Operative mortality of surgeries performed on a surgeon's birthday: observational study

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Operative mortality of surgeries performed on a surgeon's birthday: observational study

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Summary Box

What is already known on this subject?

- Distractions due to clinical or personal events in the operating room are common.

- Although laboratory experiments have shown that distractions can have a detrimental effect on surgeons' performance, empirical evidence using real-world data is limited as to how distractions in surgery affect patient outcomes.

- Operations performed on birthdays of surgeons may provide a unique opportunity to assess the relationship between personal distractions and patient outcomes, but the association between surgeon's birthday and patient mortality has not been investigated.

What this study adds

- This study examined 30-day mortality of patients who underwent common emergency surgical procedures between 2011 and 2014 in the United States, using national data on Medicare beneficiaries aged 65 to 99 years.

- Within the same surgeon, patients who underwent a surgical procedure on the operating surgeon's birthday exhibited higher mortality compared with patients who underwent surgery on other days of the year (adjusted mortality, 6.9% on surgeons' birthdays vs. 5.6% on other days).

- Our findings suggest that a surgeon's performance may be affected by potentially distracting life events that are not directly related to work.

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ABSTRACT

Objectives: Operations performed on birthdays of surgeons may provide a unique opportunity to assess the relationship between personal distractions and surgeon performance. The objective of this study was to determine whether patient post-operative mortality differs for surgeries performed on surgeons' birthdays versus other days of the year.

Design: Retrospective observational study.

Setting: US acute care and critical access hospitals.

Participants: 100% fee-for-service Medicare beneficiaries aged 65 to 99 years who underwent 1 of 17 common emergent surgical procedures in 2011-2014.

Main Outcome measures: Patient post-operative 30-day mortality rate, defined as death within 30 days following the operative procedure.

Results: Overall, 980,876 procedures performed by 47,489 surgeons were analyzed. Among those procedures, 2,064 (0.2%) procedures were performed on surgeons' birthdays. Patient characteristics, including severity of illness, were similar between patients who underwent surgery on a surgeon's birthday versus other days. The overall unadjusted 30-day mortality rate on the operating surgeon's birthday was 7.0% (145/2,064), and that on other days was 5.6% (54,824/978,812). After adjusting for patient characteristics and surgeon fixed effects, patients who underwent a surgical procedure on a surgeon's birthday exhibited higher mortality compared with patients who received surgery on other days (adjusted mortality rate, 6.9% on birthdays vs. 5.6% on other days; adjusted difference, +1.3%; 95% CI, +0.1% to +2.5%; P=0.03). Event study analysis that analyzed patient mortality by day of operation relative to a surgeon's birthday found similar results.

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Conclusions: Among Medicare beneficiaries who underwent common emergent surgeries, patients who received surgery on an operating surgeon's birthday experienced higher mortality compared with patients who underwent surgery on other days. These findings suggest that surgeon's performance may be affected by life events that are not directly related to work.

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INTRODUCTION

Surgery plays a fundamental role in healthcare, with an estimated 11-30% of the global burden of diseases requiring surgical care, anesthesia, or both.[1-3] However, the quality of surgical care is not always optimal; 5-10% of patients who undergo inpatient surgery die after the procedure,[4-9] and 20-30% of patients experience complications.[4 6-8 10-15] Of those complications, 40-60% are considered avoidable[10 16 17] and 20-40% of deaths after surgical procedures are estimated to be preventable.[10]

Although many system- and physician-level factors influence surgical outcomes,[18-20] one area that has received little empirical investigation is the role of distractions. Distractions in the operating room are common including noise (e.g., calls from ward, beeper pages), equipment problems, and conversations not pertinent to the surgical procedure.[21-24] Although laboratory experiments have shown that distractions can have a detrimental effect on surgeons' performance such as time to task completion, surgical errors, and accuracy,[25-28] empirical evidence using real-world data is limited as to how distractions in surgery affect patient outcomes. Outside of health care, studies have found that distractions due to extraneous factors, including outdoor temperatures and losses of local sports teams, have a meaningful impact on people's decision-making process.[29-31] However, as surgeon-level information on potentially distracting events is difficult to obtain, how distractions caused by extraneous factors affect surgeons' performance and patient outcomes has not been investigated.

Operations performed on birthdays of surgeons may provide a unique opportunity to assess the relationship between personal distractions and patient outcomes, under the hypothesis that surgeons may be more likely to become distracted or rushed to finish procedures on their birthdays, and therefore, patient outcomes may differ on those days. To test this hypothesis, we used national

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data on Medicare beneficiaries aged 65 to 99 years in the U.S. who underwent one of 17 common surgeries between 2011-2014, linked to information on surgeon birthdays, to examine whether patients' post-operative mortality differed for surgeries performed on surgeons' birthdays versus other days of the year.

METHODS

Data sources

We analyzed 100% of Medicare fee-for-service beneficiaries aged 65 to 99 treated at acute care and critical access hospitals in 2011-2014. To minimize the impact of potential selection bias due to surgeons choosing patients based on illness severity, or patients choosing operating surgeons based on their preference, we focused our analyses on emergency procedures defined as emergent/urgent admissions or admissions from trauma centers, identified using claim inpatient admission type code.[32 33] To ensure that procedures were emergency, we also restricted analysis to surgeries performed within three days of hospital admission.[34-36] We excluded patients with cancer and patients discharged to hospice to avoid patients' care preferences (including end-of-life care preference) affecting post-operative mortality. We also excluded patients who left against medical advice. To allow for sufficient follow-up after surgery, we excluded patients who underwent procedures in December 2014 from our analyses.

We identified all patients who underwent one of 17 major surgical procedures: 4 common cardiovascular surgeries examined in prior studies (carotid endarterectomy, heart valve procedures, coronary artery bypass grafting, and abdominal aortic aneurysm repair), [18 33 37 38] and the 13 most common non-cardiovascular surgeries in the Medicare population (hip and femur fracture, colorectal resection, cholecystectomy and common duct procedures, excision of peritoneal adhesions, fracture or dislocation of lower extremity other than hip or femur, lung

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resection, amputation of lower extremity, nephrectomy, appendectomy, small bowel resection, spinal fusion, gastrectomy, and splenectomy). A list of ICD-9 (international classification of disease, version 9) codes is available in the Supplementary Appendix Table S1.

Surgeon characteristics

We identified the surgeon who performed each procedure using the national provider identifier (NPI) listed in the operating physician field of the inpatient claim, an approach validated in previous studies.[18 35 37 39] Surgeon characteristics, including their birthdays, were obtained from the Centers for Medicare & Medicaid Services' MD-PPAS file. The MD-PPAS included information on the surgeon's birthday, sex, and specialty. Approximately 98% of our Medicare beneficiary data could be linked to the MD-PPAS using NPI.

Patient outcomes

The primary outcome was 30-day mortality, defined as death within 30 days following the operative procedure. Information on death dates, including out-of-hospital deaths, was available in the Medicare Beneficiary Summary Files, where more than 99% of death dates are verified using death certificates.[40] We excluded <1% of patients whose death dates were not verified.

Adjustment variables

We adjusted for patient characteristics and hospital or surgeon fixed effects (depending on model). Patient characteristics included the type of procedure (indicator variables for 17 surgical procedures), age (a continuous variable with quadratic and cubic terms, allowing for nonlinear relationship), sex, race and ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), indicator variables for 24 comorbidities (Elixhauser comorbidity index),[41] median household income estimated from residential zip codes (as a continuous variable with

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quadratic and cubic terms), an indicator for dual-Medicaid coverage, and year and day of the week of surgery (to allow for the possibility that patients undergoing weekend surgery may have worse outcomes[42 43]). Hospital fixed effects were indicator variables for each hospital, and surgeon fixed effects were indicator variables for each surgeon. Including hospital or surgeon fixed effects as adjustment variables in regression analysis controlled for both measured and time-invariant unmeasured characteristics of hospitals or surgeons, including differences in patient populations, effectively comparing outcomes of patients who were treated at the same hospital or those who were operated on by the same surgeon.[44 45]

Statistical analysis

We first examined whether surgeons' birthdays were evenly distributed throughout the year and compared patient characteristics and patients' illness severity on an operating surgeon's birthday and other days, to investigate whether patients' illness severity differed based on the date of surgery. To estimate illness severity for each patient, we regressed 30-day mortality on patients' characteristics (see Adjustment variables for details) using a logistic regression model and estimated the predicted probability of 30-day mortality for each patient. Additionally, we evaluated the number of procedures per surgeon on and around their birthdays to examine whether surgeons changed their decision to perform surgeries (e.g., changed their operative volume) on their birthdays.

