Check for updates

Association between patient-surgeon gender concordance and mortality after surgery in the United States: retrospective observational study

Christopher JD Wallis, [1, 2, 3] Angela Jerath, [4] Ryo Ikesu, [5, 6] Raj Satkunasivam, [7, 8, 9] Justin B Dimick, [10] E John Orav, [11, 12] Melinda Maggard-Gibbons, [13] Ruixin Li, [5] Arghavan Salles, [14] Zachary Klaassen, [15] Natalie Coburn, [16, 17] Barbara L Bass, [18] Allan S Detsky, [17, 19, 20] Yusuke Tsugawa [5, 21]

ABSTRACT

OBJECTIVE

To determine whether patient-surgeon gender concordance is associated with mortality of patients after surgery in the United States.

DESIGN

Retrospective observational study.

SETTING

Acute care hospitals in the US.

PARTICIPANTS

100% of Medicare fee-for-service beneficiaries aged 65-99 years who had one of 14 major elective or non-elective (emergent or urgent) surgeries in 2016-19.

MAIN OUTCOME MEASURES

Mortality after surgery, defined as death within 30 days of the operation. Adjustments were made for patient and surgeon characteristics and hospital fixed effects (effectively comparing patients within the same hospital).

RESULTS

Among 2 902 756 patients who had surgery, 1 287 845 (44.4%) had operations done by surgeons of the same gender (1 201 712 (41.4%) male patient and male surgeon, 86 133 (3.0%) female patient and female surgeon) and 1 614 911 (55.6%) were by surgeons of different gender (52 944 (1.8%) male patient and female surgeon, 1 561 967 (53.8%) female patient and male surgeon). Adjusted 30 day mortality after surgery was 2.0% for male patient-male surgeon dyads, 1.7% for male patient-female surgeon dyads, 1.5% for female patient-male surgeon dyads, and 1.3% for female patient-female surgeon dyads. Patient-surgeon gender concordance was associated with a slightly lower mortality for female patients (adjusted risk difference −0.2 percentage point (95% confidence interval −0.3 to −0.1); P<0.001), but a higher mortality for male patients (0.3 (0.2 to 0.5); P<0.001) for elective procedures, although the difference was small and not clinically meaningful. No evidence suggests that operative mortality differed by patient-surgeon gender concordance for non-elective procedures.

CONCLUSIONS

Post-operative mortality rates were similar (ie, the difference was small and not clinically meaningful) among the four types of patient-surgeon gender dyads.

Introduction

Surgical care contributes to the management or cure of approximately a third of the global burden of disease.[1 2] Surgical outcomes reflect a complex interplay of patient comorbidities, disease characteristics, and perioperative care delivery. To date, much focus has been on features of the health care system (ie, hospital level volume[3]) and of the surgeon as they relate to surgical outcomes through perioperative care delivery.[4 -7]

However, emphasis is increasingly being put on how the sociocultural characteristics of the treating physician affect patient outcomes. Gender concordance between patients and physicians has the potential to improve the quality of care and patient outcomes through more effective communication,[8 -11] reduced (implicit and explicit) sex and gender bias,[12] and better rapport.[13] Research in specialties outside of surgery has shown that the patient-physician gender concordance was generally associated with higher quality processes of care[14 -18] and improved patient outcomes.[5 19] Multiple mechanisms explain how patient-surgeon gender concordance can potentially improve patient outcomes. For instance, improved communication and rapport between patients and surgeons could encourage patients to comfortably ask questions and report subtle post-operative symptoms, potentially leading to improved outcomes if surgeons proactively address these concerns. Additionally, a better patient-surgeon relationship could increase the likelihood of patients adhering to post-operative care recommendations, including proper medication use.

Evidence is limited about the effect of patient-surgeon gender concordance in outcomes of patients undergoing a surgical procedure. The only study on this subject, conducted in a single Canadian province, identified an association between patient-surgeon gender concordance and improved outcomes among female patients undergoing elective procedures; no difference was found for female patients involved in non-elective procedures, or for male patients (elective and non-elective procedures).[5] The study also showed significant heterogeneity based on the type of procedure performed. Nevertheless, whether these findings are generalizable to healthcare systems in other regions and countries is unclear. Considering the varying degrees of structural sexism in surgical training across different countries (eg, the gender disparity in the volume of procedures experienced by surgeons during their training may differ from country to country), the effect of patient-surgeon gender concordance on patient outcomes may also vary by country.

In this context, the objective of this observational study was to examine the association between the patient-surgeon gender concordance and postoperative mortality in common major surgeries using national data of Medicare fee-for-service beneficiaries in the US who underwent one of 14 common major surgeries between 2016 and 2019. Given that gender concordance between patients and surgeons has the potential to improve the quality of care, we hypothesised that patients treated by surgeons of the same gender would have a lower postoperative mortality rate compared with patients treated by gender discordant surgeons.

Methods

Data sources and study population

We used 2016-19 data for Medicare fee-for-service beneficiaries from the 100% Medicare inpatient file. The data on self-reported surgeon gender was collected using the Medicare Data on Provider Practice and Specialty (MD-PPAS) database.

We restricted our sample to people aged 65-99 years who were continuously enrolled in Medicare parts A and B (part A covers inpatient hospital stays, case in a skilled nursing facility, hospice care, and some home health care; part B covers certain doctors' services, outpatient care, medical supplies, and preventive services) in a given year undergoing one of 14 common surgical procedures: abdominal aortic aneurysm repair, appendectomy, cholecystectomy, colectomy, coronary artery bypass surgery, knee replacement, hip replacement, hysterectomy, laminectomy or spinal fusion, liver resection, lung resection, prostatectomy, radical cystectomy, and thyroidectomy.[20] The 14 procedures were selected from a larger pool of approximately 30 frequently delivered procedures to Medicare fee-for-service beneficiaries, based on multiple external data sources. The list was reviewed and refined by authors with diverse surgical expertise (CJDW, AJ, RS, JBD, and MMG), ensuring that commonly performed procedures with substantial perioperative mortality rates were included. We used International Classification of Diseases, 10th Revision Procedure Coding System (ICD-10-PCS) codes from prior publications and from the Agency for Healthcare Research and Quality to identify each procedure.

This study was reported according to strengthening the reporting of observational studies in epidemiology (STROBE) guidelines [21] and the reporting of studies conducted using observational routinely collected health data (RECORD) statement.[22] The institutional review board of University of California, Los Angeles determined that this study did not require ethical approval.

