

In-hospital Death following Inpatient Surgical Procedures in the United States, 1996–2006

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Abstract

Background Over the past decade, improvements in perioperative care have been widely introduced throughout the United States, yet there is no clear indication that the death rate following surgery has improved. We sought to evaluate the number of deaths after surgery in the United States over a 10-year period and to evaluate trends in postoperative mortality.

Methods Using the National Hospital Discharge Survey, we identified patients who underwent a surgical procedure and subsequently died in the hospital within 30 days of admission.

Results In 1996 there were 12,250,000 hospitalizations involving surgery, rising to 13,668,000 in 2006. Postoperative deaths, however, declined during this same period, from 201,000 to 156,000 ($P < 0.01$), giving a postoperative in-hospital death ratio (death per hospitalization) of

1.64 and 1.14% ($P < 0.001$), respectively, for the two time frames.

Conclusions The death rate following surgery is substantial but appears to have improved. Such mortality statistics provide an essential measure of the public health impact of surgical care. Incorporating mortality statistics following therapeutic intervention is an essential strategy for regional and national surveillance of care delivery.

Introduction

Every year the National Center for Health Statistics, Centers for Disease Control and Prevention (CDC), collects and publishes information on causes of death in the United States [1]. Such mortality data have long been used to identify and prioritize public health issues. Life expectancy and maternal death rates have also been used to measure the efficacy of health systems [2]. While mortality from specific disease entities, such as heart disease and diabetes, is carefully followed, data collection does not routinely include information about death following medical treatment. To our knowledge, there has never been a published evaluation of death following all surgery at a national level in the United States. Such information would be useful for guiding quality improvement programs, highlighting safety lapses or areas for improvement, and assessing health system performance.

Advancements in surgical knowledge, techniques, and systems of care appear to have made surgery safer, but also more common and increasingly complex. Such complexity challenges both the clinicians providing care and entire health systems. Over the last decade, new technologies and guidelines aimed at improving standards of surgical care have been introduced [3]. Such standards are now central to

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national surgical quality improvement initiatives, including the Surgical Quality Improvement Program (SCIP) measures, the Joint Commission Universal Protocol, and Medicare “never events” [4–7]. Despite clinical advancements and these initiatives, there is no clear evidence that they are making a difference in safety or outcomes nationwide.

Recent findings have highlighted the importance of evaluating mortality rates following surgery. One study of hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) demonstrated that these hospitals have significantly improved mortality rates, even after adjusting for patient co-morbidity and type of intervention received [8]. Another study demonstrated that improvement in mortality appears to be influenced by institutional efforts that help identify complications and support patients who experience them throughout the course of their recovery [9]. Neither study, however, evaluated nationwide trends, as both were limited to general and vascular procedures at institutions participating in ACS-NSQIP. A recent evaluation of major oncologic procedures demonstrated improved results over a 10-year period but was limited to pancreatectomy, esophagectomy, gastrectomy, or major lung resection [10]. The importance of understanding such trends in surgical mortality was highlighted in a set of novel metrics proposed by the World Health Organization [11]. We sought to evaluate the inpatient mortality ratio per hospitalization for patients undergoing surgery in the United States and whether all-cause in-hospital mortality following surgery has improved over the last decade.

Methods

NCHS database

The National Center for Health Statistics (NCHS) conducts and publishes an annual National Hospital Discharge Survey (NHDS). Data are collected from inpatient discharges sampled from general hospitals, children’s general hospitals, and hospitals with an average length of stay of fewer than 30 days. Federal, military, and Department of Veterans Affairs hospitals, as well as hospital units of institutions (such as prison hospitals), and hospitals with fewer than six beds are excluded. The survey is based on a national probability sample of hospitals using a three-stage sampling design. The details of this data collection are described elsewhere [12]. For each year included in this analysis, the NHDS surveyed approximately 500 hospitals and obtained a response rate of >90%, with more than 275,000 discharges sampled. Of particular note, because persons with multiple discharges during a specific year can

be sampled more than once, the NHDS produces estimates for discharges rather than for individual patients.