Second, we compared the operative mortality of patients who underwent surgery on a surgeon's birthday versus patients whose operation was performed on other days of the year. We constructed three regression models. Model 1 adjusted for patient characteristics only. Model 2 adjusted for all variables in model 1 plus hospital fixed effects, effectively comparing patient outcomes within the same hospital. Model 3 adjusted for all variables in model 1 plus surgeon

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fixed effects, a within-surgeon analysis that compared outcomes for surgeries performed on surgeons' birthdays versus other days on which the same surgeon operated. We used multivariable linear probability models (fitting ordinary least-squares to binary outcomes) for the main analyses to overcome the issue of complete or quasi-complete separation of logistic regression models, due to a large number of fixed effects.[46 47] Standard errors were clustered at the surgeon level to account for potential correlation between patient outcomes within the same surgeon. After fitting regression models, adjusted patient outcomes were calculated using the marginal standardization form of predictive margins.[48]

Finally, we conducted an event study analysis to investigate how patient 30-day mortality differed around surgeons' birthdays. We regressed patient 30-day mortality on a set of relative date indicators within two weeks before and after a surgeon's birthday (using other days of the year as the reference category), adjusting for patient characteristics and surgeon fixed effects (Model 3). To avoid unstable estimates due to relatively small sample sizes for any given day, we grouped every two days into a single category. We then calculated adjusted 30-day mortality rates for each date within 2 weeks of the operating surgeon's birthday, and compared them with adjusted mortality rates of patients who underwent a procedure on other days of the year.

Secondary analyses

We conducted several secondary analyses. First, to examine whether our findings were sensitive to the selection of follow-up periods for calculating patient mortality, we reanalyzed the data using in-hospital mortality, instead of 30-day mortality, as an outcome. Second, to address the possibility that some surgeons may manipulate the timing of operations (e.g., postpone non-urgent surgical procedures) based on their birthday, we tested whether our findings were affected by additionally adjusting for the timing of surgery (date of surgery relative to the admission date)

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in our regression analyses. Third, we tested whether our findings were affected by including both hospital and surgeon fixed effects in the same regression models. Fourth, to address the possibility that a small number of outlier surgeons may dominate our findings, we reanalyzed the data after excluding the top 1% of surgeons with the highest mortality. Fifth, we used logistic regression models instead of linear probability models, adjusting for patient characteristics and hospital or surgeon fixed effects. Sixth, to assess whether our findings were explained by a small set of procedures, we conducted a stratified analysis by individual procedures patients received, adjusted for patient characteristics and surgeon fixed effects (Model 3). To avoid unstable estimates due to the small sample sizes, we restricted to procedures for which the number of surgeries on surgeon's birthday was more than 10. Seventh, we conducted a simulation analysis to assess the likelihood of our findings being explained by random chance. To do so, we assigned surgeons randomly generated "pseudo-birthdays" and examined the association between these pseudo-birthdays and 30-day mortality rates in 1,000 estimations, adjusted for patient characteristics and surgeon fixed effects. We then compared the estimated difference in patient mortality between birthday and non-birthday surgeries generated through this simulation to the estimates obtained in our baseline multivariable analysis that included patient characteristics and surgeon fixed effects (Model 3). Eighth, we examined whether the association between surgeon's birthday and patient mortality varied according to whether an operation occurred on a special ("milestone") birthday, hypothesizing that these birthdays may lead to greater distraction. We investigated the association between 30-day mortality and surgeon's birthday at milestone ages (i.e., 40, 50, and 60 years). Finally, we investigated whether the association between 30-day mortality and operation on a surgeon's birthday varied according to whether the birthday

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occurred on a Friday versus Monday-Thursday, hypothesizing that Friday birthdays may be associated with greater distraction if celebratory activities were more likely to occur.

We used SAS version 9.4 (SAS Institute) for data preparation and Stata version 14 (Stata Corp) for all analyses. This study was approved by University of California, Los Angeles Institutional Review Board.

Patient and public involvement

No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for the design or implementation of the study. No patients were asked to advise on interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants or the relevant patient community. Patient consent was not required for this study.

RESULTS

Characteristics of study population

Our sample included 980,876 procedures operated on by 47,489 surgeons, whose birthdays were evenly distributed throughout the year (**Figure S1** in **Online Supplement**). Among those procedures, 2,064 (0.2%) procedures were performed on surgeons' birthdays. Patients who underwent operations on surgeons' birthdays had similar characteristics—including demographics, comorbidities, procedure type, and predicted mortality—to those who underwent operations on other days (**Table 1 and eTable 2** in the **Online Supplement**). For example, the predicted mortality of patients who underwent surgery on surgeons' birthdays was similar to that of patients who underwent surgery on other days (predicted mortality rate, 5.5% on surgeons' birthday vs. 5.6% on other days; P=0.35). Moreover, there was no significant difference in the distributions of predicted mortality between patients who underwent surgery on surgeons'

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birthdays and other days (**Figure 2**). Predicted mortality was also similar for operations performed in the ±14 days surrounding surgeons' birthdays (**eFigure 2** in **Online Supplement**). The average number of surgical procedures performed per surgeon was similar between birthdays and other days (**eFigure 3** in **Online Supplement**). These findings suggest that surgeons did not selectively choose which patients to operate on their birthdays on the basis of patient characteristics, including illness severity.

Mortality rates

The overall unadjusted 30-day mortality rate on the operating surgeon's birthday was 7.0% (145/2,064), and that on other days was 5.6% (54,824/978,812). After adjusting for patient characteristics, patients who underwent surgery on the operating surgeon's birthday had higher adjusted 30-day mortality compared with patients who underwent surgery on other days (adjusted mortality rate, 7.2% vs. 5.6%; adjusted difference, +1.6%; 95% CI, +0.4% to +2.8%; P=0.01) (**Table 2**). These findings remained largely consistent after additional adjustment for hospital fixed effects (Model 2) or surgeon fixed effects (Model 3). For example, after adjustment for both patient characteristics and surgeon fixed effects, 30-day mortality was higher on surgeons' birthdays compared to other days (adjusted mortality, 6.9% vs. 5.6%; adjusted difference, 1.3%; 95% CI, 0.1 to 2.5; P=0.03).

In an event study analysis of 30-day mortality, mortality was higher for operations that were performed on a surgeon's birthday compared to other days of the year (**Figure 1 and eTable 3** in the **Online Supplement**).

Secondary analyses

Our findings were qualitatively unaffected by using in-hospital mortality instead of 30-day mortality; additionally adjusting for the timing of the surgery; including both hospital and

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surgeon fixed effects in the same regression models; excluding potentially outlier surgeons with the highest mortality; or using logistic regression models instead of linear probability models (e**Tables 4-8** in the **Online Supplement**). Although the differences were not statistically significant for most procedures due to small sample sizes, we observed trends toward higher mortality on the operating surgeon's birthday for all procedures included in the stratified analysis (except for carotid endarterectomy) (**eTable 9** in the **Online Supplement**). The observed increase in patient mortality on surgeon birthdays was larger than 99.5% of simulated coefficients obtained by randomly assigning pseudo-birthdays and fitting similar regression models 1,000 times—indicating that observed increase in patient mortality on surgeons' birthday could not be explained by random chance (**Figure S4** in the **Online Supplement**). The association between surgeon's birthday and patient outcomes did not differ based on milestone age birthdays or when the birthdays were on a Friday (**eTables 10-11** in the **Online Supplement**).

