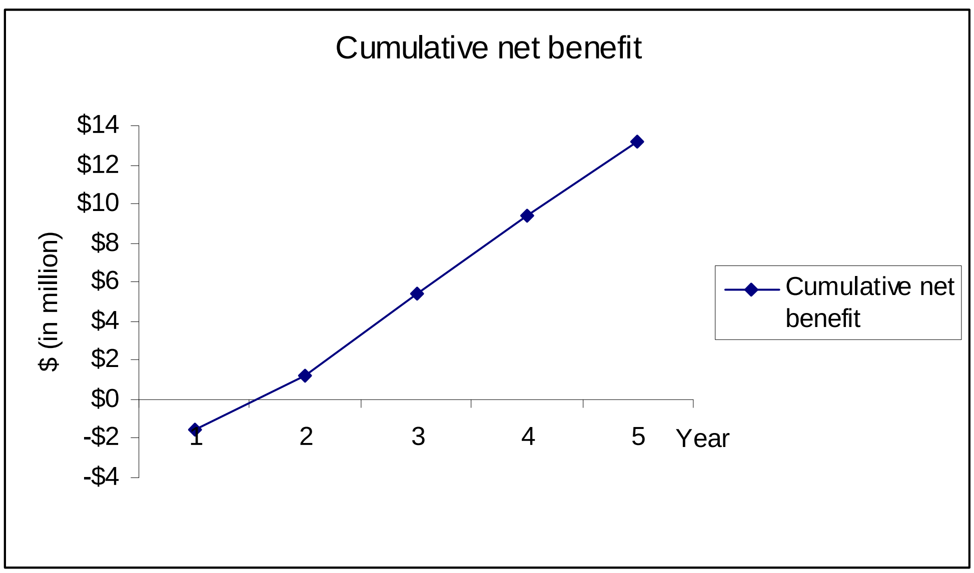
Table 2: Dollars saved from CPOE

	Amounts per admission [1]	National aggregate ($ billion)
Annualized costs	$80	$2.8
Annualized benefits	$362	$12.0
Annualized net benefits	$261	$9.2

N.B: Annual number of hospital admissions is 35.3 million

Dollars saved from the national implementation compared to no implementation, based on Massachusetts pilot study, would be $9.2 billion. The annual savings in dollars from the implementation of CPOE only for urban hospitals would be 84%, or $7.7 billion. Based on the present value, a period of 18 months is estimated to begin obtaining a favorable return on investment (Figure 1).

Figure 1: Dollars saved from CPOE over five years



Intensivist physician staffing

If all hospitals fully implemented the intensive care unit physician staffing leap, which do not currently meet the Leapfrog IPS standard, nearly fifty five thousand lives (Table 3) and $4.3 billion (Table 4) annually could be saved in the US health care system.

Table 3: Annual lives saved from IPS

Item	Number
Lives saved for adult ICU patients by IPS implementation	53,707
Lives saved for child ICU patients by IPS implementation	1,178
Total lives saved	54,885

Table 4: Dollars saved from IPS

Item	Savings
Saving per ICU admission	$2,724
No. of adult patients admitted to ICU without IPS	1,570,395
Saving in billions	$4.28

Evidence based hospital referral

Our estimate is much lower than the previous estimate based on the 2000 NIS (Birkmeyer et al., 2004), where the number of lives saved was estimated to be 7,602 (Table 5).

Table 5: Annual lives saved from evidence-based hospital referral, by procedure

High risk procedure	Share of low-volume procedures	Mortality rate of procedures under low volume	Mortality rate of procedures under high volume	No. of procedures performed	Lives saved
Pancreatic resection	37%	9.2%	2.7%	6,616	160
Esophageal resection	64%	20.7%	10.7%	3,312	210
AAA	62%	4.4%	2.2%	43,048	283
CABG	59%	2.9%	1.7%	239,043	1,710
PCI	13%	1.2%	0.6%	794,492	638
Bariatric surgery	11%	1.2%	0.3%	1,850	17
Total	25%			1,088,361	3,018

The smaller number of lives saved in the updated data was predominantly due to the change in lives saved in the procedures of CABG (Coronary artery bypass graft) and PCI (Percutaneous coronary interventions). In both cases, the change in the total number of admissions and the share of low volume procedures create a large change in the number of lives saved. For all high risk procedures except esophageal resection, the baseline mortality rates also have fallen substantially resulting in a smaller baseline number of lives to be able to be saved.

Summary of benefits

The summary of benefits of all Leaps is shown in Table 6.

