Patient mortality after surgery on the surgeon's birthday: observational study

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ABSTRACT

OBJECTIVE
To determine whether patient mortality after surgery differs between surgeries performed on surgeons' birthdays compared with 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 one of 17 common emergency surgical procedures in 2011-14.

MAIN OUTCOME MEASURES
Patient postoperative 30 day mortality, defined as death within 30 days after surgery, with adjustment for patient characteristics and surgeon fixed effects.

RESULTS
980 876 procedures performed by 47 489 surgeons were analyzed. 2064 (0.2%) of the procedures were performed on surgeons' birthdays. Patient characteristics, including severity of illness, were similar between patients who underwent surgery on a surgeon's birthday and those who underwent surgery on other days. The overall unadjusted 30 day mortality on the operating surgeon's birthday was 7.0% (145/2064) and that on other days was 5.6% (54 824/978 812). After adjusting for patient characteristics and surgeon fixed effects (effectively comparing outcomes of patients treated by the same surgeon on different days), patients who underwent surgery on a surgeon's birthday exhibited higher mortality compared with patients who underwent surgery on other days (adjusted mortality rate, 6.9% *v* 5.6%; adjusted difference 1.3%, 95% confidence interval 0.1% to 2.5%; P=0.03). Event study analysis of patient mortality by day of surgery relative to a surgeon's birthday found similar results.

CONCLUSIONS
Among Medicare beneficiaries who underwent common emergency surgeries, those who received surgery on the surgeon's birthday experienced higher mortality compared with patients who underwent surgery on other days. These findings suggest that surgeons might be distracted by life events that are not directly related to work.

WHAT IS ALREADY KNOWN ON THIS TOPIC

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 about how distractions in surgery affect patient outcomes

Operations performed on surgeons' birthdays might 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

Patients who underwent common emergency surgical procedures on the operating surgeon's birthday showed higher 30 day mortality compared with patients who underwent surgery on other days of the year

These findings suggest that a surgeon's performance might be affected by potentially distracting life events that are not directly related to work

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] The quality of surgical care is not always optimal; however, 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 level and physician level factors influence surgical outcomes,[18-20] the role of distractions has received little empirical investigation. Distractions are common in the operating room, including noise (eg, calls from ward, beeper pages), problems with the equipment, 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 during surgery affect patient outcomes. Outside of healthcare, 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 might 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 feel rushed to finish procedures on their birthdays, and therefore patient outcomes might worsen on those days. To test this hypothesis, we used national data on Medicare beneficiaries aged 65 to 99 years in the US who underwent one of 17 common surgeries between 2011

and 2014, linked to information on surgeon birthdays, to examine whether patients' postoperative 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 2011-14. To minimize the impact of potential selection bias from surgeons choosing patients based on illness severity, or patients choosing surgeons based on their preference, we focused our analyses on emergency procedures (defined as emergent or urgent admissions or admissions from trauma centers) identified using claim inpatient admission type code.[32 33] To ensure that procedures were emergencies, we also restricted analysis to surgeries performed within three days of hospital admission.[34-36] To avoid patients' care preferences (including end-of-life care) affecting postoperative mortality, we excluded patients with cancer and patients discharged to hospice care. We also excluded patients who left hospital against medical advice. To allow for sufficient follow-up after surgery, we excluded from our analyses those patients who underwent procedures in December 2014.

We identified all patients who underwent one of 17 major surgical procedures: four common cardiovascular surgeries examined in previous studies (carotid endarterectomy, heart valve procedures, coronary artery bypass grafting, and abdominal aortic aneurysm repair),[18 32 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 resection, amputation of lower extremity, nephrectomy, appendectomy, small bowel resection, spinal fusion, gastrectomy, and splenectomy). Supplementary eTable 1A provides a list of ICD-9 (international classification of disease, ninth revision) codes.

Surgeon characteristics

We used the national provider identifier listed in the operating physician field of the inpatient claim to identify the surgeon who performed each procedure, an approach validated in previous studies.[18 35 37 39] Surgeon characteristics were obtained from the Centers for Medicare & Medicaid Services' MD-PPAS file, which includes information on the surgeon's birthday, sex, and specialty. About 98% of our Medicare beneficiary data could be linked to the MD-PPAS file using the national provider identifier. Data on surgeons' birthdays in MD-PPAS file were extracted from the Medicare Provider Enrollment, Chain, and Ownership System, and the proportion of missing data on birthday was 0.01% in 2017.[40]

Patient outcomes

The primary outcome was 30 day mortality, defined as death within 30 days after surgery. 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.[41] We excluded less than 1% of patients whose death dates were not verified.