Inclusion criteria

Surgery is continually evolving with the development and proliferation of minimally invasive procedures. Invasive and high-risk procedures are increasingly performed in a variety of settings such as angiography and radiology suites. Therefore, we defined surgery broadly to include all operating room and non-operating room procedures involving incision, excision, manipulation, or suturing of tissue, and usually requiring regional or general anesthesia, or profound sedation to control pain [13]. Because we were concerned that this might not adequately reflect trends in what might be considered “traditional” open surgery, we created a validation group of therapeutic surgical procedures limited to those operations that usually occur in an operating room and require regional or general anesthesia, or profound sedation to control pain. Ophthalmologic and dental procedures were excluded a priori (International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes 09–14 and 23–24).

Five surgeon reviewers independently evaluated the remaining 3,664 ICD-9-CM procedure codes to determine which codes to include in these two groups. If four or more reviewers agreed on the classification of an ICD-9-CM code, this was considered adequate for consensus and the procedure was included or excluded accordingly. All codes where two reviewers disagreed with the other three were discussed among the group until consensus was reached regarding its classification. We used the Agency for Healthcare Research and Quality (AHRQ) Clinical Classification System (CCS) from 2006 to combine ICD procedure codes into groups of similar interventions for both the 1996 and 2006 data sets as a means of analyzing the types of procedures with high numbers of deaths [14]. We analyzed only those CCS categories that contained our selected ICD codes.

Analysis

Discharge data from the NHDS from 1996–2006 were matched with the ICD list of procedures, and all hospitalizations that included one or more surgical procedures were included in the analysis. For 1996 and 2006, we compared the distribution of hospitalizations with a surgical procedure by patient demographic characteristics, including age, gender, income level based on patient ZIP code of residence, and length of stay. We established income quintiles based on the 1996 data and compared them to the corresponding distribution in the 2006 sample by merging ZIP code data from each discharge in the survey with the

median family income of the discharge's ZIP code from the 2000 US Census [15, 16]. We then tested for trends in hospitalizations and deaths for 1996–2006 and analyzed the ratio of deaths to hospitalizations in 1996 and 2006 overall and by CCS category.

Because the NHDS is a survey sample, all data were weighted to produce national estimates and confidence intervals. STATA 10 SE (StataCorp LP, College Station, TX, 2009) was used to aggregate data and obtain standard errors, accounting for the complex sampling design of the survey. SAS 9.13 (SAS Institute, Inc. Cary, NC, 2009) was then used for hypothesis testing. Only estimates that met standards for statistical reliability were reported; this was particularly important in evaluating the number of hospitalizations and deaths by CCS category. These standards were based on NCHS internal guidelines stipulating that the number of observations an estimate is based on has to be at least 30 and the relative standard error, or standard error of the estimate divided by the estimate itself, has to be no more than 0.3 [12].

We compared the distribution of the number of hospitalizations with a surgical procedure in 1996 and 2006 by demographic characteristics using a two-sample Z-test with unequal variances for continuous variables and chi-square tests for categorical variables (age and income). We used weighted least squares chi-square tests (using the inverse of the variances as weights) to assess the difference in the number of hospitalizations, deaths, and the death ratio between years 1996 and 2006, as well as trends over time.

We sought to analyze all deaths that occurred within 30 days of a surgical procedure. However, approximately 40% of the data lack exact procedure dates, as some hospitals in the NHDS choose not to provide this information because of confidentiality issues. We therefore limited our analysis to patients whose length of stay was ≤ 30 days—this excluded 1.98 and 1.50% of the 1996 and 2006 hospitalizations involving surgery, respectively. Because this limit on the length of stay also excluded patients who had a prolonged hospitalization prior to surgery, we evaluated the time from admission to first surgical procedure when such information was available to see how long patients tended to be admitted prior to surgery. Because of a concern for bias against late deaths, we also evaluated deaths without the 30-day length of stay limit.

