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Dr. Elizabeth Loder,
Head of Research, *The BMJ*

Dear Dr. Loder,

Thank you for giving us an opportunity to revise and resubmit our manuscript entitled "**Operative mortality of surgeries performed on a surgeon's birthday: observational study (BMJ-2020-062268)**." Below are the comments we received from the committee and reviewers (in *italics*), as well as a point-by-point response as to how we addressed them (in **boldface**).

In our revised manuscript, we included several additional analyses, including an analysis focusing on clearly emergency surgeries and a falsification test of the association between surgeons' half-birthdays and patient mortality based on the suggestions by the editors and reviewers. Given that we already had a large number of tables, we included some but not all new analyses in our revised manuscript. However, if editors prefer, we are happy to include any of the results in the online appendix of the manuscript.

We hope we have adequately addressed all points raised by the editors and reviewers. If anything remains unclear, please do not hesitate to contact us. Thank you very much for considering our manuscript.

Sincerely yours,

Anupam B. Jena, MD, PhD

Comments by the Editors:

** This is a rather large effect, and potentially worrisome.*

Thank you very much for your thoughtful comment. We agree with the editors that the observed difference in patient mortality between the surgeon's birthday and other days was large and potentially worrisome. However, given that our study had a sufficiently large sample size and given the natural experiment approach, we believe that the observed increase in patient mortality on operating surgeon's birthday could not be explained by random noise (i.e., unstable estimates) or unmeasured confounding.

** We think the hypothesis that surgeons are more distracted on their birthdays is really tricky - you argue that they will try to rush to complete their surgeries earlier. Could we see if there is a dose response effect (ie, more surgeries performed on the day is worse)? We recognise you may not have time stamps to examine time of day. Perhaps consider a falsification test - how likely is it that this is random chance - could you test their half-birthdays too to see if there is an effect?*

This is an excellent point. As suggested, we conducted an additional analysis examining whether there is a "dose-response effect." As the editors have correctly described, Medicare data do not have information on time stamps to examine the time of day a surgery was performed. Therefore, we operationalized this as follows. First, we calculated the number of total surgical procedures (including both elective and emergency surgeries) performed by each surgeon. Then, after adjusting for potential confounders (including hospital/surgeon fixed effects), we compared post-operative mortality of patients who underwent emergency surgeries (to prevent the probability that the severity of illness differs among groups) among the following 3 groups:

(1) Patients who underwent surgery on the operating surgeon's birthday, when the operating surgeon was performing a high volume (above mean) of procedures on that day.
(2) Patients who underwent surgery on the operating surgeon's birthday, when the operating surgeon was performing low volume (below mean) of procedures on that day.
(3) Patients who underwent surgery on days other than the operating surgeon's birthday.

Given that model 3 included surgeon fixed effects (effectively comparing patients treated by the same surgeon on different dates), we can interpret the results as to whether surgeons' performance on their birthday varies between busy (high operation volume) vs. less busy (low operation volume) days. We found that patient mortality was higher when surgeons performed a large number of procedures on their birthday, compared with that when surgeons performed a smaller number of procedures on their birthday, although the difference was not statistically significant (eTable 20 in Online Supplement). This is consistent with the editors' hypothesis that surgeons perform worse when more surgeries were performed on their birthday (perhaps because they have to rush to complete the procedures).

We also examined the association between surgeons' half-birthdays (calculated by adding 183 days to operating surgeons' birthday) and patient mortality. We found no evidence that patients who received surgery on operating surgeons' half-birthdays experienced higher mortality compared with patients who underwent surgery on other days, suggesting that our findings could not be explained by random chance. We have included the results in our revised manuscript (eTable 15 in the Online Supplement).

eTable 20. Association between operating surgeon's birthday, procedure volume, and patient mortality

Category	No. of procedures	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
Patients who underwent surgery on the operating surgeon's birthday, when the operating surgeon performed high volume (above mean) of procedures on that day.	418	9.1 (5.2 to 13.1)	+3.5 (-0.4 to +7.5)	0.08	8.8 (4.9 to 12.7)	+3.2 (-0.7 to +7.1)	0.11
Patients who underwent surgery on the operating surgeon's birthday, when the operating surgeon performed low volume (below mean) of procedures on that day.	1,646	6.7 (5.6 to 7.8)	+1.1 (-0.002 to +2.2)	0.05	6.5 (5.3 to 7.6)	+0.9 (-0.3 to +2.0)	0.13
Patients who underwent surgery on days other than operating surgeon's birthday.	978,812	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.**

eTable 15. Association between operating surgeon's half-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 half-birthday	2,755	5.7 (4.8 to 6.7)	+0.1 (-0.8 to +1.1)	0.76	5.8 (4.9 to 6.8)	+0.2 (-0.7 to +1.2)	0.64	5.8 (4.9 to 6.8)	+0.2 (-0.7 to +1.2)	0.61
Other days	978,121	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. Half-birthday was calculated by adding 183 days to operating surgeons' birthday.**

** Our statistician noted that Figure 1 is very striking. He also felt that the analysis is comprehensive, with many sensitivity analyses in supplementary tables.*

Thank you for positive comments regarding our analyses.