Variable

We evaluated the association between the patient-surgeon gender concordance and patient mortality adjusting for patient and surgeon characteristics and hospital fixed effects (including hospital identifier as adjustment variable, effectively comparing patients treated at the same hospital). Initial analyses were based on a binary exposure, comparing mortality between patients with a gender-concordant surgeon and patients with a gender-discordant surgeon. We were also interested in the possibility that the effect of patient-surgeon gender concordance may vary based on the gender of the patient. Therefore, we categorised the patient-surgeon gender concordance into the four permutations of patient and surgeon gender: female patient-female surgeon; female patient-male surgeon; male patient-female surgeon; and male patient-male surgeon. We identified the surgeon performing the procedure from the operating physician field of the inpatient claim on the basis of their national provider identifier, an approach validated in prior

studies.[4 20 23 -26] Surgeon gender was extracted from the Medicare Data on Provider Practice and Specialty (MD-PPAS) data.[27]

Outcome

Our primary outcome was death within 30 days of a surgical procedure. The Medicare beneficiary summary file was used for date of death, which is verified using death certificates. We excluded approximately 1% of patients whose date of death was not validated. Our secondary outcomes were readmission to a hospital within 30 days, length of stay in a hospital, complication rates up to 30 days, and failure to rescue (defined as missed or delayed identification of and prompt response to complications arising from a medical condition or a medical procedure in a patient in a hospital).

Adjustments

We adjusted for patient and surgeon level adjustment variables as well as hospital fixed effects. Patient level adjustment variables included procedure type (indicator variable for 14 types of procedures), electiveness of the procedure (elective v non-elective (emergent or urgent procedures performed within three days of admission)), gender, age (defined categorically in five year age groups), race and ethnic group (non-Hispanic white, non-Hispanic black, Hispanic, and other), Medicaid coverage (as an indicator of socioeconomic status), 27 chronic conditions (comorbidities) in the Medicare master beneficiary summary chronic condition warehouse file, weekend (versus weekday), and month and year of surgery. We adjusted for patients' race and ethnic group because patients who are of racial and ethnic minority may be more or less likely to be treated by gender-concordant surgeons than other patients, and patients' post-operative mortality may differ by race and ethnic group. Surgeon level adjustment variables included surgeons' years in practice and the procedure specific operative volume (volume of each operation that a given patient's surgeon performed during the four year study period and categorized this value into procedure-specific thirds). We also adjusted for hospital fixed effects (indicator variables for each hospital), which effectively allowed comparison between patients treated at the same hospital.

Statistical analysis

Patient and surgeon characteristics for each of the four exposure groups (patient gender-by-surgeon gender) are displayed as percentages and means, and compared using χ^2 tests and analysis of variance. To compare patients' illness severity between the four types of patient-surgeon dyads, we calculated the predicted 30 day mortality for each patient by regressing patient mortality on patient level variables (procedure type and all patient level variables explained previously in this article) using a logistic regression model. The C-statistics of this prediction model was 0.87, indicating that this prediction model had good discrimination performance.

We first examined the association between the patient-surgeon gender concordance and 30 day patient mortality using a multivariable linear probability model, adjusted for the covariates listed above. A directed acyclic graph for our analyses was presented in the supplement (efigure 1). We conducted a stratified analysis based on the electiveness of procedures, distinguishing between elective and non-elective procedures. Notably, in the case of elective procedures, patients in the US typically have the autonomy to select their surgeon. By contrast, for non-elective procedures, patients are generally (quasi-randomly) assigned to on-call surgeons. Therefore, the analysis of non-elective surgeries functions as a natural experiment because this variable substantially reduces the likelihood of patients choosing their surgeons or surgeons choosing their patients. To assess potential heterogeneity of association, we

further stratified our analyses by patient gender and the 14 procedure types. Next, we examined the association between surgeon gender (as opposed to the patient-surgeon gender concordance) and 30 day patient mortality, adjusting for the same adjustment variables as our main regression model for the analysis of the patient-surgeon gender concordance. Similarly, we examined the association between patient gender and 30 day patient mortality. After fitting the regression model, we calculated adjusted patient mortality using the marginal standardization technique. That is, we estimated the probability of mortality for each patient averaged over the distribution of covariates in our national data, fixing the indicator variable for patient and surgeon gender for either male or female.[28]

Secondary analyses

We conducted several sensitivity analyses. Firstly, to test whether our findings were sensitive to the model specification, we reanalyzed the data using hospital random effects instead of hospital fixed effects. Secondly, to examine the potential effect of including hospitals with no female surgeons on our findings, we reanalyzed the data after limiting our sample to hospitals with at least one or 10 surgical procedures performed by female surgeons. Thirdly, to assess whether different window periods to define non-elective procedures may affect our findings, we repeated our analysis after changing our window period to define non-elective procedures from three days to seven or 14 days of admission. Fourthly, to address a possibility of insufficient adjustment for the severity of illness, we repeated our analysis additionally adjusting for individual ICD-10-PCS procedure codes (instead of adjusting for the procedure type). Fifthly, to address the possibility that patients with socioeconomic disadvantage were more likely to be treated by surgeons of certain gender, we additionally adjusted for social deprivation index based on patient zip code.[29] Sixthly, as frailty is a predictor of surgical outcomes, we repeated our analysis additionally adjusting for claims based frailty index.[30]

We also conducted stratified analyses. To address the possibility that the inclusion of surgeries led by trainees with attending supervision may affect our findings, we stratified our analysis by hospital teaching status (because surgeries are less likely to be led by trainees in non-teaching hospitals). Additionally, to assess the possibility that our findings were driven by hospital structure and environment, we conducted a stratified analysis by rates of hospital level mortality. We regressed 30 day mortality on indicator variables for each hospital as well as patient and procedure level characteristics, and divided hospitals into two equal sized groups by the coefficient of the hospital indicator variables that represented mortality due to hospital structure and environment.

We used the Bonferroni method to account for multiple comparisons (for each patient gender, 14 procedure specific comparisons and one comparison pooling all the 14 procedures) and considered a P value of less than 0.0017 to be statistically significant. All analyses were done using Stata, version 16.1 (StataCorp LLC).

Patient and public involvement

Although we support the importance of patient and public involvement, this research was an analysis of secondary data of existing claims data where the identifiers were not available for patients or members of the public for analysis, and as such, their involvement was not practical.