Results

In 1996 there were 12,250,000 hospitalizations lasting ≤ 30 days (CI: 11,402,000–13,098,000) that involved a surgical procedure. In 2006, 13,668,000 hospitalizations involving surgery occurred (CI 12,572,000–14,764,000; $P < 0.05$ comparing the 2 years). As shown in Table 1, the

average length of stay differed significantly between the two groups, with the 1996 group discharged after 4.8 days and the 2006 group after 4.5 days. The mean age of the patients was not significantly different between the two samples (48.0 years and 49.1 years for 1996 and 2006, respectively; $P > 0.05$). When categorized by age group, there was a greater proportion of hospitalizations with a surgical procedure among older patients in 2006 compared to 1996 ($P < 0.05$). Women accounted for 53.4% of the 1996 sample and 54.7% of the 2006 sample ($P < 0.001$). There was no difference in the percentage of hospitalizations with a surgical procedure by income quintile between the 2 years ($P > 0.05$).

Of the hospitalizations involving surgery in 1996, 201,000 patients died in the hospital, whereas in 2006 156,000 patients died (CI 180,000–223,000 and 137,000–175,000, respectively; $P < 0.01$). As Table 2 shows, the ratio of deaths to hospitalizations in 1996 was 1.64%; in 2006 this ratio declined to 1.14% ($P < 0.001$). Figure 1a, b shows the overall trend for hospitalizations involving a surgical procedure and death during hospitalization from 1996 to 2006. Absolute numbers of hospitalizations involving surgical procedures increased over this 10-year period while the absolute number of in-hospital deaths fell significantly ($p < 0.001$ for trend for both hospitalizations and deaths). Figure 2a, b shows the same trend for the therapeutic surgery validation group ($P < 0.001$ for hospitalization trend; $p < 0.05$ for death trend); there was an overall decrease in the death ratio from 1.44 to 1.06% between 1996 and 2006 ($P < 0.001$; Table 2).

After eliminating all CCS categories that did not meet standards of statistical reliability, 13 remained. Only one—tracheostomy (CCS34)—demonstrated a significant improvement in the death ratio from 1996 to 2006. No death ratio became significantly worse in the comparison between the 2 years (Table 3).

From the original 1996 NHDS sample, 61.5% of the hospitalizations included information on the date of admission and date of operation; this information was available for 60.3% of patients whose hospitalization ended in death. In the 2006 sample, 58.0% of hospitalizations recorded included information on the date of admission and the date of operation. This information was available for 59.0% of patients whose admission ended in death. Surgical procedures were performed within 7 days of admission for $>96\%$ of patients in both the 1996 and 2006 samples for which such data were available. In comparison to hospital admissions of any length, the 30 day length of stay accounted for 87.4 and 87.2% of all deaths for 1996 and 2006, respectively (1996: 201,000 deaths with LOS ≤ 30 days versus 230,000 deaths during the entire hospitalization; 2006: 156,000 deaths with LOS ≤ 30 days vs. 179,000 deaths during the entire hospitalization).

Table 1 Demographic Information for hospitalized patients who underwent a surgical intervention

	1996		2006		<i>P</i> value [‡]
	Result	Standard error	Result	Standard error	
Number of hospitalizations	12,250,000	433,000	13,668,000	559,000	<0.05
Length of stay					
Mean (days)	4.8	0.06	4.5	0.05	<0.01
Median (days)	3		3		
Gender	53.4% Female	0.0041	54.7% Female	0.0043	<0.01
Age					
Mean (years)	48.0	0.44	49.1	0.52	>0.05
Median (years)	51		53		
Age group composition					
Newborn	9.8%	0.4%	8.3%	0.3%	<0.05
<1 year	0.8%	0.1%	0.8%	0.2%	
1–4 years	0.9%	0.2%	0.9%	0.2%	
5–14 years	2.0%	0.2%	1.9%	0.3%	
15–24 years	6.4%	0.2%	6.8%	0.3%	
25–34 years	11.6%	0.3%	10.9%	0.3%	
35–44 years	11.3%	0.2%	10.4%	0.2%	
45–54 years	11.3%	0.2%	12.3%	0.2%	
55–64 years	11.7%	0.2%	14.2%	0.3%	
65–74 years	16.5%	0.3%	14.8%	0.3%	
≥75 years	17.7%	0.4%	18.7%	0.4%	
1996 income quintiles					
<\$30,835 ^a	21.8%	1.8%	19.8%	1.4%	>0.05
\$30,835–\$37,526	20.9%	1.1%	20.1%	1.1%	
\$37,527–\$44,671	19.0%	0.9%	18.7%	0.9%	
\$44,672–\$56,488	16.8%	0.9%	17.9%	0.9%	
>\$56,488	16.1%	1.1%	18.4%	1.3%	
Not recorded	5.3%	0.7%	5.0%	0.8%	