Table 6: Summary of health benefits of all Leaps

Leap	Annual benefits	Units (annual benefits)
CPOE*	3,105,021	Adverse drug events averted
	$7.74 billion	Financial equivalence of adverse drug events benefited to urban hospitals
EBHR	3018	Lives saved
IPS	$4.3 billion	Dollars saved
	54,885	Lives saved
Total	12.04 billion	Dollars saved
	57,903	Lives saved

From full implementation of all three leaps in the urban hospitals, 12.04 billion dollars and 57,903 lives could be saved annually.

N.B: * For the CPOE Leap, the figures estimated were derived as the difference between full implementation of CPOE in all urban hospitals and no implementation at all in even a single urban hospital. The other two Leaps are based on the existing level of implementation of Leap standards.

Discussion

Recent studies were focused on understanding the mechanisms that result in saved lives within the Leaps, rather than re-measuring the number of lives saved by implementation. In general, the studies seek to better understand causative factors in addition to finding the direct relationships of the Leap standards.

The figures cited in this update are a mixture of evidence and assumptions. The heterogeneity of evidence does not allow a single, incontrovertible view. The authors have therefore sought to apply a reasonable interpretation of the existing evidence.

Crosscutting study across Leaps

One study, Jha et al. (2008), found that each of the Leaps was associated with lower mortality. Implementation of the Leap also was associated with better processes of care and clinical outcomes. This study reported lower mortality rates for acute myocardial infarction (AMI) and pneumonia, and better quality scores for AMI and congestive heart failure (CHF) in the group that has begun the implementing CPOE. It was also reported that the hospitals which had implemented the IPS standard had higher quality scores and lower mortality rates for at least two out of three disease conditions that were examined. Performance scores were better in AMI and pneumonia in hospitals with the EBHR Leap standard. It was also observed that the hospitals meeting the EBHR Leap standard had lower AMI mortality and modestly lower pneumonia mortality.

One caveat for these evidences was the safety-centered culture of the hospital environment itself (Pronovost et al., 2007). While the study reported the evidence of higher quality scores and lower mortality rates in hospitals that adopted the Leapfrog standards, The authors reflected that it was also likely that the hospitals meeting Leapfrog standards were likely paying attention to other patient safety practices and this might also be contributing to the lower mortality rates.

Computerized physician order entry

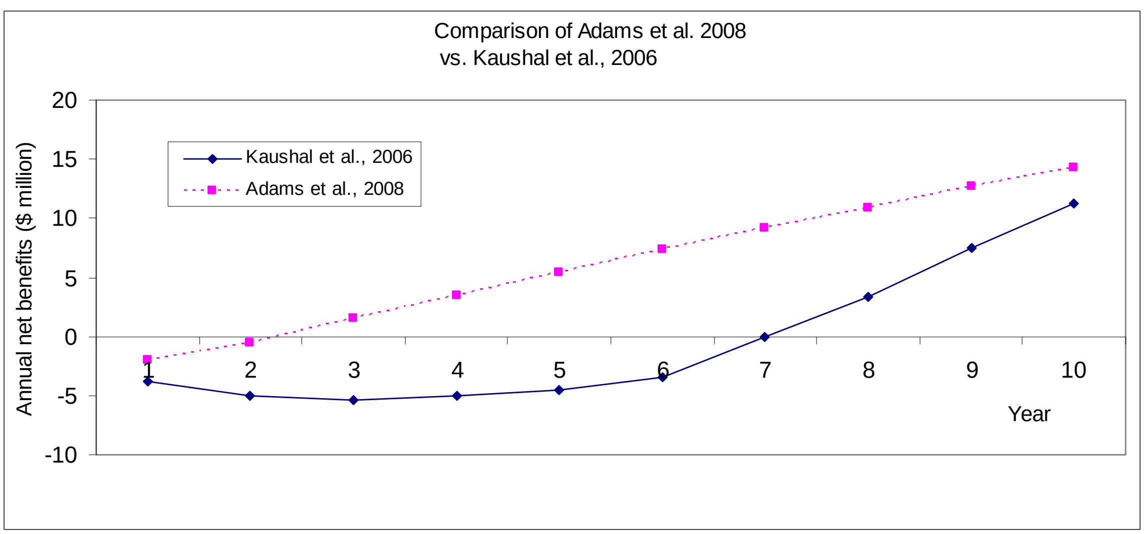
Our estimate was derived from the financial impact analysis carried out by the Massachusetts Hospital CPOE initiative which performed the clinical baseline study to estimate five areas of improvement directly resulted from implementing CPOE at the Brigham and Women's Hospital. These areas are the prevention of adverse drug events (ADEs); the inappropriate utilization of expensive medications; the prevention of medication errors in renal dosing; the timely substitution of oral for intravenous medications; and the reduction of redundant ordering of laboratory tests.