Results

We identified 2 902 756 patients who had one of the 14 included procedures during the study interval. Among these, 1 287 845 (44.4%) were in concordant dyads (86 133 (3.0%) female patient-female surgeon and 1 201 712 (41.4%) male patient-male surgeon) and 1 614 911 (55.6%) were in discordant dyads (52 944 (1.8%) male patient-female surgeon and 1 561 967 (53.8%) female patient-male surgeon). The surgical procedures differed among these four dyads. Compared with male surgeons, female surgeons were more likely to treat patients who had conditions that were predictive of higher risk of death. Patient characteristics based on patient and surgeon gender are shown in table 1.

Table 1 | Baseline characteristics, stratified by patient-surgeon gender dyads, number (percentage)

Characteristics	All	Female patient-female surgeon	Female patient- male surgeon	Male patient-male surgeon	Male patient-female surgeon	P value
Total cases	2 902 756	86 133 (3.0)	1 561 967 (53.8)	1 201 712 (41.4)	52 944 (1.8)	N/A
Patient characteristics						
Mean age (SD)	74.9 (6.7)	75.1 (7.1)	75.1 (6.9)	74.6 (6.4)	75.1 (6.7)	<0.001
Race and ethnic group:						
Non-Hispanic white	2 581 200 (88.9)	73 477 (85.3)	1 382 505 (88.5)	1 079 360 (89.8)	45 858 (86.6)	
Non-Hispanic black	146 408 (5.0)	5499 (6.4)	86 049 (5.5)	52 215 (4.4)	2645 (5.0)	<0.001
Hispanic	101 849 (3.5)	3918 (4.6)	54 952 (3.5)	40 641 (3.4)	2338 (4.4)	
Others	73 299 (2.5)	3239 (3.8)	38 461 (2.5)	29 496 (2.5)	2103 (4.0)	
Medicaid coverage	267 782 (9.2)	11 771 (13.7)	168 742 (10.8)	81 744 (6.8)	5525 (10.4)	<0.001
No. of chronic conditions:						
0-5	859 935 (29.6)	28 537 (33.1)	457 234 (29.3)	358 640 (29.8)	15 524 (29.3)	
6-10	1 457 015 (50.2)	40 301 (46.8)	787 926 (50.4)	603 188 (50.2)	25 600 (48.4)	<0.001
>10	585 806 (20.2)	17 295 (20.1)	316 807 (20.3)	239 884 (20.0)	11 820 (22.3)	
Procedures						
Abdominal aortic aneurysm repair	64 842 (2.2)	950 (1.1)	15 025 (1.0)	45 897 (3.8)	2970 (5.6)	
Appendectomy	51 887 (1.8)	5126 (6.0)	24 216 (1.6)	19 384 (1.6)	3161 (6.0)	
Coronary artery bypass surgery	159 409 (5.5)	1341 (1.6)	39 956 (2.6)	114 158 (9.5)	3954 (7.5)	
Cholecystectomy	172 001 (5.9)	11 213 (13.0)	73 588 (4.7)	76 041 (6.3)	11 159 (21.1)	
Colectomy	233 490 (8.0)	20 956 (24.3)	117 629 (7.5)	83 210 (6.9)	11 695 (22.1)	
Cystectomy	14 236 (0.5)	306 (0.4)	2994 (0.2)	10 324 (0.9)	612 (1.2)	
Hip replacement	728 335 (25.1)	10 421 (12.1)	457 472 (29.3)	255 394 (21.3)	5048 (9.5)	<0.001
Hysterectomy	46 380 (1.6)	17 355 (20.2)	29 025 (1.9)	N/A	N/A	
Knee replacement	868 168 (29.9)	8775 (10.2)	541 786 (34.7)	313 120 (26.1)	4487 (8.5)	
Laminectomy or spinal fusion	410 277 (14.1)	5417 (6.3)	215 993 (13.8)	184 234 (15.3)	4633 (8.8)	
Liver resection	2254 (0.1)	80 (0.1)	897 (0.1)	1156 (0.1)	121 (0.2)	
Lung resection	84 861 (2.9)	3783 (4.4)	41 188 (2.6)	36 870 (3.1)	3020 (5.7)	
Prostatectomy	62 364 (2.2)	N/A	N/A	60 526 (5.0)	1838 (3.5)	
Thyroidectomy	4252 (0.2)	410 (0.5)	2198 (0.1)	1398 (0.1)	246 (0.5)	
Weekend surgery	133 016 (4.6)	6558 (7.6)	71 482 (4.6)	49 959 (4.2)	5017 (9.5)	<0.001
Elective surgery	2 293 666 (79.0)	58 430 (67.8)	1 243 685 (79.6)	960 153 (79.9)	31 398 (59.3)	<0.001
Predicted mortality % (SD):						
Overall (elective and non-elective surgery, combined)	1.7 (3.5)	2.5 (4.5)	1.4 (3.2)	1.9 (3.7)	3.5 (5.4)	<0.001
Elective surgery	0.7 (1.4)	1.1 (1.6)	0.5 (1.1)	0.9 (1.6)	1.7 (2.2)	<0.001
Non-elective surgery	5.4 (6.2)	5.4 (6.7)	4.9 (5.6)	5.9 (6.6)	6.3 (7.6)	<0.001
Surgeon characteristics						
Mean age (SD)	49.0 (10.2)	44.2 (8.6)	49.8 (10.0)	49.5 (10.1)	42.9 (7.9)	<0.001
Surgical volume (thirds):						
1 (lowest)	84 004 (2.9)	7693 (8.9)	40 877 (2.6)	31 396 (2.6)	4038 (7.6)	
2	490 030 (16.9)	20 557 (23.9)	254 247 (16.3)	199 719 (16.6)	15 507 (29.3)	<0.001
3 (highest)	2 328 722 (80.2)	57 883 (67.2)	1 266 843 (81.1)	970 597 (80.8)	33 399 (63.1)	

Predicted mortality was calculated by regressing 30-day mortality on patient characteristics and procedure types using a logistic regression model. N/A=not available; SD=standard deviation.

Patient-surgeon gender concordance and patient outcomes

Unadjusted mortality rates were 1.9% (23 385/1 201 712) for male patient-male surgeon dyads, 3.4% (1806/52 944) for male patient-female surgeon dyads, 1.4% (22 299/1 561 967) for female patient-male surgeon dyads, and 2.5% (2160/86 133) for female patient-female surgeon dyads.