[‡] Tests of significance for number of hospitalizations, length of stay, gender, and mean age were performed with two-sample Z-tests with unequal variance. For categorical variables, age and income, tests of significance were performed with chi-square tests

^a In FY 2000 U.S. dollars

Discussion

Over the past 10 years, hospitalizations involving surgery have increased in the United States, while all-cause mortality following surgical procedures has declined significantly. Had death ratios in 2006 been the same as in 1996, over 68,000 more inpatient deaths following surgery would be expected. Although neither the cause of death nor the cause of improvement can be specifically identified in this study, these discharge statistics suggest that inpatient surgery as a whole is safer than it was a decade earlier. However, the absolute volume of in-hospital death after surgical procedures remains large.

There are four potential explanations for our findings: changes in patient selection; changes in surgical case mix; changes in techniques, technology, and supportive care; and improved quality assurance. First, surgeons may have become better at judging which patients are the best operative candidates, thus avoiding operations in surgically

Table 2 Death ratios for surgery in the United States, 1996–2006

Year	Death ratio, any surgical intervention (deaths/admissions)	Death ratio, therapeutic surgery (deaths/admissions)
1996	1.64%	1.44%
1997	1.53%	1.29%
1998	1.58%	1.30%
1999	1.65%	1.42%
2000	1.48%	1.18%
2001	1.45%	1.24%
2002	1.45%	1.23%
2003	1.36%	1.24%
2004	1.26%	1.11%
2005	1.29%	1.15%
2006	1.14%	1.06%
<i>P</i> value for trend	<0.001	<0.001

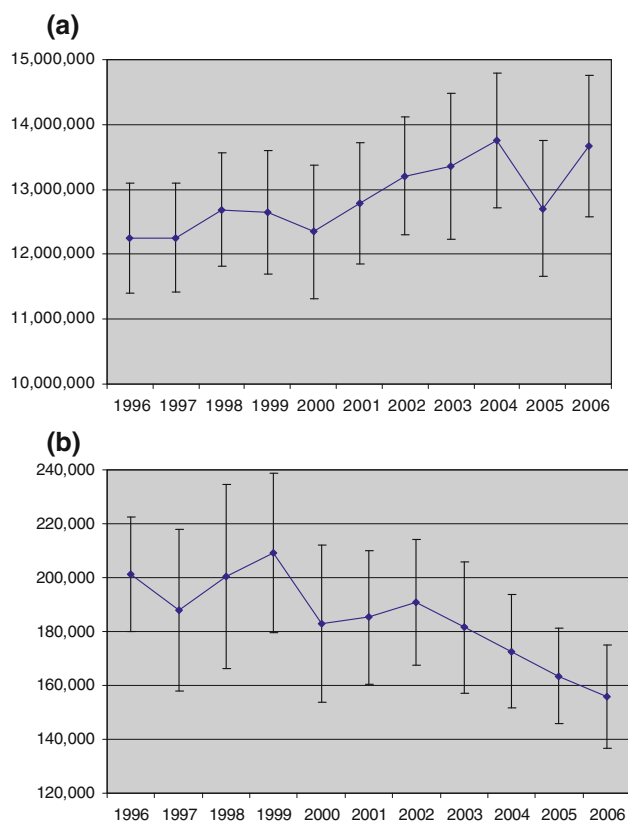


Fig. 1 **a** Hospitalizations (≤ 30 days) involving a surgical intervention, 1996–2006 ($P < 0.001$ for trend). **b** Death during hospitalization (≤ 30 days) involving a surgical intervention, 1996–2006 ($P < 0.001$ for trend)