** We wonder why you fit fixed effect rather than random effect models, but don't view this as critical.*

We adjusted for surgeon fixed effects in this study to compare outcomes of patients who were operated on by the same surgeons, on different days (the surgeon's birthday vs. other days of the year). Including surgeon fixed effects in regression analysis control for both measured and unmeasured characteristics of surgeons, effectively comparing the mortality of patients who were treated by the same surgeon. To clarify this point, we revised the abstract as follows (page 3):

"Main Outcome measures: Patient post-operative 30-day mortality rate, defined as death within 30 days following the operative procedure, with adjustment for patient characteristics and surgeon fixed effects (effectively comparing outcomes of patients treated by the same surgeon on different days)."

Although surgeon random effects account for potential correlation (clustering) of patients treated by the same surgeon, it does not allow us to compare the outcomes of patients treated by the same surgeon. In other words, the comparison would be within-surgeon for the analysis with surgeon fixed effects, whereas it would be between-surgeon for the analysis with surgeon random effects. Given that some surgeons may not work on their birthday, it is important for us to use surgeon fixed effects and compare outcomes of patients treated by the same surgeon.

Having said that, as suggested by the editors, we conducted an additional analysis using surgeon random effects, instead of surgeon fixed effects, and confirmed that our findings were qualitatively unaffected by this model specification. We added this result into the Online Supplement. The comparison of the results using surgeon random effects (eTable 10) vs. fixed effects (Table 2) is shown below.

eTable 10. Association between operating surgeon's birthday and patient mortality, adjusting for hospital/surgeon random effects

Day	No. of procedures	Model 2: Patient Characteristics* + Hospital Random Effects			Model 3: Patient Characteristics* + Surgeon Random Effects		
		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)	+1.5 (+0.3 to +2.7)	0.01
Other days	978,812	5.6 (5.5 to 5.7)	Reference		5.7 (5.6 to 5.7)	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.**

Table 2. **Association between operating surgeon's birthday and patient mortality, adjusting for hospital/surgeon fixed effects**

Day	No. of procedures	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
Surgeon's birthday	2,064	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 (5.6 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.**

**2064 out of the 980,876 procedures were on the surgeon's birthday. If birthdays and operations are uniformly distributed then this proportion ought to be 1/365 or 0.27%, whereas the actual proportion is 0.2% or 1/475, i.e. 23% smaller. This suggests that surgeons are less keen to work on their birthdays. Yet eFigure 3 shows the same number of procedures per surgeon on their birthday as on neighbouring days, and this confuses us. We need to know the distribution of this same prevalence of birthday procedures per surgeon, as it could generate bias.*

In our data, 1805 surgeons performed procedures on their birthdays, 2144 surgeons one day before their birthdays, and 2027 surgeons one day after their birthdays, indicating that some surgeons actually choose not to operate on their birthday, as pointed out by the editors. However, when we investigate the average number of surgical procedures performed per surgeon, we found that they were similar between surgeons' birthdays and other days, indicating that surgeons who work on their birthdays do not reduce the number of procedures they perform on their birthday. This has an interesting and supporting implication for the potential causality of our findings. It suggests that birthdays are a significant enough factor for some surgeons to choose not to operate, which supports the credibility of our assumption that a birthday could be a distracting factor for those surgeons who choose to operate on their birthday. We mention this implication in the Discussion (page 16, paragraph 3).

"although the average number of surgical procedures performed per surgeon was similar between birthdays and other days, indicating that surgeons who work on their birthdays do not reduce their operative volume on their birthday, we found that some surgeons did not work on their birthdays (1805 surgeons performed procedures on their birthday vs. 2144 surgeons one day before their birthday and 2027 surgeons one day after their birthday). This suggests that birthdays are a significant enough factor for some surgeons to choose not to operate on their birthday, which supports the

credibility of our assumption that a birthday could be a distracting factor for those surgeons who choose to operate on their birthday."