In adjusted models accounting for patient and surgeon characteristics and hospital fixed effects, we found that patient-surgeon gender concordance was associated with a lower

mortality for female patients (adjusted risk difference −0.2 percentage point (95% confidence interval −0.3 to −0.1); P<0.001) but a higher mortality for gender concordance in male patients (0.3 (0.2 to 0.5); P<0.001) for elective procedures (14 procedures combined) (table 2). The adjusted mortality 30 days after a surgical operation was the lowest for female patients treated by female surgeons (0.4%), followed by female patients treated by male surgeons (0.6%), male patients treated by female surgeons (0.6%), and the worst for male patients treated by male surgeons (1.0%). Variation was noted at the procedure level in these associations between patient-surgeon gender concordance and mortality. We found no evidence that adjusted 30 day mortality differed by patient-surgeon gender concordance for non-elective procedures (table 3).

Table 2 | Association between patient and surgeon gender concordance and patient adjusted 30 day mortality for elective surgical procedures

Concordance	No. of patients (No. of surgeons)	Adjusted mortality rate % (95% CI)	Adjusted risk difference pp (95% CI)	P value
14 procedures (combined):				
F patient-F surgeon	58 430 (6781)	0.4 (0.3 to 0.5)	−0.2 (−0.3 to −0.1)	<0.001
F patient-M surgeon	1 243 685 (37 655)	0.6 (0.6 to 0.6)	Reference	
M patient-M surgeon	960 153 (37 283)	1.0 (1.0 to 1.0)	0.3 (0.2 to 0.5)	<0.001
M patient-F surgeon	31 398 (3715)	0.6 (0.5 to 0.8)	Reference	
Knee replacement:				
F patient-F surgeon	8350 (363)	0.1 (0.03 to 0.2)	−0.01 (−0.1 to 0.1)	0.75
F patient-M surgeon	521 291 (10 360)	0.1 (0.1 to 0.1)	Reference	
M patient-M surgeon	301 381 (9963)	0.2 (0.2 to 0.3)	0.1 (−0.04 to 0.3)	0.15
M patient-F surgeon	4266 (316)	0.1 (−0.03 to 0.3)	Reference	
Hip replacement:				
F patient-F surgeon	5054 (330)	0.3 (0.1 to 0.5)	−0.02 (−0.2 to 0.2)	0.82
F patient-M surgeon	311 189 (9386)	0.3 (0.3 to 0.3)	Reference	
M patient-M surgeon	192 001 (8598)	0.4 (0.4 to 0.4)	−0.1 (−0.5 to 0.3)	0.51
M patient-F surgeon	2617 (273)	0.5 (0.1 to 0.9)	Reference	
Laminectomy or spinal fusion:				
F patient-F surgeon	4765 (316)	0.2 (0.04 to 0.4)	−0.1 (−0.3 to 0.1)	0.41
F patient-M surgeon	195 535 (6154)	0.3 (0.3 to 0.3)	Reference	
M patient-M surgeon	163 071 (6188)	0.6 (0.6 to 0.7)	−0.04 (−0.4 to 0.3)	0.82
M patient-F surgeon	3871 (320)	0.7 (0.3 to 1.0)	Reference	
Colectomy:				
F patient-F surgeon	14 126 (2416)	1.6 (1.3 to 1.8)	−0.4 (−0.6 to −0.1)	0.010
F patient-M surgeon	79 938 (11 054)	1.9 (1.8 to 2.0)	Reference	
M patient-M surgeon	57 693 (9997)	2.9 (2.7 to 3.0)	0.3 (−0.1 to 0.8)	0.15
M patient-F surgeon	7458 (1646)	2.5 (2.1 to 2.9)	Reference	
Cholecystectomy:				
F patient-F surgeon	2379 (1222)	2.0 (1.3 to 2.7)	−0.5 (−1.3 to 0.3)	0.20
F patient-M surgeon	18 502 (6817)	2.5 (2.3 to 2.8)	Reference	
M patient-M surgeon	19 384 (6658)	3.1 (2.8 to 3.3)	0.8 (−0.1 to 1.6)	0.069
M patient-F surgeon	2188 (1036)	2.3 (1.5 to 3.1)	Reference	
Coronary artery bypass surgery:				
F patient-F surgeon	939 (122)	3.7 (2.1 to 5.3)	−0.3 (−2.0 to 1.4)	0.70
F patient-M surgeon	27 647 (2295)	4.0 (3.8 to 4.3)	Reference	
M patient-M surgeon	82 896 (2638)	2.3 (2.2 to 2.4)	0.2 (−0.5 to 0.9)	0.62
M patient-F surgeon	2908 (163)	2.1 (1.5 to 2.8)	Reference	
Lung resection:				
F patient-F surgeon	3602 (218)	1.2 (0.8 to 1.7)	−0.1 (−0.5 to 0.4)	0.80
F patient-M surgeon	39 008 (2353)	1.3 (1.2 to 1.4)	Reference	
M patient-M surgeon	34 165 (2465)	2.3 (2.2 to 2.5)	−0.1 (−0.8 to 0.6)	0.71
M patient-F surgeon	2815 (211)	2.5 (1.8 to 3.1)	Reference	
Abdominal aortic aneurysm repair:				
F patient-F surgeon	689 (299)	4.1 (2.1 to 6.1)	−0.2 (−2.3 to 1.9)	0.83
F patient-M surgeon	11 991 (2902)	4.3 (3.9 to 4.7)	Reference	
M patient-M surgeon	37 998 (3646)	1.9 (1.8 to 2.1)	0.3 (−0.4 to 1.1)	0.39
M patient-F surgeon	2259 (392)	1.6 (0.9 to 2.3)	Reference	
Appendectomy:				
F patient-F surgeon	1944 (866)	1.6 (1.0 to 2.1)	0.2 (−0.5 to 0.9)	0.50
F patient-M surgeon	6615 (3362)	1.3 (1.0 to 1.6)	Reference	
M patient-M surgeon	3904 (2689)	3.0 (2.5 to 3.6)	0.9 (−1.6 to 3.3)	0.48
M patient-F surgeon	440 (347)	2.2 (−0.04 to 4.4)	Reference	
Cystectomy:				

Table 2 | Association between patient and surgeon gender concordance and patient adjusted 30 day mortality for elective surgical procedures *(Continued)*