DISCUSSION

Using a national sample of Medicare beneficiaries who underwent common emergency surgical procedures, we found that patients who underwent a surgical procedure on an operating surgeon's birthday experienced higher post-operative mortality compared with patients who received a procedure on other days of the year. This finding persisted in a within-surgeon analysis that compared outcomes of patients who underwent surgery on a given surgeon's birthday compared to patients who underwent surgery by that same surgeon on other days of the year. There was no difference in a broad range of patient characteristics, including predicted morality rates, between patients who underwent surgery on a surgeon's birthday versus other days of the year, indicating that these findings were unlikely to be explained by differences in

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patient factors. Taken together, these findings suggest that a surgeon's performance may be affected by life events that are not directly related to work, a hypothesis that while intuitive has been otherwise difficult to assess due to lack of detailed information on events that are potentially distracting to an individual surgeon.

The effect size of surgeons' birthday observed in our analysis (1.3 percentage point increase or a 23% increase in mortality), while substantial, is comparable to the impact of other events, including holidays (e.g., Christmas and New Year) and weekends, which have been argued to affect the quality of care patients receive.[49-51] For example, patients who were emergently admitted to hospitals on public holidays in Scotland showed a 27% increase in 30-day mortality compared to patients admitted on other days.[49] Our use of surgeon birthdays as a "natural experiment" is arguably better than using other distracting events used in prior studies, because those events do not only affect physicians' performance, but also influence patients' decision to seek care (i.e., patients seeking care on these special days may be sicker than those who seeking care on other days), as well as hospital staffing. In contrast, patient case-mix (it is unlikely that patients know their surgeons' birthday) and hospital staffing are similar on surgeons' birthdays. The estimated effect was also measured with uncertainty and relationships of a smaller, but non-zero, magnitude cannot be ruled out.

There are several potential mechanisms that may explain why patient mortality was higher on surgeons' birthdays. First, surgeons may be under relatively higher time pressure—feeling rushed to complete procedures on time—on their birthday compared to other days of the year, because they may have important evening plans to celebrate their birthday. Research suggests that time pressure may impair the ability to avoid errors of intuitive judgment and may cause heuristic decisions during and after operations, which may lead to a higher likelihood of

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errors and overlooking signals of clinical deterioration of patients.[52 53] Time pressure may also increase the risk of confirmation bias[54]—the tendency to gather evidence that confirms preexisting expectations (or biases) while dismissing or failing to seek contradictory evidence.[55] In this case, surgeons may, probably unconsciously, gather the information that supports a surgeon's expectation that surgery was performed successfully. Second, conversations related to birthdays with other team members (e.g., anesthesiologists, operating room nurses) during surgical procedures may be distracting, leading to medical errors.[56] Third, "decision fatigue" due to other competing non-work-related decisions that may be made on birthdays could make it harder for surgeons to make appropriate decisions during and after procedures.[57] Finally, it is also possible that post-operative care decisions may differ on surgeons' birthdays. For example, surgeons may be less likely to return to the hospital to see their patients when patients show signs of deterioration if they are having dinner with family and friends, compared to regular evenings.

The major threat to the internal validity of our findings is that surgeons may selectively operate on sicker and more complex patients on their birthday, perhaps because those patients cannot have their procedures delayed. However, this is unlikely to explain our findings because we found that patients who underwent surgery on the surgeon's birthday were similar in all observable characteristics to patients who underwent surgery on other days. Furthermore, severity of illness as measured by predicted mortality, and the number of procedures performed, also did not differ based on whether a surgery occurred on a surgeon's birthday compared to other days.

To our knowledge, our study is the first to empirically test whether physicians' practice patterns and outcomes vary due to life events outside of their work environment. Other studies

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not focused on individual life events have nonetheless demonstrated how physician decisions may be affected by other factors that may systematically lead to distraction or rushing. For example, one study found that clinicians are more likely to prescribe antibiotics to patients with upper respiratory infections as the workday progresses, probably because the cumulative cognitive demand of clinical decisions progressively impairs clinician's ability to avoid clinically inappropriate decisions.[58] Comparable findings were observed for the prescription of opioids as well.[59] Similarly, one study found that clinicians' ordering of cancer screening tests decreased as the workday progressed.[60] Outside of healthcare, studies of how judges make decisions about parole, sentence lengths, and immigration have found that their decisions are sensitive to extraneous factors, including taking a food break, experiencing unexpected losses of football games, and an increase in outdoor temperature. [29-31]

Our study has limitations. First, although we adjusted for a broad set of patient-level confounders and hospital or surgeon fixed effects, it is still possible that unmeasured confounders may bias our estimates. However, characteristics of patients, including severity of illness, were similar between operations performed on surgeons' birthdays versus other days, suggesting the validity of the quasi-randomization assumption of patients to surgeons for emergency surgeries. Second, due to the lack of detailed clinical information in the claims data, we were not able to identify the mechanisms (e.g., reductions in operation times or earlier-than-typical completion of the day's final surgery) through which patients experienced higher mortality when they received surgeries on surgeons' birthdays. Third, we were not able to analyze the cause of death due to the lack of information in our data. Finally, our analyses focused on 17 most common procedures received by Medicare patients aged 65-99 years, and therefore, may not be generalizable to other patient populations or to other surgical procedures.

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In conclusion, using national data on hospitalized Medicare beneficiaries undergoing emergency surgical procedures, we found that patients who underwent surgery on a surgeon's birthday experienced higher 30-day mortality. These findings illustrate how large data may be used to assess whether surgeon performance is influenced by life events outside of their work environment.

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Contributors: All authors conceived and designed the study, analyzed and interpreted the data, and critically revised the manuscript for important intellectual content. HK and YT conducted the statistical analysis. HK is the guarantor.

Data sharing: No additional data available.

Transparency statement: The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: This study was a retrospective observational study. No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for the design or implementation of the study. No patients were asked to advise on interpretation or writing up of

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results. There are no plans to disseminate the results of the research to study participants or the relevant patient community. The results of this work will be disseminated to the public through institutional press release, ensuing news articles, and an opinion piece authored by the study's authors that describe the study's findings for the public.

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Table 1. Characteristics of the study population

	Surgeon birthdays	Other days	P value
No. of procedures	2,064	978,812	
Age, mean (SD), yr	78.6 (8.4)	78.6 (8.4)	0.95
Female, No. (%)	1273 (61.7)	607829 (62.1)	0.69
Race/Ethnicity, No. (%)			
White	1800 (87.2)	852607 (87.1)	0.90
Black	115 (5.6)	53066 (5.4)	
Hispanic	88 (4.3)	44843 (4.6)	
Others	61 (3.0)	28296 (2.9)	
Median household income, mean (SD), $	60,665 (24,495)	61,072 (25,028)	0.46
Medicaid status, No. (%)	334 (16.2)	165548 (16.9)	0.38
Coexisting condition, No. (%)			
Congestive heart failure	256 (12.4)	127799 (13.1)	0.38
Chronic obstructive pulmonary disease	449 (21.8)	207606 (21.2)	0.55
Diabetes	565 (27.4)	266753 (27.3)	0.90
Renal failure	315 (15.3)	154544 (15.8)	0.51
Neurological disorders	274 (13.3)	122787 (12.5)	0.32
Mental illness	288 (14.0)	138170 (14.1)	0.83
Predicted mortality rate*, mean (SD), %	5.5 (6.6)	5.6 (6.8)	0.35

*The predicted mortality rate was calculated by regressing 30-day mortality on patient characteristics using a logistic regression model.