We also made sure that the fact that some surgeons do not work on their birthday does not affect our findings. In particular, we adjusted for surgeon fixed effects, and effectively compared outcomes of the same surgeons on their birthday vs. other days. In addition, to further address the editors' concern, as a sensitivity analysis, we also reanalyzed the data restricting to surgeons who performed procedures on their birthdays in our sample (i.e., excluding surgeons who performed no surgeries on their birthdays), and confirmed that our overall findings did not qualitatively change (eTable 11 in the Online Supplement).

eTable 11. Association between operating surgeon's birthday and patient mortality, restricting to surgeons who performed procedures on their birthday

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	6.9 (5.7 to 8.1)	+1.7 (+0.5 to +2.9)	0.01	6.7 (5.6 to 7.9)	+1.5 (+0.3 to +2.7)	0.01	6.5 (5.4 to 7.7)	+1.3 (+0.1 to +2.5)	0.03
Other days	86,046	5.2 (5.0 to 5.4)	Reference		5.2 (5.1 to 5.3)	Reference		5.2 (5.2 to 5.2)	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.**

** Figure 2 could be omitted, and eTable 2 could add a column showing the inverse of the proportion of birthday procedures as 1/nnn to compare with the expected 1/365.*

Thank you for your thoughtful comment. We have moved Figure 2 to the online supplement based on the editors' suggestion.

As suggested, we have also calculated the inverse of the proportion of birthday procedures (Table A below). Because some surgeons actually choose not to operate on their birthday, the proportion of surgeries on surgeons' birthdays was smaller than 1/365. However, as we describe above, this does not affect the validity of our findings because we are comparing the performance of the same surgeons on their birthday vs. other days (by including surgeon fixed effects in our regression model). Given that this may be somewhat confusing for the readers, we decided not to add 1/nnn to eTable 2. However, if editors prefer, we are happy to add this information to eTable 2.

Table A. Types of procedures performed on surgeons' birthdays and other days, with the proportion of birthday procedures

	Surgeon's birthday	Other days	Proportion of birthday procedures
No. of procedures	2,064	978,812	1/475
Type of procedure, No. (%)			
Coronary artery bypass grafting (CABG)	134 (6.5)	63633 (6.5)	1/476
Carotid endarterectomy	36 (1.7)	17547 (1.8)	1/488
Valve replacement	45 (2.2)	20160 (2.1)	1/449
Abdominal aortic aneurysm repair	43 (2.1)	15142 (1.6)	1/353
Hip and femur fracture	734 (35.6)	364817 (37.3)	1/498
Colorectal resection	132 (6.4)	66355 (6.8)	1/504
Cholecystectomy and common duct procedures	292 (14.2)	135279 (13.8)	1/464
Excision lysis peritoneal adhesions	158 (7.7)	77387 (7.9)	1/491
Fracture or dislocation of lower extremity	147 (7.1)	63295 (6.5)	1/432
Lung resection	14 (0.7)	5370 (0.6)	1/385
Amputation of lower extremity	68 (3.3)	28995 (3.0)	1/427
Nephrectomy	6 (0.3)	3395 (0.4)	1/567
Appendectomy	98 (4.8)	41434 (4.2)	1/424
Small bowel resection	82 (4.0)	38779 (4.0)	1/474
Spinal fusion	66 (3.2)	30340 (3.1)	1/461
Gastrectomy	4 (0.2)	3403 (0.4)	1/852
Splenectomy	5 (0.2)	3481 (0.4)	1/697

** In eTable 8, why not 2064 birthday procedures?*

In eTable 8 of our original submission (eTable 9 in our revised manuscript), we reported the results from a logistic regression analysis. The number of procedures in this table is different from that of our main analysis, because some observations were dropped from the analysis due to complete or quasi-complete separation problems of logistic regression models (i.e., perfect or nearly perfect prediction of the outcome by the model). To clarify this, we added the following explanation to the legend of the eTable 9:

"Sample sizes differ from our main analysis due to complete or quasi-complete separation problems of logistic regression models (i.e., perfect or nearly perfect prediction of the outcome by the model)."