Adjustment variables

Depending on the model, we adjusted for patient characteristics and hospital or surgeon fixed effects. Patient characteristics included the type of procedure (indicator variables for 17 surgical procedures), age (a continuous variable with quadratic and cubic terms, allowing for a non-linear relationship), sex, race and ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), indicator variables for 24 comorbidities (Elixhauser comorbidity index),[42] median household income estimated from residential zip codes (as a continuous variable with 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 might have worse outcomes[43 44]). 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 time invariant measured and 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.[45 46]

Statistical analysis

We 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 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 his or her birthday to examine whether surgeons changed their decision to perform surgeries (eg, their operative volume) on their birthdays. Finally, we compared the characteristics of surgeons who performed procedures on their birthdays with those who did not.

Next, we compared the operative mortality of patients who underwent surgery on an operating surgeon's birthday with 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 fixed effects, a within surgeon analysis that compared outcomes for surgeries performed on surgeons' birthdays versus other days on which the same surgeon operated. The analyses adjusting for hospital fixed effects (model 2) compared outcomes of patients treated at the same hospital and therefore relied on variation between surgeons within the same hospital. In contrast, the analyses adjusting for physician fixed effects (model 3) compared outcomes of patients who underwent surgery by the same surgeon, effectively addressing the research question of whether individual surgeons perform differently on their birthday compared with other days of the year. 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, owing to a large number of fixed effects.[47 48] Standard errors were clustered at the surgeon level to account for potential correlation between patient outcomes within the same surgeon. After fitting regression models, we calculated adjusted patient outcomes using the marginal standardization form of predictive margins.[49]

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 from relatively small sample sizes for any given day, we grouped every two days into a single category for the event study analysis (we did not group days for all other analyses). We then calculated adjusted 30 day mortality rates for each date within two 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 a series of secondary analyses.

- 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.
- To address the possibility that some surgeons might manipulate the timing of operations (eg, postpone non-urgent surgical procedures) based on their birthday, in our regression analyses, we tested whether findings were affected by additional adjustment for the timing of surgery (date of surgery relative to admission date).
- To test whether our findings were affected by including both hospital and surgeon fixed effects in the same regression models.

- To test the possibility that a small number of outlier surgeons might dominate our findings, we reanalyzed the data after excluding the top 1% of surgeons with the highest patient mortality.
- We used logistic regression models instead of linear probability models, adjusting for patient characteristics and hospital or surgeon fixed effects.
- To test whether our findings were sensitive to the model specification, we fitted random effects models instead of fixed effects models, adjusting for patient characteristics and hospital or surgeon random effects.
- To address the possibility that some surgeons might choose not to work on their birthdays, we reanalyzed our data restricting to surgeons who performed procedures on their birthdays in our sample (ie, excluding surgeons who performed no surgeries on their birthdays). This problem was also addressed by including surgeon fixed effects in model 3.
- To examine the possibility that other events on surgeons' birthdays, other than the birthday itself, might affect patient mortality, we reanalyzed the data after additionally adjusting for the day of the year of surgery (ie, indicator variables for the calendar date).
- As there might be outlier birthdays on which a larger than expected number of surgeons reported birthdays, we reanalyzed the data after excluding surgeons who were born on these days.
- We conducted a stratified analysis by the individual procedures received by patients, adjusted for patient characteristics and surgeon fixed effects (model 3). To avoid unstable estimates as a result of small sample sizes, we restricted our analyses to procedures for which the number of surgeries was more than 10 on a surgeon's birthday.
- To test whether our findings were explained by random chance, we examined the association between surgeons' half birthdays (calculated by adding 183 days to operating surgeons' birthday) and patient mortality.
- For the same reason, we also conducted a simulation analysis assigning randomly generated "pseudo-birthdays" to surgeons and examined the association between these pseudo-birthdays and 30 day mortality in 1000 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 with the estimates obtained in our baseline multivariable analysis that included patient characteristics and surgeon fixed effects (model 3).
- We reanalyzed the data using more restrictive definitions of emergency surgeries, defined as 10 procedures with the highest average mortality, or patients with the highest severity of illness (in the top 25% of predicted 30 day mortality).