Concordance	No. of patients (No. of surgeons)	Adjusted mortality rate % (95% CI)	Adjusted risk difference pp (95% CI)	P value
F patient-F surgeon	288 (120)	0.8 (−1.0 to 2.5)	−1.8 (−3.7 to 0.2)	0.073
F patient-M surgeon	2838 (1084)	2.5 (2.0 to 3.1)	Reference	
M patient-M surgeon	9794 (1861)	2.9 (2.6 to 3.3)	0.4 (−1.1 to 2.0)	0.58
M patient-F surgeon	583 (115)	2.5 (1.0 to 4.0)	Reference	
Thyroidectomy:				
F patient-F surgeon	380 (233)	0.6 (0.2 to 1.1)	0.2 (−0.2 to 0.5)	0.36
F patient-M surgeon	1993 (1166)	0.5 (0.2 to 0.7)	Reference	
M patient-M surgeon	1281 (831)	1.5 (0.8 to 2.2)	−0.04 (−2.6 to 2.5)	0.97
M patient-F surgeon	233 (142)	1.6 (−0.7 to 3.8)	Reference	
Liver resection:				
F patient-F surgeon	70 (51)	6.5 (−1.2 to 14.3)	2.9 (−5.4 to 11.1)	0.50
F patient-M surgeon	824 (434)	3.7 (2.4 to 5.0)	Reference	
M patient-M surgeon	1038 (481)	5.5 (4.2 to 6.9)	3.8 (−1.9 to 9.5)	0.19
M patient-F surgeon	102 (55)	1.7 (−3.4 to 6.9)	Reference	
Prostatectomy:				
F patient-F surgeon	N/A	N/A	N/A	N/A
F patient-M surgeon	N/A	N/A	N/A	
M patient-M surgeon	55 547 (5087)	0.8 (0.7 to 0.9)	0.5 (−0.1 to 1.1)	0.092
M patient-F surgeon	1658 (323)	0.3 (−0.2 to 0.9)	Reference	
Hysterectomy:				
F patient-F surgeon	15 844 (3303)	0.8 (0.6 to 0.9)	−0.1 (−0.4 to 0.1)	0.20
F patient-M surgeon	26 314 (4965)	0.9 (0.8 to 1.0)	Reference	
M patient-M surgeon	N/A	N/A	N/A	N/A
M patient-F surgeon	N/A	N/A	N/A	

Adjusted for patient characteristics (age, race and ethnic group, 27 chronic conditions, procedure type (for the analysis pooling the 14 procedure types), weekend versus weekday, month and year of surgery, and Medicaid coverage), surgeon characteristics (years of experience and operative volume), and hospital fixed effects (indicator variables for each hospital, effectively comparing patients treated at the same hospital). F=female; M=male. N/A=not available; pp=percentage point.

Table 3 | Association between patient-surgeon gender concordance and patient adjusted 30 day mortality for non-elective surgical procedures

Concordance	No. of patients (No. of surgeons)	Adjusted mortality rate, % (95% CI)	Adjusted risk difference, pp (95% CI)	P value
14 procedures (combined):				
F patient-F surgeon	27 703 (4954)	4.8 (4.5 to 5.1)	−0.1 (−0.4 to 0.2)	0.44
F patient-M surgeon	318 282 (34 312)	4.9 (4.9 to 5.0)	Reference	
M patient-M surgeon	241 559 (34 530)	5.9 (5.9 to 6.0)	0.2 (−0.2 to 0.6)	0.30
M patient-F surgeon	21 546 (4311)	5.8 (5.4 to 6.1)	Reference	
Knee replacement:				
F patient-F surgeon	425 (97)	2.0 (0.5 to 3.5)	1.3 (−0.3 to 2.8)	0.11
F patient-M surgeon	20 495 (3682)	0.7 (0.6 to 0.8)	Reference	
M patient-M surgeon	11 739 (2771)	0.7 (0.6 to 0.9)	0.7 (−0.9 to 2.3)	0.37
M patient-F surgeon	221 (65)	0.002 (−1.5 to 1.5)	Reference	
Hip replacement:				
F patient-F surgeon	5367 (743)	4.6 (3.9 to 5.2)	0.2 (−0.5 to 0.8)	0.63
F patient-M surgeon	146 283 (13 232)	4.4 (4.3 to 4.5)	Reference	
M patient-M surgeon	63 393 (11 563)	7.9 (7.7 to 8.1)	0.6 (−0.7 to 1.8)	0.40
M patient-F surgeon	2431 (601)	7.4 (6.1 to 8.6)	Reference	
Laminectomy or spinal fusion:				
F patient-F surgeon	652 (222)	2.2 (0.8 to 3.7)	0.01 (−1.5 to 1.5)	0.99
F patient-M surgeon	20 458 (4316)	2.2 (2.0 to 2.4)	Reference	
M patient-M surgeon	21 163 (4539)	4.3 (4.0 to 4.6)	−0.5 (−2.5 to 1.6)	0.64
M patient-F surgeon	762 (254)	4.8 (2.8 to 6.8)	Reference	
Colectomy:				
F patient-F surgeon	6830 (2452)	12.6 (11.7 to 13.5)	−0.9 (−2.0 to 0.1)	0.071
F patient-M surgeon	37 691 (10 560)	13.5 (13.2 to 13.9)	Reference	
M patient-M surgeon	25 517 (9289)	14.7 (14.2 to 15.1)	0.9 (−0.5 to 2.3)	0.21
M patient-F surgeon	4237 (1935)	13.8 (12.5 to 15.0)	Reference	
Cholecystectomy:				
F patient-F surgeon	8834 (2301)	2.2 (1.9 to 2.6)	−0.2 (−0.6 to 0.2)	0.37
F patient-M surgeon	55 086 (10 494)	2.4 (2.3 to 2.6)	Reference	
M patient-M surgeon	56 657 (10 449)	2.5 (2.3 to 2.6)	0.5 (0.1 to 0.8)	0.015
M patient-F surgeon	8971 (2282)	2.0 (1.7 to 2.3)	Reference	
Coronary artery bypass surgery:				
F patient-F surgeon	402 (110)	4.8 (1.7 to 7.9)	−1.9 (−5.0 to 1.3)	0.26
F patient-M surgeon	12 309 (2020)	6.7 (6.3 to 7.1)	Reference	
M patient-M surgeon	31 262 (2287)	3.7 (3.5 to 3.9)	−0.4 (−1.9 to 1.2)	0.65
M patient-F surgeon	1046 (133)	4.0 (2.5 to 5.5)	Reference	
Lung resection:				
F patient-F surgeon	181 (92)	1.0 (−5.2 to 7.3)	−5.6 (−12.5 to 1.2)	0.11
F patient-M surgeon	2180 (979)	6.7 (5.6 to 7.7)	Reference	
M patient-M surgeon	2705 (1235)	7.7 (6.7 to 8.7)	−1.9 (−7.9 to 4.1)	0.54
M patient-F surgeon	205 (111)	9.6 (3.9 to 15.3)	Reference	
Abdominal aortic aneurysm repair:				
F patient-F surgeon	261 (167)	20.7 (13.8 to 27.7)	1.2 (−6.1 to 8.6)	0.74
F patient-M surgeon	3034 (1665)	19.5 (18.1 to 20.9)	Reference	
M patient-M surgeon	7899 (2596)	15.9 (15.1 to 16.8)	−1.9 (−5.7 to 1.8)	0.31
M patient-F surgeon	711 (304)	17.9 (14.4 to 21.4)	Reference	
Appendectomy:				
F patient-F surgeon	3182 (1666)	2.4 (1.8 to 3.0)	0.2 (−0.4 to 0.9)	0.51
F patient-M surgeon	17 601 (7569)	2.2 (1.9 to 2.4)	Reference	
M patient-M surgeon	15 480 (7160)	2.8 (2.5 to 3.1)	−0.1 (−0.9 to 0.8)	0.91
M patient-F surgeon	2721 (1455)	2.8 (2.1 to 3.6)	Reference	
Cystectomy:				