** Several editors were concerned about borderline p-values (and attendant risk for Type 1 error), and thought we need more information on a number of things, including confounding by "surgeon mix". Some surgeons will care about working on their birthday and will be organised enough to plan ahead or be confident or senior enough etc to actually book the time off. Some won't for whatever reason and it seems possible that the surgeons who actually work on their birthdays may be systematically different to those who do not work on their birthdays. A design that skirts this problem would be to compare each surgeon's mortality rate on their birthday with their mortality rate on other days. This design also addresses more directly the RQ "Do individual surgeons perform differently on their birthdays?" At the moment the study answers the question "Do patients operated on by a doctor who works on their birthday fare differently?"... not quite the same. You say they have adjusted for individual surgeon (that's an awful lot of indicator variables) and maybe this goes some of the way to addressing this but we weren't sure. Can you comment?*

We agree with the editors that potential confounding by "surgeon mix" is an important factor to consider. <u>However, it is also important to note that our results adjusted for surgeon fixed effects</u> (in model 3); therefore, we were effectively comparing the outcomes of patients treated by the same surgeon. As such, we have effectively addressed the important question that you raise. In fact, we showed the results both using hospital fixed effects (model 2) and surgeon fixed effects (model 3), each of which answers the RQ you specified. Our results from model 3 answer the RQ "Do individual surgeons perform differently on their birthdays?" and the results from model 2 answer the RQ "Do patients operated on by a doctor who works on their birthday have different outcomes?" To clarify this point, we revised our manuscript as follows (page 9, paragraph 1):

"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 operated by the same surgeon, effectively addressing the research question whether individual surgeons perform differently on their birthday versus other days of the year."

** Can you provide information on surgeons' characteristics, e.g. are younger or female surgeons more likely to take a day off for birthdays? (Earlier papers showed that these had lower mortality rates too). Are "better" doctors more likely to be in a position to take their birthday off?*

Based on your comment, we presented surgeons' characteristics in terms of age and gender (eTable 3 in the online appendix). We found that surgeons who work on their birthday were on average older, and more likely to be male. However, our results adjusting for surgeon fixed effects effectively

compare outcomes of patients treated by the same surgeon on different days, and therefore, are unaffected by the fact that certain types of surgeons are more or less likely to work on their birthday.

eTable 3. Surgeon characteristics according to the surgeon's working schedules

	Surgeons who did not perform procedures on their birthdays	Surgeons who performed procedures on their birthdays	P value
No. of surgeons	45,684	1,805	
Age*, mean (SD), yr	46.9 (10.7)	47.6 (10.1)	0.01
Female, No. (%)	4015 (8.8)	100 (5.5)	<0.001

*** Surgeon age was defined as that on January 1, 2011.**

** The distribution of birthdays had several outliers, including January 1, which would have emergency procedures only. We are concerned about the accuracy of birthdates, noting bunching on several dates that seems improbable. Can a subset of birthday dates be checked in some way, for example with the doximity database? Could this skew the results? As the denominator in the birthday procedures is not that large, you only need a few procedures going wrong to get a difference.*

As much as we would like to validate the information on surgeons' birthday using the Doximity database, the database, unfortunately, does not include the information on physicians' birthday.

The birthday data used in this study were extracted from the Centers for Medicare & Medicaid Services' MD-PPAS file, which was collected from the data reported in the Medicare Provider Enrollment, Chain, and Ownership System (PECOS), which is the online Medicare enrollment management system.[1] Because physicians provide their birthday when they enroll as Medicare providers, the data is arguably accurate. The proportion of missing data for physician birthday was 0.01% in 2017.[1] We now include this information in our revised manuscript (page 7, paragraph 2):

"The data on surgeons' birthday in MD-PPAS file were extracted from Medicare Provider Enrollment, Chain, and Ownership System (PECOS), and the proportion of missing data was 0.01% in 2017.[40]"

To further address the editors' concerns, as a sensitivity analysis, we also examined the association between surgeons' birthdays and patient mortality after excluding 4 "outlier birthdays" (i.e., January 1, January 12, March 6, and October 15), and confirmed that our findings were qualitatively unaffected by excluding these data. We added this result into the online appendix (eTable 13).

eTable 13. Association between operating surgeon's birthday and patient mortality, excluding outlier birthdays[§]

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	2,037	7.3 (6.1 to 8.5)	+1.7 (+0.5 to +2.9)	0.01	7.3 (6.1 to 8.5)	+1.7 (+0.5 to +2.9)	0.01	7.0 (5.8 to 8.2)	+1.4 (+0.2 to +2.6)	0.03
Other days	963,817	5.6 (5.6 to 5.7)	Reference		5.6 (5.6 to 5.7)	Reference		5.6 (5.6 to 5.6)	Reference	

[§] Days on which a large number of surgeons report birthday (January 1, January 12, March 6, and October 15) were selected based on eFigure 1, and excluded from the analysis.

***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. For this analysis, we excluded surgeons who were born on January 1, January 12, March 6, or October 15.**

** Our statistician commented that this is a natural experiment and as such we can't argue with the design but we can worry about bias. He suggested that there may well be bias operating in the way surgeons conduct surgery on their birthday but it seems perfectly clear that mortality is raised. Because it's a natural experiment many of the biases we can think of don't exist and this raises the possibility that relatively minor distraction is sufficient to have an impact on mortality.*

Thank you for the positive comment.