futile cases. The experience from cardiac surgery following the implementation of outcomes monitoring and reporting suggests that some improvement may indeed be due to changes in patient selection [17, 18]. Second, the inpatient surgical case mix is likely to have changed between 1996 and 2006, such that the types of operations being performed in 2006 carried less risk of mortality. This might be further explained by advancements in surgical techniques, in particular minimally invasive therapies and technology, which could account for some of the reduction in mortality as many minimally invasive interventions allow for faster recovery and discharge. As our data reflect only in-hospital deaths, shorter lengths of stay or more aggressive discharge policies would skew the reported death numbers. The slight drop in length of stay that we noted between 1996 and 2006, however, is unlikely to have masked impending deaths that would otherwise have occurred in the hospital. In addition, while improved ICU care and the ability to rescue patients suffering complications from surgery represent an important component of quality in surgical care, it is unlikely that these advances alone account for the improvements seen in our population-based study. This conclusion is demonstrated by the similar findings obtained

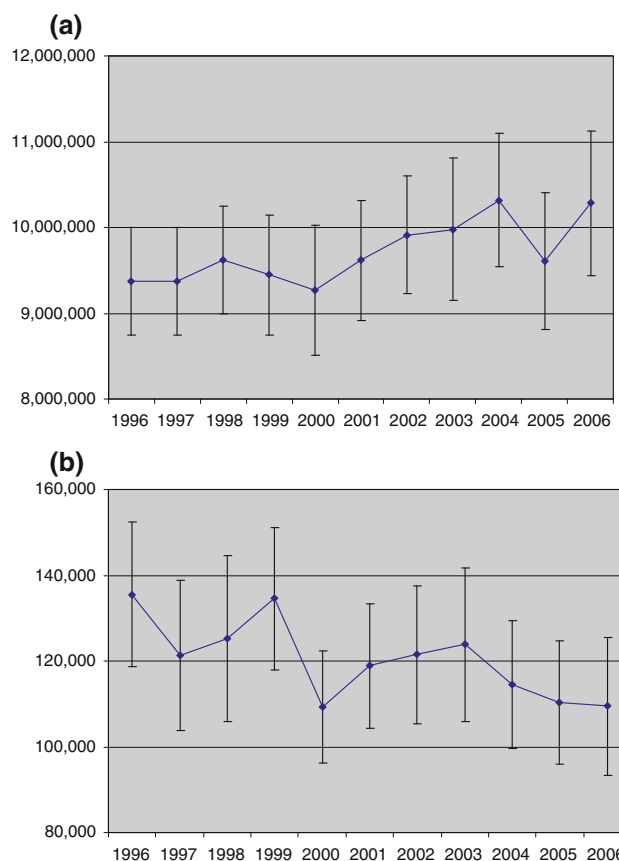


Fig. 2 **a** Hospitalizations (≤ 30 days) involving the therapeutic surgery validation group, 1996–2006 ($P < 0.001$ for trend). **b** Death during hospitalization (≤ 30 days) involving the therapeutic surgery validation group, 1996–2006 ($P < 0.05$ for trend)

when including all admissions and not just those limited to a 30 day length of stay. Finally, attention to patient safety since the publication of the Institute of Medicine report in 1999 and quality improvement initiatives such as those spearheaded by AHRQ may have helped prevent complications and deaths by improving basic safety practices and routines [19, 20]. Improved antibiotic timing and glucose control, prevention of hypothermia, reduction of unnecessary transfusions, venous thromboembolism prophylaxis, and appropriate beta blocker therapy have all been shown to reduce complications and deaths [21–25]. Health systems around the country are incorporating these practices into the perioperative routine [26].