The proxy for the cost of injuries of patients suffering from ADEs is measured in terms of an increase in the hospital length of stay by an adverse drug event. While mentioning the estimate of the study from the Brigham and Women's hospital in Massachusetts, the AHRQ estimated an additional length of stay from an adverse drug event was a range between eight to twelve days. We used the landmark of the lower range, eight days for calculating our estimate. The estimate from the study of Massachusetts hospitals was based on preventable adverse drug events rather than any drug event. The estimate from Bates et al., (1997) reported that for any drug event, an average increase in hospital length of stay was 2.2 days and for a preventable adverse drug event, the increase was 4.6 days.

So our estimate of additional length of stay was still conservative albeit this length of stay used in our report was higher than that used for the study of the Massachusetts CPOE initiative study. The caveat is adverse drug events identified could be severe enough to significantly affect the increase in hospital length of stay. These estimates could be an overstatement if there were a considerable number of less severe drug events that didn't affect and that resulted in a shorter length of stay so that the actual mean from the population could be lower.

The estimates for the capital cost and the consequential annual costs for implementation of CPOE in the Massachusetts initiative study were more conservative than that of Kaushal's study which estimated the initial capital cost to $3.7 million and the costs for ensuing years to be $600,000 to $1.1 million. The Kaushal et al. (2006) study collected the financial data from 1993 to 2002, and also incorporated estimates of benefits from CPOE that were not reflected in the hospital budgets. From this study, using a three percent discount rate basis for calculating the present values, we estimated that the hospital's return on investment would first begin after seven years (84 months). Contrary to this, the estimates from the Massachusetts CPOE initiative study suggested that the return on investment could start as early as 26 months. For our estimate that used a longer length of stay, the full payback could start as early as 18 months. Both Adams et al. (2008) and Kaushal et al. (2006) estimated that after eleven years of investment, the cumulative benefit can be as high as 15 millions (Figure 2).

Figure 2: Comparison of studies of CPOE



In general, the recent studies showed evidence of improvement in quality performance, such as reduction in mortality rates, reduction in harmful drug events, a change in behavior towards less costly prescribing, or a favorable return on investment. There is one glaring exception, however. Han et al. (2005) reported an unexpected and paradoxical result of higher mortality from implementation of CPOE in a tertiary care level children hospital. Beccaro et al. (2006), who didn't find adverse impact on mortality in the Children's Hospital and Regional Medical Centre in Seattle, compared his findings with Han’s previous results. The study concluded that the implementation of CPOE needs to be linked with the careful institutional arrangements such as skipping inconvenient workflows and preparing specific order sets for patients to meet the time-effective demands of emergency clinical problems. According to a personal comment from David Bates and William Tierney on the online forum for ongoing peer review of the Paediatrics Journal, neither Brigham and Women Hospital nor Wishard Memorial Hospital experienced a change in mortality with implementation of CPOE (Paediatrics Peer review forum, 2005-2006).

The emergence of a more sophisticated clinical decision support system will progressively resolve the adverse problems of the system change for CPOE. The user-interfaces should be more aligned with the nuances of the system users needs. At the same time, more sophisticated systems demand more time from the end-users to become proficient. To help consumers and employers monitor progress, The Leapfrog Group has already implemented an online evaluation of a hospital’s CPOE implementation by assessing hospital performance with hypothetical patients and orders.

Over all, the implementation of CPOE has evolved, along with behavioral change for both physicians and organizations in adaptation to the human machine interfaces. While CPOE brings the promise of medication error reduction, the studies and insights pointed out that a careful, comprehensive, well-designed, efficient and detailed plan must be implemented in order for a CPOE system to fully meet this Leap.

Intensivist physician staffing

The same estimate of 30% decrease in mortality rates and many other assumptions from the report of Birkmeyer et al., 2004 was used for updating the lives saved based on the new data on the number of annual admissions and the share of admissions to ICUs without IPS among all admissions. The new estimate is approximately the same as the last estimate showing substantial savings--54,885 lives saved. For estimating the national saving in dollars from implementing this Leap, the financial model of Pronovost et al., 2006 was also used to extrapolate the result.

New articles in this Leap (IPS) are limited in number in comparison to the other two Leaps (CPOE and EBHR).