** Can you say more about why a birthday is such a distracting event? A surgical trainee at the meeting noted that "This is very topical. Human factors and distraction in the OR is a huge topic." She thought more focus on elective vs emergency surgery would be important, since that has an effect on 30 day mortality. She also wondered about the focus on mortality rather than complications, as she thought surgical complications would be a more common outcome with distraction.*

Prior studies have reported that distractions in the operating room are common, including noise (e.g., calls from the ward, beeper pages) and conversations not pertinent to the surgical procedure,[2-5] and it is possible that those factors are more frequent and salient on surgeons' birthday.

As suggested, we examined the association between surgeons' birthdays and patient mortality for elective procedures (defined as surgeries performed during elective admissions). We found no evidence that surgeons' birthdays were associated with the mortality of patients who underwent elective procedures.

In addition, we examined the association between surgeons' birthdays and complications, 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 (PSI): retained surgical item or unretrieved device fragment count (PSI 05), perioperative hemorrhage or hematoma (PSI 08), and post-operative wound dehiscence (PSI 14).[6] These 3 are the only complications we could validly and reliably measure using claims data. We found no evidence that the complication rates differed for patients who underwent a surgical procedure on the surgeon's birthday. This may be due to the narrowness of the AHRQ PSI indicators (i.e., wound dehiscence, retained object, hematoma) for surgery. We added these results in the online supplement (eTable 18 and eTable 19 in the Online Supplement).

eTable 18. Association between operating surgeon's birthday and patient mortality, elective surgeries

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	2,701	1.6 (1.1 to 2.1)	-0.2 (-0.7 to +0.4)	0.54	1.6 (1.1 to 2.1)	-0.2 (-0.7 to +0.4)	0.53	1.6 (1.1 to 2.1)	-0.2 (-0.7 to +0.4)	0.56
Other days	1,217,919	1.8 (1.7 to 1.8)	Reference		1.8 (1.7 to 1.8)	Reference		1.8 (1.8 to 1.8)	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.**

eTable 19. Association between operating surgeon's birthday and patient complications

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	0.8 (0.3 to 1.2)	+0.1 (-0.4 to +0.5)	0.79	0.8 (0.3 to 1.2)	+0.1 (-0.4 to +0.5)	0.82	0.8 (0.3 to 1.2)	+0.04 (-0.4 to +0.5)	0.85
Other days	978,812	0.7 (0.7 to 0.7)	Reference		0.7 (0.7 to 0.7)	Reference		0.7 (0.7 to 0.7)	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.**

** You attribute mortality to the lead surgeon, but often there are assistants, including trainees. Might it be the case that surgeons trying to get home for a birthday celebration will allow trainees to do more during the surgery in order to shorten the time, or will scrub out and leave junior assistants to finish?*

Thank you for this excellent comment. As editors suggested, it is possible that surgeons trying to get home for a birthday celebration allow trainees to do more during the surgery in order to shorten the time. Base on your comment, we revised our manuscript as follows (page 18, paragraph 1):

"it is possible that the operating surgeons may allow trainees to do more during the surgery performed on the surgeon's birthday in order to get home early for a birthday celebration, leading to poorer outcomes."

** A surgeon on the committee comments that before covid surgeons often had their phones in the OR and that messages, especially birthday messages, could be distracting. During covid phones are no longer allowed.*

We agree with the editors that birthday messages may be distracting. To clarify this point, we revised our manuscript as follows (page 18, paragraph 1):

"surgeons may receive messages congratulating their birthday on their phones in the operating room (i.e., may receive a larger total number of messages on birthdays compared to other days), which can be a potential source of distraction, as indicated from prior studies indicating that distractions in the operating room are common including noise (e.g., calls from the ward, beeper pages) and conversations not pertinent to the surgical procedure.[21-24] "

** Your model has a lot of dummy variables. On the one hand does that reduce power. The p values are borderline for such a large database, so we are at risk for a type 1 error here.*

Although our data were large, we found no statistically significant differences for a broad set of patient characteristics between patients who underwent operations on surgeons' birthdays and those who received surgeries on other days (these factors are at risk for type 1 error as much as patient mortality). In addition, using the large database, we found that there was no association between surgeons' half-birthdays or randomly-generated "pseudo-birthdays" and patient mortality. Therefore, we believe that it is unlikely that we are at risk for a type 1 error.