Table 3 | Association between patient-surgeon gender concordance and patient adjusted 30 day mortality for non-elective surgical procedures *(Continued)*

Concordance	No. of patients (No. of surgeons)	Adjusted mortality rate, % (95% CI)	Adjusted risk difference, pp (95% CI)	P value
F patient-F surgeon	18 (18)	−12.6 (−62.0 to 36.8)	−21.8 (−76.7 to 33.2)	0.41
F patient-M surgeon	156 (120)	9.1 (2.6 to 15.7)	Reference	
M patient-M surgeon	530 (314)	5.3 (3.5 to 7.1)	2.7 (−10.4 to 15.7)	0.69
M patient-F surgeon	29 (22)	2.7 (−9.8 to 15.1)	Reference	
Prostatectomy:				
F patient-F surgeon	N/A	N/A	N/A	N/A
F patient-M surgeon	N/A	N/A	N/A	
M patient-M surgeon	4979 (2061)	2.0 (1.6 to 2.4)	−1.8 (−6.5 to 2.8)	0.44
M patient-F surgeon	180 (101)	3.8 (−0.7 to 8.3)	Reference	
Hysterectomy:				
F patient-F surgeon	1511 (687)	2.4 (1.5 to 3.3)	−0.04 (−1.4 to 1.3)	0.95
F patient-M surgeon	2711 (1103)	2.4 (1.8 to 3.1)	Reference	
M patient-M surgeon	N/A	N/A	N/A	N/A
M patient-F surgeon	N/A	N/A	N/A	

Adjusted for patient characteristics (age, race and ethnic group, 27 chronic conditions, procedure type (for the analysis pooling the 14 procedure types), weekend versus weekday, month and year of surgery, and Medicaid coverage), surgeon characteristics (years of experience and operative volume), and hospital fixed effects (indicator variables for each hospital, effectively comparing patients treated at the same hospital). Thyroidectomy and liver resection were removed as the estimate did not converge due to the small sample size (fewer than 10 patients). CI=confidence interval; F=female; M=male; N/A=not available; pp=percentage point.

We found no evidence that the patient-surgeon gender concordance was associated with the secondary outcomes, except for 30 day readmission rates (adjusted risk difference −0.4 percentage point (95% confidence interval −0.6 to −0.2); P<0.001), length of stay (adjusted difference −0.2 days (95% confidence interval −0.2 to −0.1); P<0.001), and complication rates (adjusted risk difference −0.5 percentage point (−0.7 to −0.2); P<0.001) among female patients (etables 2-5).

Surgeon gender and patient outcomes

Female surgeons had lower adjusted 30 day mortality than male surgeons for elective procedures (adjusted mortality 0.5% for female surgeons *v* 0.8% for male surgeons; adjusted risk difference −0.3 percentage point (95% confidence interval −0.3 to −0.2); P<0.001) (table 4), although the difference was not significant for non-elective procedures (adjusted mortality 5.2% for female surgeons *v* 5.4% for male surgeons; −0.1 (−0.4 to 0.1); P=0.25) (table 5). When we stratified by procedure types, surgeon gender was associated with patient mortality for elective colectomy, but the associations were not significant for the other procedures after accounting for multiple comparisons.

Table 4 | Comparison of patient adjusted 30 day mortality rates between female versus male surgeons for elective surgical procedures