- We examined the association between surgeons' birthdays and patient mortality for elective procedures (defined as surgeries performed during elective admissions), and between surgeons' birthdays and complications for emergency procedures, defined as whether patients experienced at least one complication measure related to surgeons' performance in Agency for Health Research and Quality's Patient Safety Indicators: retained surgical item or unretrieved device fragment count (PSI 05), perioperative hemorrhage or hematoma (PSI 08), and postoperative wound dehiscence (PSI 14).[33]

- To test the hypothesis that surgeons might feel particularly rushed to complete surgeries on birthdays with a high volume of procedures, we calculated the number of total procedures (including both elective and emergency) performed by each surgeon. After adjusting for potential confounders (including hospital or surgeon fixed effects), we then compared postoperative mortality of patients who underwent emergency surgeries among three groups: patients who underwent surgery on the operating surgeon's birthday, when the surgeon was performing a high volume (above mean) of procedures on that day; patients who underwent surgery on the operating surgeon's birthday, when the surgeon was performing a low volume (below mean) of procedures on that day; and patients who underwent surgery on days other than the operating surgeon's birthday.

- 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 might lead to greater distraction. We investigated the association between 30 day mortality and surgeon's birthday at milestone ages (ie, 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 occurred on a Friday versus on a Monday to Thursday, hypothesizing that Friday birthdays might 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) for all analyses.

Patient and public involvement

Although we support the importance of patient and public involvement, this was a secondary data analysis of existing claims data where the records were not available for patients or members of the public for analysis and as such it was not practical to involve them as members of this research study.

Results

Characteristics of study population

The study sample included 980 876 procedures performed by 47 489 surgeons, whose birthdays were evenly distributed throughout the year (supplementary eFigure 1). Among those procedures, 2064 (0.2%) were performed on surgeons' birthdays. Patients who underwent operations on surgeons' birthdays had similar characteristics, including personal, comorbidities, procedure type, and predicted mortality, to those who underwent operations on other days (table 1 and supplementary eTable 2). For example, the mean predicted mortality rate of patients who underwent surgery on surgeons' birthdays was similar to that of patients who underwent surgery on other days (5.5% v 5.6%; P=0.35). Moreover, no significant difference was observed in the distributions of predicted mortality between patients who underwent surgery on surgeons' birthdays and those who underwent surgery on other days (supplementary eFigure 2). Predicted mortality was also similar for operations performed in the 14 days before or after the surgeons' birthdays (supplementary eFigure 3). The average number of surgical procedures performed by each surgeon was similar between birthdays and other days (supplementary eFigure 4). These findings suggest that surgeons did not selectively choose which patients to operate on on their birthdays on the basis of patient characteristics, including illness severity. Surgeons who worked on their birthday were on average older and more likely to be men (supplementary eTable 3), although these differences did not affect the results of analyses that adjusted for surgeon fixed effects (effectively comparing outcomes of patients treated by the same surgeon).

Mortality rates

The overall unadjusted 30 day mortality of patients on the surgeon's birthday was 7.0% (145/2064), 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 (7.2% v 5.6%; adjusted difference 1.6%, 95% confidence interval 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 with other days (6.9% v 5.6%; adjusted difference 1.3%, 0.1% to 2.5%; P=0.03). In an event study analysis, 30 day mortality was higher for surgeries that were performed on a surgeon's birthday compared with other days (fig 1 and supplementary eTable 4).

Secondary analyses

Findings were qualitatively unaffected by: using in-hospital mortality instead of 30 day mortality;

Table 1 | Characteristics of patients who underwent surgery on the surgeon's birthday or on other days. Values are numbers (percentages) unless stated otherwise

Characteristics	Surgeon's birthdays	Other days	P value
No of procedures	2064	978 812	
Mean (SD) age (years)	78.6 (8.4)	78.6 (8.4)	0.95
Women	1273 (61.7)	607 829 (62.1)	0.69
Race or ethnicity:			
White	1800 (87.2)	852 607 (87.1)	
Black	115 (5.6)	53 066 (5.4)	
Hispanic	88 (4.3)	44 843 (4.6)	0.90
Others	61 (3.0)	28 296 (2.9)	
Mean (SD) of median household income ($)	60 665 (24 495)	61 072 (25 028)	0.46
Medicaid status	334 (16.2)	165 548 (16.9)	0.38
Coexisting condition:			
Congestive heart failure	256 (12.4)	127 799 (13.1)	0.38
Chronic obstructive pulmonary disease	449 (21.8)	207 606 (21.2)	0.55
Diabetes	565 (27.4)	266 753 (27.3)	0.90
Renal failure	315 (15.3)	154 544 (15.8)	0.51
Neurological disorders	274 (13.3)	122 787 (12.5)	0.32
Mental illness	288 (14.0)	138 170 (14.1)	0.83
Mean (SD) predicted mortality rate* (%)	5.5 (6.6)	5.6 (6.8)	0.35

$1.00 (£0.76; €0.84).
*Calculated by regressing 30 day mortality on patient characteristics using a logistic regression model.