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Table 2. Association between operating surgeon's birthday and patient mortality

Day	No. of procedures	Model 1: Patient Characteristics*			Model 2: Patient Characteristics* + Hospital Fixed Effects			Model 3: Patient Characteristics* + Surgeon Fixed Effects		
		Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value
Surgeon's birthday	2,064	7.2 (6.0 to 8.4)	+1.6 (+0.4 to +2.8)	0.01	7.2 (6.0 to 8.4)	+1.6 (+0.4 to +2.8)	0.01	6.9 (5.7 to 8.1)	+1.3 (+0.1 to +2.5)	0.03
Other days	978,812	5.6 (5.5 to 5.7)	Reference		5.6 (5.6 to 5.7)	Reference		5.6 (5.6 to 5.6)	Reference	

*Patient characteristics included patient age, sex, race/ethnicity, procedure type, coexisting conditions, median household income in zip code, Medicaid status, year indicators, and day of the week of surgery.

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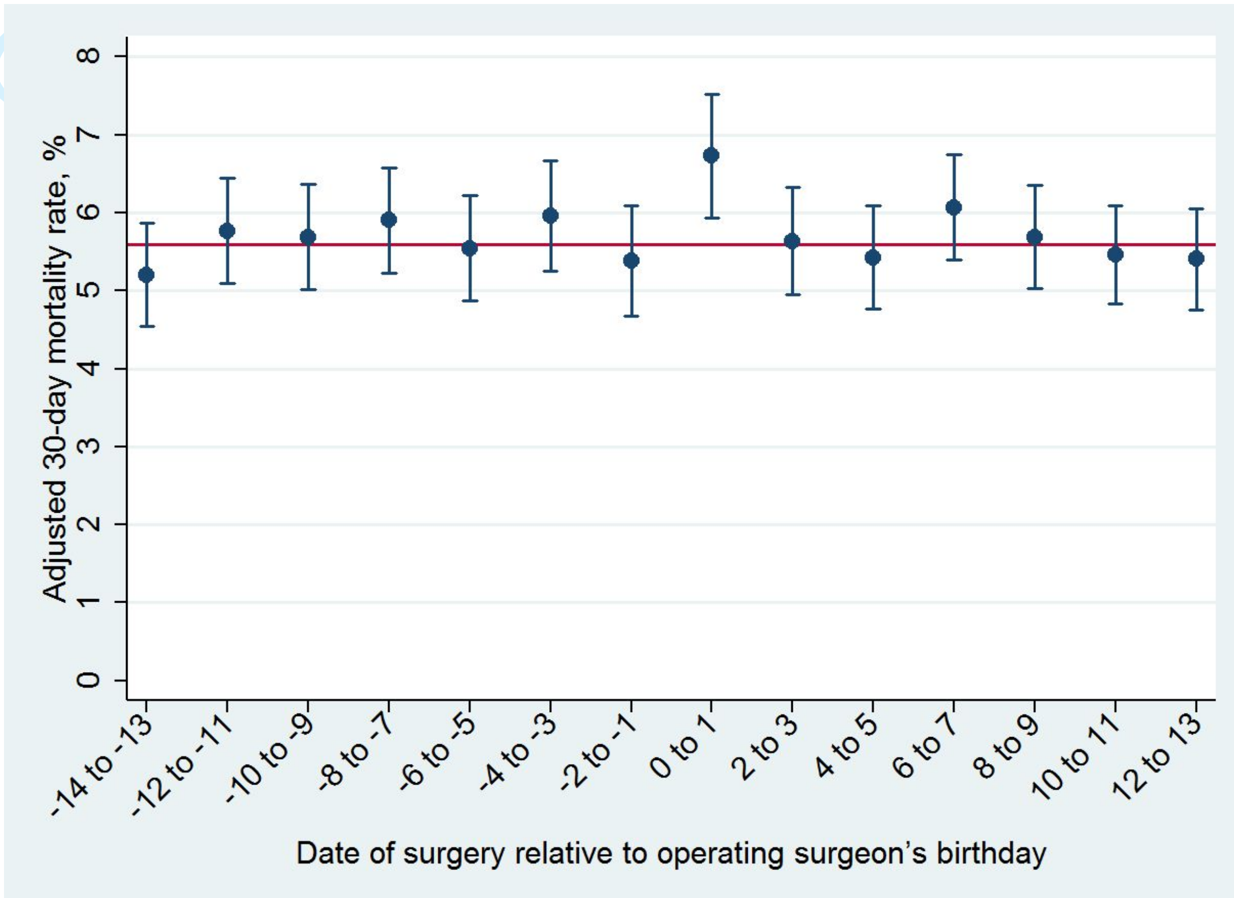
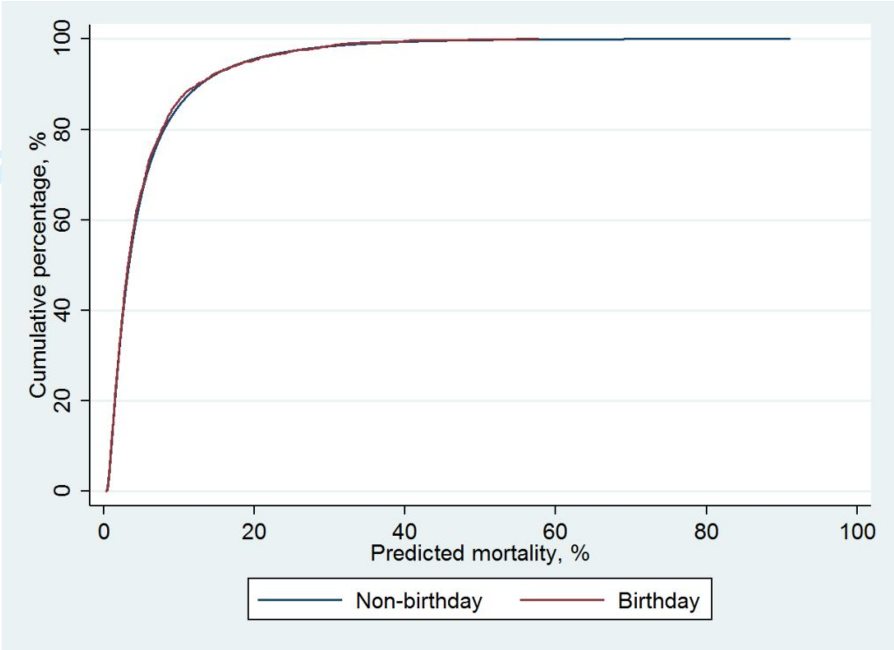
Figure 1. Adjusted 30-day mortality rates by day of surgery relative to operating surgeon's birthday, event study analysis



Notes: Figure plots adjusted 30-day mortality from an event study analysis that compared 30-day mortality of patients on the day of surgery relative to the operative surgeon's birthday, adjusting for patient characteristics and surgeon fixed effects (thereby comparing patients undergoing surgery by the same surgeon on that surgeon's birthday and surrounding days versus days other than within 2 weeks of the operating surgeon's birthday). The red horizontal line represents the adjusted mortality rate for surgical procedures performed on days other than within 2 weeks of the operating surgeon's birthday. Days were grouped into categories of two days to avoid unstable estimates arising from too few observations within single day categories. Error bars show 95% confidence intervals.

Figure 2. Comparison of predicted mortality rates of patients undergoing surgery on surgeons' birthdays vs. other days



Notes: We evaluated the cumulative distributions of predicted mortality, estimated from a regression of 30-day mortality on patient characteristics using a logistic regression model, for all patients in our sample on surgeon birthdays and other days. This figure shows that there was no difference in these distributions, and the Kolmogorov-Smirnov test comparing these distributions confirms that these distributions are not statistically significantly different (P=0.46).