There are several limitations of our study. Because the NHDS is based on survey data, there is a potential for sampling error. Small discrepancies in the surveys could potentially translate into larger differences in the reported national estimates. Given the consistency with which the survey is conducted, there is little likelihood that this is the case, however, and the confidence intervals should account for the sampling technique. As the data are based on

Table 3 Estimates of number of hospitalizations and deaths by CCS category, 1996 and 2006, along with *P* values for the change in death ratios between the 2 years

CCS category	1996		2006		<i>P</i> value for difference in death ratio
	Hospitalizations (SE)	Death ratio (SE)	Hospitalizations (SE)	Death ratio (SE)	
34: Tracheostomy; temporary and permanent	44,000 (5000)	0.282 (0.033)	63,000 (6000)	0.140 (0.025)	<0.001
43: Heart valve procedures	73,000 (8000)	0.056 (0.013)	94,000 (8000)	0.038 (0.01)	>0.05
44: Coronary artery bypass graft (CABG)	358,000 (31000)	0.035 (0.006)	248,000 (20000)	0.021 (0.005)	>0.05
45: Percutaneous transluminal coronary angioplasty (PTCA)	473,000 (43000)	0.014 (0.003)	650,000 (46000)	0.011 (0.002)	>0.05
71: Gastrostomy; temporary and permanent	147,000 (8000)	0.085 (0.013)	150,000 (11000)	0.062 (0.013)	>0.05
73: Ileostomy and other enterostomy	32,000 (3000)	0.142 (0.034)	31,000 (4000)	0.088 (0.025)	>0.05
75: Small bowel resection	56,000 (4000)	0.103 (0.02)	73,000 (6000)	0.081 (0.019)	>0.05
78: Colorectal resection	244,000 (12000)	0.037 (0.006)	291,000 (14000)	0.034 (0.006)	>0.05
89: Exploratory laparotomy	36,000 (4000)	0.078 (0.015)	26,000 (3000)	0.101 (0.024)	>0.05
90: Excision; lysis peritoneal adhesions	330,000 (15000)	0.020 (0.004)	333,000 (18000)	0.021 (0.005)	>0.05
169: Debridement of wound; infection or burn	281,000 (14000)	0.024 (0.005)	332,000 (39000)	0.021 (0.004)	>0.05

hospital discharges, patients who die outside the hospital are not included in the analysis. Furthermore, patients who are discharged following surgery but then readmitted and die without any further operative intervention would also not be counted in the death numbers. Individual patients who are admitted and have procedures multiple times over the course of a year are double counted in the discharge data. In none of these scenarios, however, would we expect a systematic problem to bias the results based on the way NHDS is conducted.

We limited the analysis to hospitalizations of up to 30 days only because a large proportion of the data lack exact surgical procedure dates, and we were concerned that analyzing data for hospitalizations of longer duration might include patients who had an early intervention and then died more than 30 days following surgery. This does not invalidate our findings, however, as it leads to a conservative mortality estimates. Because most surgical procedures were performed early during an admission, limiting the analysis to hospitalizations with lengths of stay less than 30 days should be an adequate proxy for deaths that occurred within 30 days of a procedure. Our analysis of the entire data set without limiting the length of stay demonstrated that >85% of deaths in both 1996 and 2006 occurred in this first 30 day period and that the significant decrease in death ratios remained.

Most important, we are unable to make any determination regarding either the cause of death following surgery or the cause of improvement in the death rate. Many deaths are unlikely to be attributable to the operation, and some proportion of the deaths would likely have been inevitable,

even without surgical intervention. Furthermore, because of the small sample size, we were unable to identify specific procedures associated with the decline in deaths (other than tracheostomy). However, the findings suggest that there are substantial numbers of patients who die immediately following surgery and hence receive limited benefit from the procedure; at a time where costs are being carefully examined, better patient selection could improve resource allocation and help lower costs. Work to improve results will continue to be necessary, and national mortality statistics can provide a metric of success and help identify areas for further investigation.

The NHDS has been used for more than 40 years, and the techniques for assessment are well established. Because of the systematic manner in which data are collected, comparison between years is possible. If the health care system were able to report trends in mortality for different medical treatments or following improvement initiatives, it would provide a powerful tool to help address systemic shortcomings and safety issues, and to evaluate future changes in the health care system. With healthcare safety a major priority, a robust process for measuring outcomes will help assess the effect of safety initiatives on the public's health.

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Conflict of interest None.

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