One of the overwhelming concerns for implementation of this Leap is the implementation costs. There were some factors identified as disincentives. As Kahn et al. (2007b) pointed out and as Pronovost noted in his financial model (Pronovost et al. 2004), gaining financial benefit could be slower in small ICUs, and reimbursements are also dependent on the case-mix standards. Medicare’s DRG (diagnosis-related group) payment system could result in underpayment of critical care services (Dorman et al., 2007) even though providers tried to promote these safety practices. The organizational factors like controversy of authority between physicians and intensivists and the need of a policy champion were also reported as important factors to be considered in implementing the

Leap. Some studies also suggested alternative solutions to hiring intensivists that will incur high costs. Tenner et al. (2003) reported a decline in mortality rates from after-hours coverage of hospitalists. Kahn et al. (2007a) suggested the use of evidence based practices through care protocols, nurse staffing or multidisciplinary care. A few studies were reported on the intensivist to bed ratio and its relationship with mortality. Peelen et al. (2007) reported a perverse relationship of the risk adjusted mortality rate and the intensivist-to-bed ratio. Dara et al. (2005) reported that there was no difference in mortality rates for a wide range of intensivist-to-bed ratios from 1:7.5 through 1:15.

More evidence could be necessary to increase awareness for implementation of the IPS standard, such as lower mortality rates associated with increases in intensivist-to- patient bed ratio. The care protocols could also be a more direct link for the quality improvement than the presence of intensivists. There should also be future research for efficient ways to overcome the financial disincentives in initiating IPS and to removing the barriers to implementation.

Evidence based hospital referral

Our update of the estimates of lives saved in this report (Table 7) was much lower than the previous estimate from Birkmeyer et al., 2004. As different way of expressing the results, from each high-risk surgery, a baseline number of 100 procedures was used to calculate how much lives in total could be saved among the 100 procedures in all these high-risk surgeries performing EHR standards (Table 8).

Table 7: Potential lives saved based on weighted averages

Weighted saving (100 procedures)	New estimate (2006 NIS)	Old estimate (2000 NIS)
Pancreatic resection	0.04	0.03
Esophageal resection	0.03	0.02
AAA	0.09	0.05
CABG	0.27	0.46
PCI	0.45	0.60
Bariatric surgery	0.00	0.00
Average saving among 100 procedures	0.87	1.16
Potential lives saved	9,527	12,514

This weighted average method for 100 procedures worked out well. Our estimate based on 2006 NIS was 0.9 lives saved for 100 procedures of all high risk surgeries performed by hospitals meeting the Leapfrog standard. The previous estimate based on 2000 NIS turned out to be that 1.2 lives can be saved for all 100 procedures. As an approximation, one life out of 100 procedures can be saved for the high risk operations currently performing EHR standards.

Extrapolating this figure, it could be assumed that if all hospitals performing these high-risk surgeries had adopted the EBHR standards, an average number of 9,500 to 12,500 lives could have been saved in a single year.

The recent articles continued to provide evidence of a volume-outcome relationship for these high risk procedures and conditions. The recent studies reported higher volumes were associated with lower short-term, risk-adjusted mortality rates, better processes of care, and long term survival rates. Brooke et al. (2008) also reported lower in-hospital mortality rates in adopting the beta-blocker standard of Leapfrog. Hollenbeck et al. (2007a) reported that reliance exclusively on the SEER-Medicare data set could underestimate volume-outcome relationships of some selective surgeries due to misclassifications of procedure volume. Phibbs et al. (2007) reported higher mortality rates for very-low birth-weight-infants in low volume hospitals with low levels of care. Moscucci et al. (2005) reported that lower *operator* volume for PCI was related to higher rates of major adverse cardiovascular events. Hannan et al. (2005) reported greater adverse outcomes (in-hospital mortality, higher incidence of the same-stay surgery as well as same-day surgery) in *hospitals* with low volumes of percutaneous coronary intervention (PCI). In addition, this study also reported higher incidences of same-stay and same-day surgery as adverse outcomes among low-volume *operators* performing PCI.

A recommended next step for examining evidence about the EBHR Leap would be the study of processes of care related to outcomes. At least two studies suggested that the processes found in high volume hospitals may be the cause of favorable outcomes (Brooke et al., 2008, Hollenbeck et al., 2007b). Yet, the mechanisms creating the volume-outcome relationship need to be identified. Accordingly, Hollenbeck et al. (2007b) suggested that replication of the best practices of care from high-volume hospitals to low volume hospitals might be the most feasible solution to achieve better results in mortality.

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