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Online Supplement

Operative mortality of surgeries performed on a surgeon's birthday: observational study

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eTable 1. ICD-9 (International Classification of Diseases, 9th Edition) codes

Procedures		ICD-9 codes
Cardiovascular procedures	Coronary artery bypass grafting (CABG)	3610, 3611, 3612, 3613, 3614, 3615, 3616, 3617, 3619, 362, 363, 3631, 3632, 3633, 3634, 3639
	Carotid endarterectomy	3811, 3812
	Valve replacement	3500, 3501, 3502, 3503, 3504, 3505, 3506, 3507, 3508, 3509, 3510, 3511, 3512, 3513, 3514, 3520, 3521, 3522, 3523, 3524, 3525, 3526, 3527, 3528, 3596, 3597, 3599
	Abdominal aortic aneurysm repair	3834, 3844, 3864, 3971, 3973, 3978
Non-cardiovascular procedures	Hip and femur fracture	7855, 7865, 7905, 7915, 7925, 7935, 7945, 7955, 7965, 7975, 7985, 7995
	Colorectal resection	1731, 1732, 1733, 1734, 1735, 1736, 1739, 4571, 4572, 4573, 4574, 4575, 4576, 4579, 458, 4581, 4582, 4583, 4840, 4841, 4842, 4843, 4849, 485, 4850, 4851, 4852, 4859, 4861, 4862, 4863, 4864, 4865, 4866, 4869
	Cholecystectomy and common duct procedures	5121, 5122, 5123, 5124, 5141, 5142, 5143, 5149, 5151, 5159
	Excision lysis peritoneal adhesions	545, 5451, 5459
	Fracture or dislocation of lower extremity	7856, 7857, 7858, 7866, 7867, 7868, 7906, 7907, 7908, 7916, 7917, 7918, 7926, 7927, 7928, 7936, 7937, 7938, 7946, 7956, 7966, 7967, 7968, 7976, 7977, 7978, 7986, 7987, 7988, 7996, 7997, 7998
	Lung resection	3220, 3221, 3222, 3223, 3224, 3225, 3226, 3227, 3229, 323, 3230, 3239, 324, 3241, 3249, 325, 3250, 3259
	Amputation of lower extremity	8410, 8411, 8412, 8413, 8414, 8415, 8416, 8417, 8418, 8419
	Nephrectomy	5501, 5502, 5503, 5504, 5511, 5512
	Appendectomy	470, 4701, 4709, 471, 4711, 4719
	Small bowel resection	4561, 4562, 4563
	Spinal fusion	8100, 8101, 8102, 8103, 8104, 8105, 8106, 8107, 8108, 8109, 8130, 8131, 8132, 8133, 8134, 8135, 8136, 8137, 8138, 8139, 8161, 8162, 8163, 8164, 8451
	Gastrectomy	435, 436, 437, 4381, 4382, 4389, 4391, 4399
	Splenectomy	411, 412, 4141, 4142, 4143, 415, 4193, 4195, 4199

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eTable 2. Types of procedures performed on surgeons' birthdays and other days

	Surgeon's birthday	Other days
No. of procedures	2,064	963,935
Type of procedure, No. (%)		
Coronary artery bypass grafting (CABG)	134 (6.5)	63633 (6.5)
Carotid endarterectomy	36 (1.7)	17547 (1.8)
Valve replacement	45 (2.2)	20160 (2.1)
Abdominal aortic aneurysm repair	43 (2.1)	15142 (1.6)
Hip and femur fracture	734 (35.6)	364817 (37.3)
Colorectal resection	132 (6.4)	66355 (6.8)
Cholecystectomy and common duct procedures	292 (14.2)	135279 (13.8)
Excision lysis peritoneal adhesions	158 (7.7)	77387 (7.9)
Fracture or dislocation of lower extremity	147 (7.1)	63295 (6.5)
Lung resection	14 (0.7)	5370 (0.6)
Amputation of lower extremity	68 (3.3)	28995 (3.0)
Nephrectomy	6 (0.3)	3395 (0.4)
Appendectomy	98 (4.8)	41434 (4.2)
Small bowel resection	82 (4.0)	38779 (4.0)
Spinal fusion	66 (3.2)	30340 (3.1)
Gastrectomy	4 (0.2)	3403 (0.4)
Splenectomy	5 (0.2)	3481 (0.4)

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eTable 3. Adjusted 30-day mortality rates by day of surgery relative to a surgeon's birthday

	No. of procedures	Model 3: Patient Characteristics* + Surgeon Fixed Effects		
		Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value
Other days	906,999	5.6 (5.6 to 5.6)	Reference	
13-14 days before surgery	5,450	5.2 (4.5 to 5.9)	-0.4 (-0.4 to +1.0)	0.25
11-12 days before surgery	5,478	5.8 (5.1 to 6.4)	+0.2 (-0.4 to +1.0)	0.62
9-10 days before surgery	5,512	5.7 (5.0 to 6.4)	+0.1 (-0.4 to +1.0)	0.79
7-8 days before surgery	5,618	5.9 (5.2 to 6.6)	+0.3 (-0.4 to +1.0)	0.37
5-6 days before surgery	5,310	5.5 (4.9 to 6.2)	-0.1 (-0.7 to +0.6)	0.88
3-4 days before surgery	5,076	6.0 (5.3 to 6.7)	+0.4 (-0.3 to +1.1)	0.31
1-2 day(s) before surgery	4,693	5.4 (4.7 to 6.1)	-0.2 (-0.9 to +0.5)	0.55
Surgery day + 1 day after surgery	4,539	6.7 (5.9 to 7.5)	+1.1 (+0.3 to +1.9)	0.01
2-3 days after surgery	5,187	5.6 (4.9 to 6.3)	+0.04 (-0.7 to +0.7)	0.91
4-5 days after surgery	5,381	5.4 (4.8 to 6.1)	-0.2 (-0.8 to +0.5)	0.62
6-7 days after surgery	5,559	6.1 (5.4 to 6.7)	+0.5 (-0.2 to +1.2)	0.18
8-9 days after surgery	5,334	5.7 (5.0 to 6.4)	+0.1 (-0.6 to +0.8)	0.78
10-11 days after surgery	5,366	5.5 (4.8 to 6.1)	-0.1 (-0.8 to +0.5)	0.66
12-13 days after surgery	5,374	5.4 (4.8 to 6.1)	-0.2 (-0.8 to +0.5)	0.57

*Patient characteristics included patient age, sex, race/ethnicity, procedure type, coexisting conditions, median household income estimated from residential zip codes, Medicaid status, year indicators, day of the week of surgery.

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eTable 4. Association between operating surgeon's birthday and in-hospital mortality rate

Day	No. of procedures	Model 1: Patient Characteristics*			Model 2: Patient Characteristics* + Hospital Fixed Effects			Model 3: Patient Characteristics* + Surgeon Fixed Effects		
		Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value
Surgeon's birthday	2,064	5.0 (4.0 to 6.1)	+1.5 (+0.4 to +2.5)	0.01	5.0 (4.0 to 6.1)	+1.5 (+0.4 to +2.5)	0.01	4.8 (3.7 to 5.8)	+1.2 (+0.2 to +2.2)	0.02
Other days	978,812	3.6 (3.5 to 3.6)	Reference		3.6 (3.5 to 3.6)	Reference		3.6 (3.6 to 3.6)	Reference	

*Patient characteristics included patient age, sex, race/ethnicity, procedure type, coexisting conditions, median household income estimated from residential zip codes, Medicaid status, year indicators, and day of the week of surgery.