Outcomes	No. of patients (No. of surgeons)	Adjusted mortality rate, % (95% CI)	Adjusted risk difference, pp (95% CI)	P value
14 procedures (combined):				
Female surgeon	89 828 (7600)	0.5 (0.4 to 0.6)	−0.3 (−0.3 to −0.2)	<0.001
Male surgeon	2 203 838 (43 916)	0.8 (0.7 to 0.8)	Reference	
Knee replacement:				
Female surgeon	12 616 (405)	0.1 (0.1 to 0.2)	−0.04 (−0.1 to 0.04)	0.30
Male surgeon	822 672 (10 846)	0.2 (0.2 to 0.2)	Reference	
Hip replacement:				
Female surgeon	7671 (385)	0.3 (0.2 to 0.5)	0.01 (−0.2 to 0.2)	0.89
Male surgeon	503 190 (9980)	0.3 (0.3 to 0.3)	Reference	
Laminectomy or spinal Fusion:				
Female surgeon	8636 (381)	0.4 (0.2 to 0.6)	−0.04 (−0.2 to 0.1)	0.63
Male surgeon	358 606 (6801)	0.5 (0.4 to 0.5)	Reference	
Colectomy:				
Female surgeon	21 584 (2772)	1.9 (1.7 to 2.1)	−0.4 (−0.7 to −0.2)	<0.001
Male surgeon	137 631 (13 244)	2.3 (2.2 to 2.4)	Reference	
Cholecystectomy:				
Female surgeon	4567 (1698)	2.2 (1.7 to 2.7)	−0.6 (−1.2 to −0.1)	0.026
Male surgeon	37 886 (9339)	2.8 (2.7 to 3.0)	Reference	
Coronary artery bypass surgery:				
Female surgeon	3847 (175)	2.5 (1.9 to 3.2)	−0.2 (−0.9 to 0.5)	0.53
Male surgeon	110 543 (2794)	2.8 (2.7 to 2.8)	Reference	
Lung resection:				
Female surgeon	6417 (262)	1.8 (1.4 to 2.2)	0.01 (−0.4 to 0.4)	0.96
Male surgeon	73 173 (2854)	1.8 (1.7 to 1.9)	Reference	
Abdominal aortic aneurysm repair:				
Female surgeon	2948 (438)	2.1 (1.4 to 2.8)	−0.4 (−1.1 to 0.4)	0.34
Male surgeon	49 989 (3965)	2.5 (2.4 to 2.6)	Reference	
Appendectomy:				
Female surgeon	2384 (1090)	1.8 (1.2 to 2.4)	−0.1 (−0.8 to 0.6)	0.78
Male surgeon	10 519 (5075)	1.9 (1.7 to 2.2)	Reference	
Cystectomy:				
Female surgeon	871 (184)	2.1 (1.0 to 3.2)	−0.8 (−1.9 to 0.4)	0.20
Male surgeon	12 632 (2144)	2.8 (2.6 to 3.1)	Reference	
Thyroidectomy:				
Female surgeon	613 (300)	0.8 (0.01 to 1.7)	−0.1 (−1.0 to 0.8)	0.88
Male surgeon	3274 (1605)	0.9 (0.6 to 1.2)	Reference	
Liver resection:				
Female surgeon	172 (83)	3.7 (−0.4 to 7.8)	−1.0 (−5.4 to 3.4)	0.66
Male surgeon	1862 (680)	4.7 (3.8 to 5.7)	Reference	
Prostatectomy:				
Female surgeon	1658 (323)	0.3 (−0.2 to 0.9)	−0.5 (−1.1 to 0.1)	0.092
Male surgeon	55 547 (5087)	0.8 (0.7 to 0.9)	Reference	
Hysterectomy:				
Female surgeon	15 844 (3303)	0.8 (0.6 to 0.9)	−0.1 (−0.4 to 0.1)	0.20
Male surgeon	26 314 (4965)	0.9 (0.8 to 1.0)	Reference	

Adjusted for patient characteristics (age, gender, race and ethnic group, 27 chronic conditions, procedure type (for the analysis pooling the 14 procedure types), weekend versus weekday, month and year of surgery, and Medicaid coverage), surgeon characteristics (years of experience and operative volume), and hospital fixed effects (indicator variables for each hospital, effectively comparing patients treated at the same hospital). CI=confidence interval; pp=percentage point.

Table 5 | Comparison of patient adjusted 30 day mortality between female versus male surgeons for non-elective surgical procedures

Outcomes	No. of patients (No. of surgeons)	Adjusted mortality rate, % (95% CI)	Adjusted risk difference, pp (95% CI)	P value
14 procedures (combined):				
Female surgeon	49 249 (5729)	5.2 (5.0 to 5.5)	−0.1 (−0.4 to 0.1)	0.25
Male surgeon	559 841 (39 685)	5.4 (5.3 to 5.4)	Reference	
Knee replacement:				
Female surgeon	646 (122)	1.1 (−0.1 to 2.4)	0.4 (−0.8 to 1.7)	0.52
Male surgeon	32 234 (4601)	0.7 (0.6 to 0.8)	Reference	
Hip replacement:				
Female surgeon	7798 (802)	5.4 (4.8 to 6.0)	−0.1 (−0.7 to 0.6)	0.87
Male surgeon	209 676 (13 895)	5.5 (5.4 to 5.6)	Reference	
Laminectomy or spinal fusion:				
Female surgeon	1414 (311)	3.4 (2.2 to 4.7)	0.1 (−1.1 to 1.4)	0.83
Male surgeon	41 621 (5351)	3.3 (3.1 to 3.5)	Reference	
Colectomy:				
Female surgeon	11 067 (2905)	13.2 (12.4 to 13.9)	−0.8 (−1.6 to −0.01)	0.046
Male surgeon	63 208 (12 419)	14.0 (13.7 to 14.2)	Reference	
Cholecystectomy:				
Female surgeon	17 805 (2733)	2.2 (1.9 to 2.4)	−0.3 (−0.6 to −0.02)	0.033
Male surgeon	111 743 (11 949)	2.4 (2.4 to 2.5)	Reference	
Coronary artery bypass surgery:				
Female surgeon	1448 (153)	4.3 (3.0 to 5.7)	−0.2 (−1.6 to 1.2)	0.80
Male surgeon	43 571 (2366)	4.5 (4.3 to 4.7)	Reference	
Lung resection:				
Female surgeon	386 (159)	5.9 (2.1 to 9.6)	−1.4 (−5.6 to 2.6)	0.50
Male surgeon	4885 (1673)	7.2 (6.5 to 8.0)	Reference	
Abdominal aortic aneurysm repair:				
Female surgeon	972 (349)	17.8 (14.8 to 20.8)	0.8 (−2.4 to 4.0)	0.62
Male surgeon	10 933 (2949)	17.0 (16.3 to 17.7)	Reference	
Appendectomy:				
Female surgeon	5903 (2176)	2.6 (2.2 to 3.1)	0.2 (−0.3 to 0.7)	0.45
Male surgeon	33 081 (9611)	2.4 (2.3 to 2.6)	Reference	
Cystectomy:				
Female surgeon	47 (38)	−0.1 (−9.7 to 9.4)	−6.1 (−16.4 to 4.1)	0.24
Male surgeon	686 (381)	6.0 (4.3 to 7.7)	Reference	
Thyroidectomy:				
Female surgeon	43 (39)	4.4 (−1.5 to 10.4)	3.5 (−3.1 to 10.0)	0.29
Male surgeon	322 (238)	1.0 (0.1 to 1.8)	Reference	
Liver resection:				
Female surgeon	43 (39)	0.5 (−22.0 to 22.9)	−10.5 (−36.5 to 15.5)	0.42
Male surgeon	322 (238)	10.9 (6.2 to 15.7)	Reference	
Prostatectomy:				
Female surgeon	180 (101)	3.8 (−0.7 to 8.3)	1.8 (−2.8 to 6.5)	0.44
Male surgeon	4979 (2061)	2.0 (1.6 to 2.4)	Reference	
Hysterectomy:				
Female surgeon	1511 (687)	2.4 (1.5 to 3.3)	−0.04 (−1.4 to 1.3)	0.95
Male surgeon	2711 (1103)	2.4 (1.8 to 3.1)	Reference	

Adjusted for patient characteristics (age, gender, race and ethnic group, 27 chronic conditions, procedure type (for the analysis pooling the 14 procedure types), weekend versus weekday, month and year of surgery, and Medicaid coverage), surgeon characteristics (years of experience and operative volume), and hospital fixed effects (indicator variables for each hospital, effectively comparing patients treated at the same hospital).