** Can you tell us more about model 3, for example how many surgeons were in it?*

Our sample included 980,876 procedures operated on by 47,489 surgeons for all models (sample sizes did not vary between models as we used linear probability models). We have described this in the result section of our revised manuscript.

** Another editor thought the analysis might be more convincing if you stick to the clear emergency surgeries.*

To address the editors' concern, we conducted 2 sensitivity analyses. First, we focused on procedures that had high average mortality (we added a column showing the average mortality for each procedure to eTable 2). We restricted our analysis to 10 procedures with the highest average mortality, and confirmed that our overall findings did not qualitatively change (eTable 16 in the Online

Supplement).

Second, we reanalyzed the data restricting to patients with the highest severity of illness (i.e., highest predicted mortality). 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. We considered patients in the top 25% of the predicted 30-day mortality as patients with the highest severity of illness (we used different thresholds such as top 1/3 and found that our findings were robust to the selection of the definition of highest severity of illness). Our findings were qualitatively unaffected by restricting our analysis to patients with the highest severity of illness (eTable 17 in the Online Supplement).

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

	Surgeon's birthday	Other days	Average mortality rate, %
No. of procedures	2,064	963,935	5.6
Type of procedure, No. (%)			
Coronary artery bypass grafting (CABG)	134 (6.5)	63633 (6.5)	4.3
Carotid endarterectomy	36 (1.7)	17547 (1.8)	1.5
Valve replacement*	45 (2.2)	20160 (2.1)	6.7
Abdominal aortic aneurysm repair*	43 (2.1)	15142 (1.6)	13.3
Hip and femur fracture*	734 (35.6)	364817 (37.3)	5.1
Colorectal resection*	132 (6.4)	66355 (6.8)	12.6
Cholecystectomy and common duct procedures	292 (14.2)	135279 (13.8)	2.4
Excision lysis peritoneal adhesions*	158 (7.7)	77387 (7.9)	7.5
Fracture or dislocation of lower extremity	147 (7.1)	63295 (6.5)	2.1
Lung resection*	14 (0.7)	5370 (0.6)	6.2
Amputation of lower extremity*	68 (3.3)	28995 (3.0)	8.6
Nephrectomy	6 (0.3)	3395 (0.4)	3.3
Appendectomy	98 (4.8)	41434 (4.2)	2.2
Small bowel resection*	82 (4.0)	38779 (4.0)	13.0
Spinal fusion	66 (3.2)	30340 (3.1)	3.0
Gastrectomy*	4 (0.2)	3403 (0.4)	17.8
Splenectomy*	5 (0.2)	3481 (0.4)	19.2

***Procedures used for the sensitivity analysis restricting to high-risk procedures (see eTable 16 for the results of this analysis).**

eTable 16. Association between operating surgeon's birthday and patient mortality, including ten procedures with the highest 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	1,285	9.1 (7.5 to 10.7)	+1.8 (+0.2 to +3.5)	0.03	9.1 (7.5 to 10.8)	+1.9 (+0.2 to +3.5)	0.03	8.8 (7.1 to 10.4)	+1.5 (-0.1 to +3.1)	0.07
Other days	623,889	7.3 (7.2 to 7.3)	Reference		7.3 (7.2 to 7.3)	Reference		7.3 (7.3 to 7.3)	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. For this analysis, we restricted our analysis to ten procedures with the highest average mortality (i.e., valve replacement, abdominal aortic aneurysm repair, hip and femur fracture, colorectal resection, excision lysis peritoneal adhesions, lung resection, amputation of lower extremity, small bowel resection, gastrectomy, splenectomy)**

eTable 17. Association between operating surgeon's birthday and patient mortality, restricting to patients with the highest illness severity

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	495	19.4 (15.5 to 23.2)	+5.0 (+1.1 to +8.8)	0.01	19.3 (15.5 to 23.1)	+4.9 (+1.1 to +8.7)	0.01	18.1 (14.1 to 22.0)	+3.6 (-0.3 to +7.6)	0.07
Other days	244,724	14.4 (14.3 to 14.6)	Reference		14.4 (14.3 to 14.6)	Reference		14.4 (14.4 to 14.4)	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. For this analysis, we restricted our analysis to patients in the top 25% of the predicted 30-day mortality. Predicted mortality was estimated from a regression of 30-day mortality on patient characteristics using a logistic regression model.**

Comments by the Reviewers:

Reviewer 1 (Dr. Chien-Chang Liao)

Thank you for your thoughtful comments.

1. Types of surgery, characteristics of hospital, characteristics of surgeon, and more coexisting medical conditions (such as ischemic heart disease, stroke, and liver cirrhosis) should be considered in this study. These factors are potential confounding factor for the association between surgeon's birthday and mortality risk.