additionally adjusting for the timing of the surgery; including both hospital and surgeon fixed effects in the same regression models; excluding potentially outlier surgeons with the highest mortality; using logistic regression models instead of linear probability models: using random effects models instead of fixed effects models; restricting our analysis to surgeons who performed procedures on their birthdays; additionally adjusting for the day of the year; or excluding surgeons who were born on the outlier birthdays (supplementary eTables 5-13). Although the differences were not statistically significant for most procedures owing to small sample sizes, point estimates showed higher patient mortality on the operating surgeon's birthday for all procedures included in the stratified analysis except for two: carotid endarterectomy and cholecystectomy and common duct procedures (supplementary eTable 14).

No evidence was found that patients who received surgery on operating surgeons' half birthdays experienced higher mortality compared with patients who underwent surgery on other days, indicating that the findings could not be explained by chance (supplementary eTable 15). Also, the observed increase in patient mortality on surgeons' birthdays was larger than 99.5% of simulated coefficients obtained by randomly assigning pseudo-birthdays and fitting similar regression models 1000 times (supplementary

eFigure 5). The study findings were qualitatively unaffected when the analysis was restricted to procedures with the highest average mortality or to patients with the highest severity of illness (supplementary eTables 16 and 17). No evidence was found for patient mortality being higher on surgeons' birthdays for elective surgeries (supplementary eTable 18). Also, no evidence was found for complication rates differing for patients who underwent a surgical procedure on the surgeon's birthday, perhaps related to the narrowness of the Agency for Health Research and Quality's Patient Safety Indicators for surgery (supplementary eTable 19).

Patient mortality was found to be higher when surgeons performed many procedures on their birthday, compared with when surgeons performed a smaller number of procedures on their birthday, although the difference was not statistically significant (supplementary eTable 20). The association between surgeon's birthday and patient outcomes did not differ based on milestone birthdays or when the birthdays were on a Friday (supplementary eTables 21 and 22).

Discussion

Using a national sample of Medicare beneficiaries who underwent common emergency surgical procedures, we found that postoperative 30 day mortality was higher in patients who underwent a surgical procedure

Table 2 | Association between surgeon's birthday and patient postoperative 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	2064	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 or ethnicity, procedure type, coexisting conditions, median household income in zip code, Medicaid status, year indicators, and surgical day of the week.
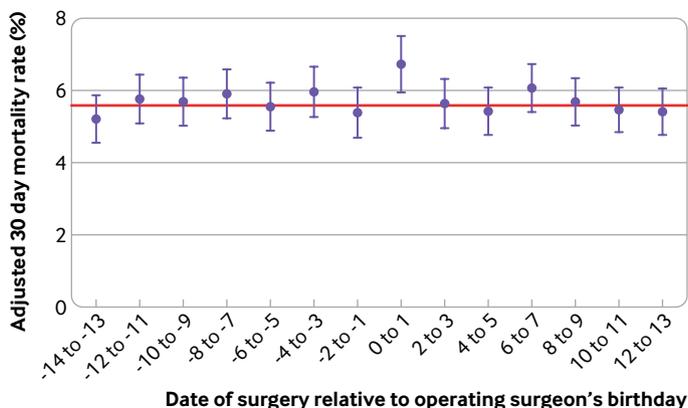
Fig 1 | Adjusted 30 day patient mortality rates from an event study (adjusting for patient characteristics and surgeon fixed effects). Red horizontal line represents adjusted mortality rate for surgical procedures performed on days other than within two weeks of operating surgeon's birthday. Days were grouped into categories of two days to avoid unstable estimates. Error bars show 95% confidence intervals

on an operating surgeon's birthday 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 with patients who underwent surgery by that same surgeon on other days of the year. No difference was found in a broad range of patient characteristics, including predicted mortality 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 patient factors. Taken together, these findings suggest that a surgeon's performance might be affected by life events that are not directly related to work, a hypothesis that while intuitive has been otherwise difficult to assess owing to lack of detailed information on events that are potentially distracting to an individual surgeon. Although the average number of surgical procedures performed by each surgeon was similar between birthdays and other days, indicating that surgeons who work on their birthdays do not reduce their operative volume on that day, we found that some surgeons did not work on their birthdays (1805 surgeons performed procedures on their birthday versus 2144 surgeons one day before their birthday and 2027 surgeons one day after their birthday). This does not affect the results of analyses using surgeon fixed effects, as patient outcomes were compared between birthday and non-birthday surgeries within the same surgeon; however, this does suggest that birthdays are an important enough factor for some surgeons to choose not to operate on that day, which supports the credibility of our assumption that a birthday could be a distracting factor for those surgeons who choose to operate on that day.