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eTable 5. Association between operating surgeon's birthday and 30-day mortality, with further adjustment for the timing of surgery

Day	No. of procedures	Model 1: Patient Characteristics*			Model 2: Patient Characteristics* + Hospital Fixed Effects			Model 3: Patient Characteristics* + Surgeon Fixed Effects		
		Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value
Surgeon's birthday	2,064	7.2 (6.0 to 8.4)	+1.6 (+0.4 to +2.8)	0.01	7.2 (6.0 to 8.4)	+1.6 (+0.4 to +2.8)	0.01	6.9 (5.7 to 8.1)	+1.3 (+0.1 to +2.5)	0.03
Other days	978,812	5.6 (5.5 to 5.7)	Reference		5.6 (5.6 to 5.7)	Reference		5.6 (5.6 to 5.6)	Reference	

*Patient characteristics included patient age, sex, race/ethnicity, procedure type, coexisting conditions, median household income estimated from residential zip codes, Medicaid status, year indicators, day of the week of surgery, and timing of surgery. The timing of surgery was calculated as the date of surgery minus the date of admission. This analysis was conducted to assess whether delays in surgery could confound our analysis if, for example, surgeries among healthier patients were postponed by surgeons to be occur on the day after a birthday, which would lead to birthday surgeries being performed on systematically sicker patients.

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eTable 6. Association between operating surgeon's birthday and patient mortality, including both hospital and surgeon fixed effects

Day	No. of procedures	Patient Characteristics* + Hospital Fixed Effects + Surgeon Fixed Effects		
		Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value
Surgeon's birthday	2,064	6.9 (5.7 to 8.1)	+1.3 (+0.1 to +2.5)	0.03
Other days	978,812	5.6 (5.6 to 5.6)	Reference	

*Patient characteristics included patient age, sex, race/ethnicity, procedure type, coexisting conditions, median household income in zip code, Medicaid status, year indicators, and day of the week of surgery.

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eTable 7. Association between operating surgeon's birthday and patient mortality, excluding physicians with the highest mortality (top 1%)

Day	No. of procedures	Model 1: Patient Characteristics*			Model 2: Patient Characteristics* + Hospital Fixed Effects			Model 3: Patient Characteristics* + Surgeon Fixed Effects		
		Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value	Adjusted mortality rate, % (95% CI)	Adjusted difference, % (95% CI)	P value
Surgeon's birthday	2,059	7.0 (5.8 to 8.2)	+1.5 (+0.3 to +2.7)	0.02	7.0 (5.8 to 8.2)	+1.5 (+0.3 to +2.7)	0.02	6.8 (5.7 to 8.0)	+1.3 (+0.1 to +2.5)	0.03
Other days	977,907	5.5 (5.5 to 5.6)	Reference		5.5 (5.5 to 5.6)	Reference		5.5 (5.5 to 5.5)	Reference	

*Patient characteristics included patient age, sex, race/ethnicity, procedure type, coexisting conditions, median household income in zip code, Medicaid status, year indicators, and day of the week of surgery.

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eTable 8. Association between operating surgeon's birthday and 30-day mortality, using logistic regression models

Day	Model 2: Patient Characteristics* + Hospital Fixed Effects			Model 3: Patient Characteristics* + Surgeon Fixed Effects		
	No. of procedures	Adjusted odds ratio (95% CI)	P-value	No. of procedures	Adjusted odds ratio (95% CI)	P-value
Surgeon's birthday	2,041	1.33 (1.09 to 1.64)	0.01	1,577	1.25 (1.01 to 1.56)	0.04
Other days	969,849	Reference		742,821	Reference	

*Patient characteristics included patient age, sex, race/ethnicity, procedure type, coexisting conditions, median household income estimated from residential zip codes, Medicaid status, year indicators, and day of the week of surgery.

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eTable 9. Association between operating surgeon's birthday and patient mortality, by types of procedures

Type of procedure	No. of procedures	Model 3: Patient Characteristics* + Surgeon Fixed Effects	
		Adjusted difference, % (95% CI)	P value
Coronary artery bypass grafting (CABG)	63767	+2.8 (-1.4 to +7.0)	0.19
Carotid endarterectomy	17583	-1.2 (-2.9 to +0.6)	0.18
Valve replacement	20205	+6.9 (-2.5 to +16.3)	0.15
Abdominal aortic aneurysm repair	15185	+1.0 (-10.8 to +12.8)	0.87
Hip and femur fracture	365551	+0.3 (-1.3 to +1.9)	0.72
Colorectal resection	66487	+0.6 (-5.6 to +6.7)	0.86
Cholecystectomy and common duct procedures	135571	-1.0 (-2.6 to +0.5)	0.20
Excision lysis peritoneal adhesions	77545	+1.5 (-3.4 to +6.3)	0.56
Fracture or dislocation of lower extremity	63442	+0.8 (-1.8 to +3.5)	0.55
Lung resection	5384	+0.6 (-2.5 to +3.8)	0.68
Amputation of lower extremity	29063	+11.3 (+0.6 to +22.1)	0.04
Appendectomy	41532	+0.2 (-2.5 to +2.8)	0.90
Small bowel resection	38861	+9.5 (+0.2 to +18.9)	0.05
Spinal fusion	30406	+4.6 (-1.0 to +10.3)	0.11

*Patient characteristics included patient age, sex, race/ethnicity, coexisting conditions, median household income estimated from residential zip codes, Medicaid status, year indicators, and day of the week of surgery.

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eTable 10. Association between operating surgeon's birthday and 30-day mortality, according to milestone birthdays occurring at age 40, age 50, and age 60

	Model 2: Patient Characteristics* + Hospital Fixed Effects		Model 3: Patient Characteristics* + Surgeon Fixed Effects	
	Adjusted difference, % (95% CI)	P value	Adjusted difference, % (95% CI)	P value
Surgeon's birthday	+1.8 (+0.5 to +3.0)	0.01	+1.4 (+0.2 to +2.7)	0.02
Age 40, 50, 60	+0.05 (-0.1 to +0.2)	0.57	-0.01 (-0.2 to +0.2)	0.91
Surgeon's birthday × Age 40, 50, 60	-2.0 (-6.5 to +2.4)	0.37	-1.5 (-5.8 to +2.9)	0.52

*Patient characteristics included age, sex, race/ethnicity, procedure type, coexisting conditions, median household income estimated from residential zip codes of residence, Medicaid status, year indicators, and day of the week of surgery.

Notes: We regressed patient 30-day mortality on an indicator for the surgeon's birthday, an indicator for whether surgeons were milestone ages (i.e., 40, 50 and 60 years), and an interaction between the two variables, adjusted for patient characteristics and surgeon fixed effects. We added the interaction between the surgeon's birthday and milestone ages in our models to examine whether the association between surgeon's birthday and patient mortality varied according to whether an operation occurred on a milestone birthday. The interaction term was not statistically significant (P = 0.52) after adjusting for patient characteristics and surgeon fixed effects.

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eTable 11. Association between operating surgeon's birthday and 30-day mortality, according to whether birthday occurred on a Friday

	Model 2: Patient Characteristics* + Hospital Fixed Effects		Model 3: Patient Characteristics* + Hospital Fixed Effects	
	Adjusted difference, % (95% CI)	P value	Adjusted difference, % (95% CI)	P value
Surgeon's birthday	+2.0 (+0.5 to +3.5)	0.01	+1.6 (+0.1 to +3.1)	0.03
Friday	-0.2 (-0.4 to -0.03)	0.02	-0.2 (-0.4 to -0.02)	0.03
Surgery day × Friday	-1.7 (-4.6 to +1.2)	0.25	-1.2 (-4.1 to +1.7)	0.40

*Patient characteristics included age, sex, race/ethnicity, procedure type, coexisting conditions, median household income estimated from residential zip codes of residence, Medicaid status, year indicators, and day of the week of surgery.

Notes: We regressed patient 30-day mortality on an indicator for the surgeon's birthday, an indicator for Friday (reference category was Monday), and an interaction between the two variables, adjusted for patient characteristics and surgeon fixed effects. We added the interaction between the surgeon's birthday and an indicator for Friday in our models to examine whether the association between the surgeon's birthday and patient mortality varied according to whether an operation occurred on a Friday. The interaction term was not statistically significant (P = 0.40) after adjusting for patient characteristics and surgeon fixed effects.