Thank you for giving us an opportunity to clarify this point. In this study, we have adjusted for a set of potential confounders the reviewer described. In particular, we adjusted for patient characteristics, including the type of surgery and 24 coexisting medical conditions (such as congestive heart failure, renal failure, hypertension, and liver disease). We also adjusted for hospital or surgeon fixed effects (depending on models). Including hospital/surgeon fixed effects as adjustment variables in regression analysis controlled for both (time-invariant) measured and unmeasured characteristics of hospitals/surgeons, including differences in patient populations. In our revised manuscript, we have also adjusted for both hospital and surgeon fixed effects (plus patient characteristics), and confirmed that this model specification does not affect our overall findings (eTable 7 in online supplement).

eTable 7. Association between operating surgeon's birthday and patient mortality, adjusting for 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.**

2. How about the ROC curve for the surgeon's birthday and mortality risk?

To our knowledge, ROC curves are often used to show the relationship between sensitivity and specificity, and they are usually not used to assess differences in patient outcomes between two groups (in our case, patients who received surgery on an operating surgeon's birthday vs. patients who received surgery on the other days). Therefore, we could not perform the analysis of the ROC curve. However, if the reviewer can provide specific and concrete suggestions as to how to perform ROC analyses in our case, we are happy to conduct any suggested analysis.

3. Please use logistic regression to calculate the risk of mortality associated with surgeon's birthday and show the OR (95% CI).

As a secondary analysis, we used logistic regression models instead of linear probability models and showed the OR (eTable 9). Our findings were qualitatively unaffected by using logistic regression models instead of linear probability models.

eTable 9. 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.**

4. Please show the IRB number of this study. It is very important whether this study was approved by the institutional review board.

As suggested, we now include the IRB number in the methods of the revised manuscript (page 13, paragraph 1):

"This study was approved by University of California, Los Angeles Institutional Review Board (IRB number, 19-000954)."

5. Please do a competing risk analysis.

We examined the difference in patient mortality between patients who underwent operations on surgeons' birthdays vs. those who underwent operations on other days, and because patients who underwent operations on surgeons' birthdays had similar "competing risks" (i.e., reasons for patient death other than a surgical procedure) to those who underwent operations on other days, competing risk, if any, would be canceled out by this comparison.

6. The discussion section should more fully discuss how to propose these results be implanted in clinical practice.

This is an excellent point. As suggested, we included the following statement in the discussion of the revised manuscript (page 20, paragraph 2):

"Our findings have several implications for clinical practice. First, our results indicate that individual surgeons' performance can 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 they receive a surgical procedure. Our findings also indicate how large data can be used to monitor the quality of care and to identify unexpected factors that may influence physicians' clinical performance and patient outcomes."

Reviewer 2 (Dr. Nick Freemantle)

Thank you for your thoughtful comments.

First, the paper is rather well described and thoroughly analysed, although some uncertainties remain on exactly what was done. Specifically the authors refer to a window around the birthday of the surgeon, and separately refer to the actual date of the birthday; please clarify what is done here as this is pretty crucial to the interpretation (it is not realistic to think that an event 13 days after a birthday is really distracted by that birthday in mature adult surgeons). On the basis of the mortality rate denominators described in the paper it seems clear that they used the actual day, so that the description needs to be clearer.

When we conducted an event study analysis, we grouped every two days into a single category to increase sample sizes. For all other analyses, we used the actual birthday of surgeons (without grouping them). To clarify this point, we revised our manuscript as follows (page 9, paragraph 2):

"To avoid unstable estimates due to 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)."

Second, the authors mention 'trends to significance' in the results section. This should be removed and replaced with less deterministic language (eg describe what is actually there rather than what might be achieved in a bigger study).

As suggested, we revised the results section to improve the clarity of our findings as follows (page 15, paragraph 1):

"Although the differences were not statistically significant for most procedures due to small sample sizes, the point estimates showed higher patient mortality on the operating surgeon's birthday for all procedures included in the stratified analysis except for two procedures: carotid endarterectomy and cholecystectomy and common duct procedures (eTable 14 in the Online Supplement)."

Third, the logistic models are over fitted (given the number of deaths, the number of surgeons and the other patient level explanatory variables) and they should be removed. The alternative of fitting surgeons as random intercept terms could be considered but it is unclear that this will add anything very much.