The effect size of surgeons' birthday observed in our analysis (1.3 percentage point increase or a 23% increase in mortality), though substantial, is comparable to the impact of other events, including holidays (eg, Christmas and New Year) and weekends, which have been argued to affect the quality of patient care.[50-52] For example, patients who were emergently admitted to hospitals on public holidays in Scotland showed a 27% increase in 30 day mortality compared with patients admitted on other days.[50] Our use of surgeon birthdays as a "natural experiment" is arguably better than using other distracting events used in previous studies, because those events not only affect physicians' performance but also influence patients' decision to seek care (ie, patients seeking care on these special days might be sicker than those 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.

Several potential mechanisms might explain why patient mortality was higher on surgeons' birthdays. First, surgeons could be under relatively higher time pressure—feeling rushed to complete procedures on time—on their birthday compared with other days of the year, because they might have important evening plans to celebrate their birthday. Research suggests that time pressure might impair the ability to avoid errors of intuitive judgment and may cause heuristic decisions during and after operations, which could lead to a higher likelihood of errors and overlooking signals of clinical deterioration in patients.[53 54] Time pressure may also increase the risk of confirmation bias[55]—the tendency to gather evidence that confirms pre-existing expectations (or biases) while dismissing or failing to seek contradictory evidence.[56] In this case, surgeons might, 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 (eg, anesthesiologists, operating room nurses) during surgical procedures could be distracting, leading to medical errors.[57] Third, surgeons may receive birthday messages on their phones in the operating room (ie, receive a larger total number of messages on birthdays compared with other days), which can be a potential source of distraction, as indicated by previous studies showing that distractions in the operating room are common, including noise (eg, calls from the ward, beeper pages) and conversations not pertinent to the surgical procedure.[21-24] Fourth, it is possible that surgeons might allow surgical trainees to do more on the surgeon's birthday in order to get home early for a celebration or other birthday related reasons, leading to poorer outcomes. Fifth, "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.[58] Finally, it is also possible that postoperative care decisions could differ on surgeons' birthdays. For example, surgeons may be less likely to return to the hospital to see their patients who show

signs of deterioration if they are having dinner with family and friends, compared with 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 per surgeon, also did not differ based on whether a surgery occurred on a surgeon's birthday compared with other days.

We empirically tested whether physicians' practice patterns and outcomes vary due to life events outside of their work environment, whereas other studies not focused on individual life events have nonetheless shown 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 tract infections as the workday progresses, probably because the cumulative cognitive demand of clinical decisions progressively impairs clinician's ability to avoid clinically inappropriate decisions.[59] Comparable findings were observed for the prescription of opioids as well.[60] Similarly, one study found that clinicians' ordering of cancer screening tests decreased as the workday progressed.[61] 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 findings have several implications for clinical practice. First, our results indicate that individual surgeons' performance may be meaningfully influenced by life events outside of their work environment. It may be possible that the patterns we observed extend to other distracting life events. Additional support for surgeons who have potentially distracting events may be warranted to make sure that patients receive high quality surgical care regardless of when undergo surgery. Our findings also indicate how large data can be used to monitor the quality of care and to identify unexpected factors that might influence physicians' clinical performance and patient outcomes.

Limitations of this study

Our study has limitations. First, although we adjusted for a broad set of patient level confounders and hospital or surgeon fixed effects, we could not eliminate the possibility of unmeasured confounding, as is the case with any observational study. In particular, it is possible that despite showing comparability of patients on the basis of a range of patient characteristics, surgeons might postpone less severe cases and operate on only the most severe cases on their birthdays. Second, as

a result of the lack of detailed clinical information in the claims data, we were not able to identify the mechanisms (eg, reductions in operation times or earlier than typical completion of the day's final surgery) through which patients experienced higher mortality when they underwent surgery on surgeons' birthdays. Third, we were not able to analyze the cause of death owing to the lack of information in our data. Finally, we focused on 17 most common procedures received by Medicare patients aged 65-99 years, and therefore the findings might not be generalizable to other patient populations or to other surgical procedures.

Conclusions

Using national data on Medicare beneficiaries undergoing emergency surgical procedures, we found a higher risk of 30 day mortality after surgery when the operation was performed on a surgeon's birthday. These findings illustrate how large data might be used to assess whether the performance of a surgeon is influenced by life events outside of his or her work environment.

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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 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 written by the study's authors that describe the study's findings for the public.

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Supplementary information: additional eTables 1-22 and eFigures 1-5