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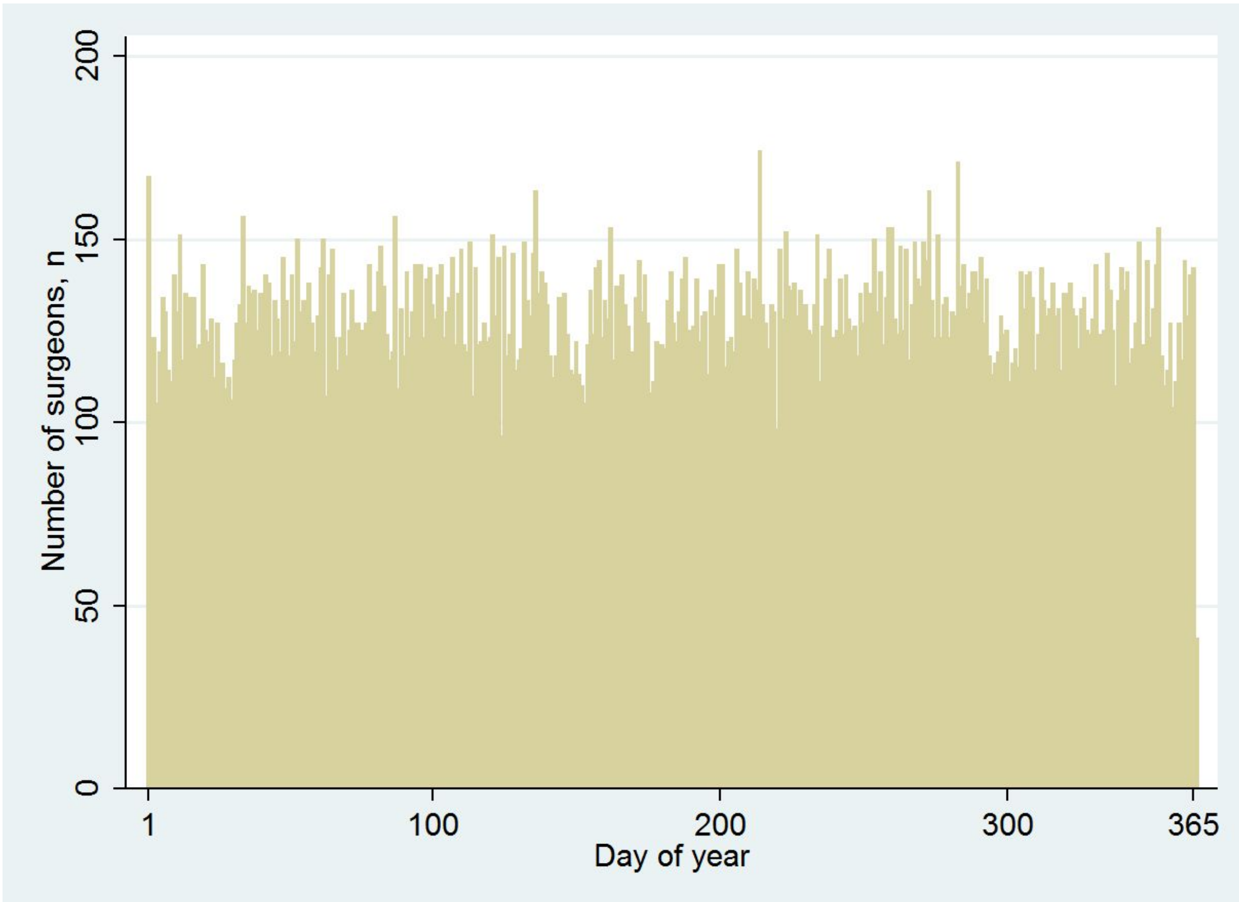
eFigure 1. Distribution of surgeons' birthdays



Notes: This figure shows the distribution of 47,489 surgeons' birthdays.

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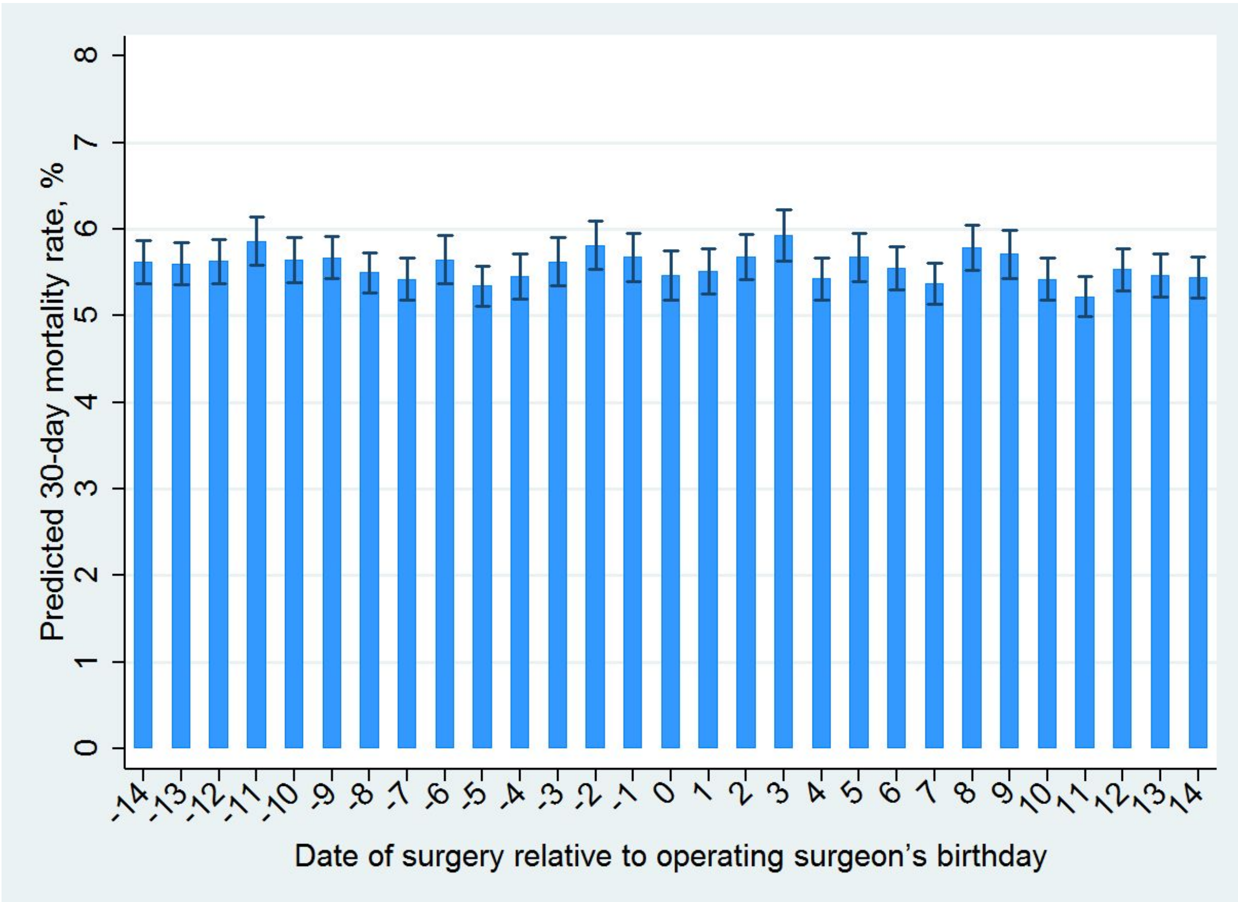
eFigure 2. Patient's illness severity by date



Predicted mortality was estimated from a regression of 30-day mortality on patient characteristics using a logistic regression model. The purpose of this analysis was to investigate for selection bias by analyzing whether predicted mortality differed for patients who underwent surgery on the day of the operating surgeon's birthday versus surrounding days. Error bars show 95% confidence intervals.