We agree with the reviewer that the logistic models had several problems, and that is why we used the linear probability models for our main analysis and used the logistic regression models as a sensitivity analysis. However, we believe it is still important that our findings were qualitatively unaffected by using logistic regression models instead of linear probability models, and therefore, we did not remove the table from the Online Supplement. The logistic analysis was suggested by other reviewers as well. However, if the editors prefer to remove the results of the logistic regression analysis, we are happy to do so.

Fourth, the table on type of procedure is rather important (e9) and might be happier in the main paper. It is quite striking to the untutored eye that a couple of clearly acute procedures (eg fracture of hip / femur and appendectomy) both have no difference, while the others often have quite a bit difference. The authors really should pull out the acute events and compare them with the planned ones. They discuss it but it should be available for all admissions. There may be a latency that less severe cases are avoided (we can imagine the way that this might happen) and only the more urgent are done. This would mean that subjects within any characteristic would be more severe in an unmeasured way which is a form of confounding by indication. This clear mechanism and potential latency in their analysis should be described as a possibility (They could refer to Ian McEwan's Saturday where a surgeon at UCLH does an operation when we might consider that they could be distracted) anyway a full discussion on this potential bias is very important and it could easily explain the results. Related, the comment in the discussion that patients are alike on observed characteristics between birthdays and non birthdays misses the point that it is these unobserved differences that lead to confounding by indication.

Thank you for this comment. Although we agree with the reviewer that eTable 9 (the table on the association between operating surgeon's birthday and patient mortality, by types of procedures) is important for this study, the number of exhibits we can include in the main manuscript is limited and as such we decided to keep it in the online supplement. If the editors prefer, however, we are happy to include eTable 9 in our main manuscript.

We also agree with the reviewer that surgeons' selection of which patients to operate on could be influenced by unmeasured factors that then create a threat to the internal validity of our findings. In particular, we were concerned that surgeons might be operating on only the most severe cases and postponing less severe cases on their birthdays in a way that could not be captured using measured variables. We tested this possibility using two approaches: (A) we compared patient characteristics and patients' illness severity on an operating surgeon's birthday and other days, and (B) we evaluated the number of procedures per surgeon on and around their birthdays. If surgeons selectively treated more severe cases on their birthdays, both observed and unobserved patients' illness severity would likely differ on surgeons' birthday, as would operative volume. We found that patients who underwent operations on surgeons' birthdays had similar observed severity of illness, and that the average number of surgical procedures performed per surgeon was similar between birthday vs. other days. Therefore, we believe that surgeons' selection of which patients to operate could not fully explain higher patient mortality on surgeons' birthday.

Nevertheless, we also acknowledge that it is still possible that those unmeasured confounders may bias our estimates because this study is an observational study, and we revised our manuscript as follows to clarify this point (page 20, paragraph 3):

"although we adjusted for a broad set of patient-level confounders and hospital or surgeon fixed

effects, as is the case with any observational studies, we could not eliminate the possibility of unmeasured confounding. In particular, it is possible that despite demonstrating comparability of patients on the basis of a range of patient characteristics, surgeons may postpone less severe cases and operate on only the most severe cases on their birthdays."

Reviewer 3 (Dr. Eric Sun)

Thank you for the thoughtful comments.

1). The authors don't seem to have adjusted for the type of surgery (i.e., surgical procedure). The data they are using should have the surgical CPT code and so perhaps to could include procedure fixed effects in their models.

We apologize if this was unclear in our original submission. We did indeed adjust for the type of surgery for all analyses, as explained in the Method section of the paper (page 7, paragraph 4):

"We adjusted for patient characteristics and hospital or surgeon fixed effects (depending on model). Patient characteristics included <u>the type of procedure (indicator variables for 17 surgical procedures)</u>, 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), 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 may have worse outcomes)."

2). To further minimize confounding, a difference-in-differences approach could be used. In essence, for a given day, the approach would compare mortality for surgeons having a birthday on that day vs., surgeons who do not (i.e., May 15, 2015 is a birthday for some surgeons and not for others). This approach could be implemented by using date effects (i.e., a dummy for May 15, 2015). However, this might not be computationally feasible given the large number of days so perhaps an alternative would be to use week fixed effects (i.e., a dummy for the week of May 15, 2015).

Thank you very much for your insightful comment. Based on your suggestion, we conducted an additional sensitivity analysis using date fixed effects (i.e., indicator variables for 365 days in a year), and confirmed that this specification does not qualitatively affect our findings. We have included the results in our revised manuscript (eTable 12 in the Online Supplement).

eTable 12. Association between operating surgeon's birthday and patient mortality, additional adjustment for the day of the year

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, day of the week of surgery, and surgery-date fixed effects (i.e., indicator variables for 365 days in a year).**

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