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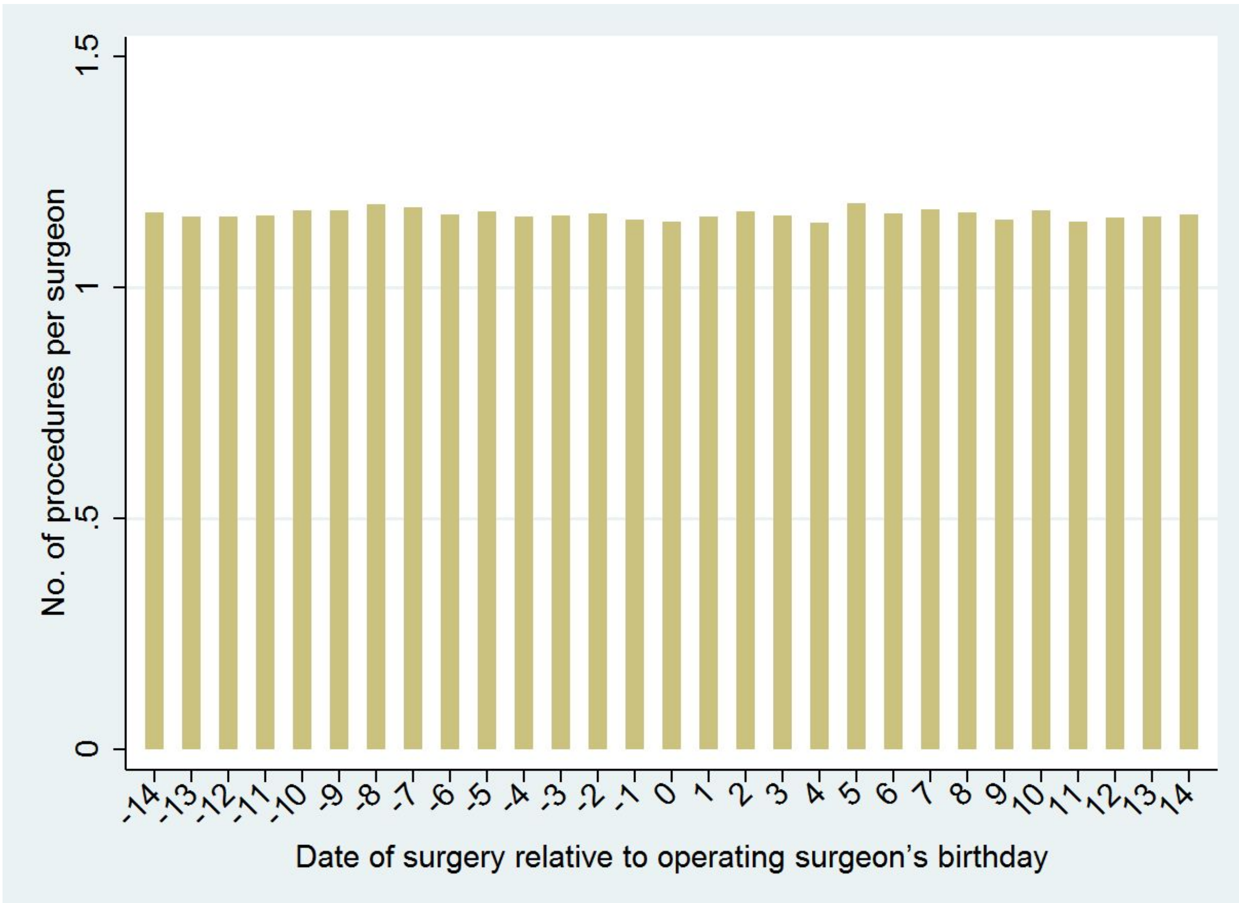
eFigure 3. Number of procedures per surgeon, by day of surgery



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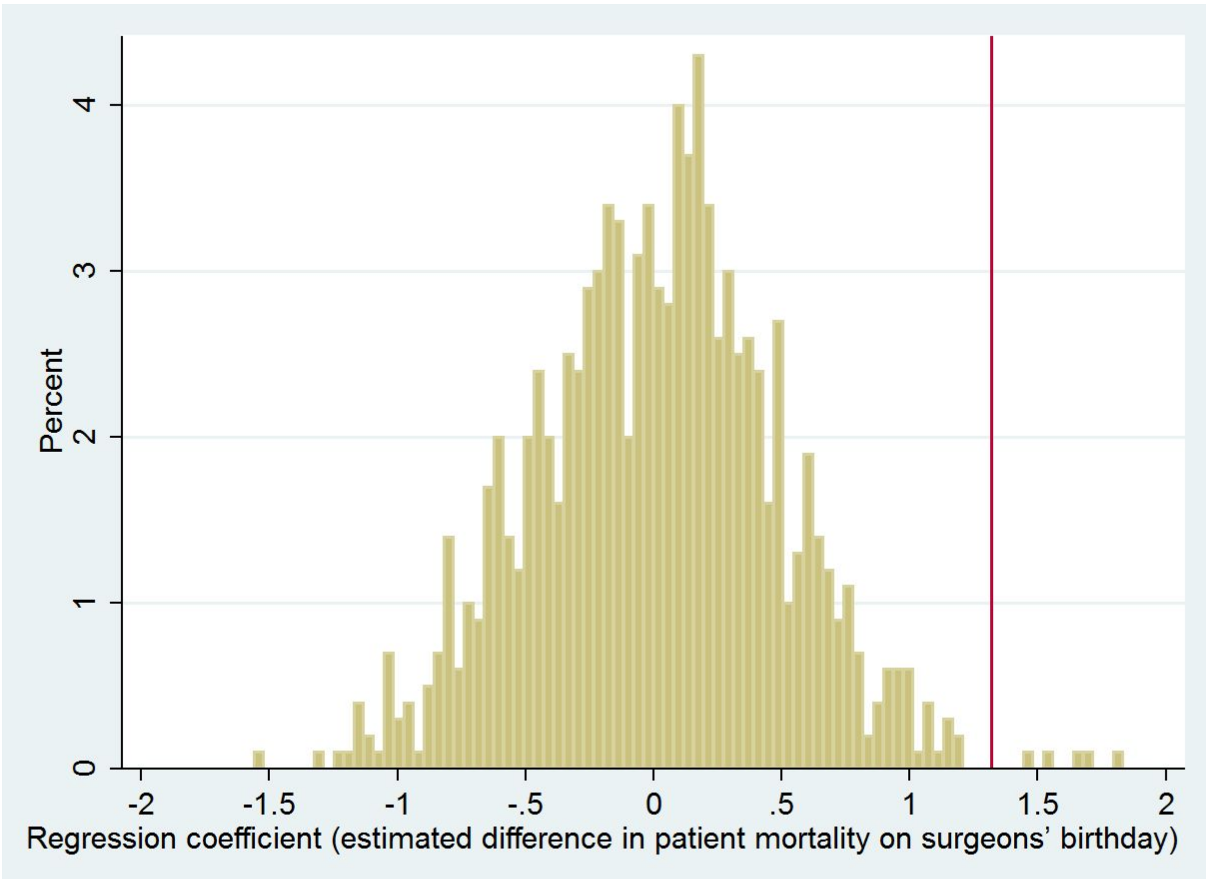
eFigure 4. Distribution of regression estimates from a simulation



Notes: The vertical red line represents the excess patient mortality on surgeons' birthdays (compared with other days) estimated in our analysis. The purpose of this analysis was to examine whether the observed increase in operative mortality for surgeries performed on a surgeon's birthday could be due to random chance, assessed by a simulation approach that estimated 1000 identical regressions that varied only in a randomly-generated 'placebo' birthday assigned to each surgeon in our data.

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