CI=confidence interval; pp=percentage point.

Patient gender and patient outcomes

We found that female patients had lower mortality after a procedure than male patients for both elective and non-elective surgeries (etables 6 and 7). Although female patients tended to have lower mortality compared with male patients across various procedure types, their mortality was higher when undergoing abdominal aortic aneurysm repair or coronary artery bypass surgery.

Secondary analyses

Our findings were qualitatively unaffected by including hospital random effects (instead of hospital fixed effects), including only hospitals where at least one or 10 surgical procedures were performed by female surgeons, applying different window periods to define non-elective procedures, adjusting for ICD-10-PCS procedure codes (instead of the procedure types), or additionally adjusting for social deprivation index or claims based frailty index (etables 8–15).

We found consistent patterns across both teaching and non-teaching hospitals, indicating that the involvement of trainees has minimal influence on our overall findings (etables 16 and 17). We did not find a clinically meaningful association between patient-surgeon gender concordance and operative mortality for both hospitals with high versus low mortality (etables 18 and 19).

Discussion

Principal findings

This analysis found that mortality after surgery was similar between patients treated by gender concordant versus gender discordant surgeons. The association varied across surgical procedures and no significant associations were identified for non-elective surgeries.

These results among older Medicare fee-for-service beneficiaries in the United States are largely consistent with a prior study conducted in Ontario, Canada that reported an association between the gender of the patient's surgeon and better outcomes for female patients, but no difference in outcomes for male patients.[5] Our study and the Canadian study had differences in health care delivery in health care systems and inclusion criteria for analyses. For example, the proportion of female surgeons as well as structural gender inequalities at a broader societal level differ between the US and Canada. Additionally, the referral patterns and the ability to direct referrals from referring physicians, as well as for patients to choose physicians, for elective procedures may differ between these two countries. Regarding the patients included, this study used national data of older Americans (aged ≥65 years) who received a surgical procedure in the US, whereas the Ontario data included younger patients (aged ≥18 years) but was restricted to one Canadian province.

We found heterogeneity by procedure type in the association between patient-surgeon gender concordance and surgical mortality. A potential reason for the heterogeneity among different types of procedures could be attributed to the complexity of the procedure. The gender concordance may be associated with lower patient mortality because of a decreased implicit gender bias among surgeons and improved patient-surgeon communication. Consequently, this effect may have a larger role in complex surgeries that have a higher baseline mortality rate and necessitate smooth communication than in relatively simple, standardized procedures.

Female v male surgeons

Our results indicate that patients of female surgeons had lower mortality after surgery compared with patients of male surgeons

for both male and female patients (only for elective surgeries). This finding suggests that surgeon gender or other characteristics may be more influential than gender concordance between patients and surgeons in terms of surgical mortality. Several potential mechanisms could explain this effect. Firstly, female surgeons may abide by clinical guidelines more than male surgeons. For example, literature suggests that female surgeons treating patients with breast cancer have been found to be more likely to offer guideline-concordant treatments,[31] recommend adjuvant radiotherapy after breast conservation surgery,[32] perform contralateral prophylactic mastectomy,[33] and they are less likely to perform lymph node dissection along with breast conservation surgery.[34] Secondly, research into economics and psychology suggests that women are generally more risk averse than men,[35][36] which also may influence decision making processes in surgical care that affect patient outcomes. Thirdly, female surgeons might have better communication and increased attention to post-operative care than male surgeons, which could affect patient mortality. Lastly, the observed association was limited to elective surgeries and as elective surgeries allow patients to choose their own surgeon, they are more prone to unmeasured confounding compared with non-elective surgeries. Therefore, our findings might be explained by unmeasured confounding. Given the constraints of the available information in the Medicare claims data, we were unable to delve into the underlying mechanisms (eg, better patient-surgeon communication or improved attention to post-operative care) that might have affected the observed disparity (or absence thereof) in patient mortality.

A slightly lower postoperative mortality among female surgeons was observed for elective procedures, but not for non-elective procedures. This differential effect between elective and non-elective surgeries could be attributed to potentially superior preoperative management and patient selection by female surgeons, influencing only elective procedures' outcomes. Alternatively, unmeasured confounding may exist, with patients treated by female surgeons possibly being less ill in ways we cannot measure (although we have no data to support or refute this possibility), as patients are more likely to select their surgeons for elective procedures than for non-elective procedures.

For elective procedures, we found that female surgeons led to slightly lower mortality compared with male surgeons, not only when they treat female patients but also when they treat male patients. These findings were largely consistent with existing studies conducted in the US and Canada.[6][20] Women are still under-represented in surgery compared with their male counterparts.[37][38] If our findings were causal, these results suggest that increasing gender diversity within the surgeon workforce has the potential to improve the quality of surgical care and patient outcomes. Given many challenges female surgeons face, such as the potential effect of marriage, childbearing, and gender discrimination on their careers as surgeons,[39][40] creating a supportive work and training environment for female surgeons has the potential to promote the gender diversity of the surgeon workforce.

Female v male patients

We also found that female patients had lower surgical mortality rates compared with male patients, and several possible explanations exist. Biological differences in response to surgical interventions between men and women may influence outcomes. Research suggests that female patients exhibited a lower likelihood of requiring intensive care after surgery.[41] Additionally, differences in healthcare seeking behaviour based on gender could affect

surgical treatment. If female patients seek medical care at earlier stages of disease, they may face a lower risk of mortality compared with male patients. Furthermore, given the limitations of the available Medicare claims data in providing detailed information to explore these potential mechanisms, female patients might have been healthier than male patients in unmeasurable ways (yet, we have no data to support or refute this possibility).

Limitations

Our study has limitations. Firstly, unmeasured confounders might not have been captured in administrative claims data such as patient and physician sociocultural aspects, structural sexism, unconscious gender and sex bias, and differential communication styles based on surgeon and patient gender. Patient gender, surgeon gender, and gender concordance could potentially affect decisions made by primary care physicians regarding the referral of their patients to specific surgeons.[42 -47] This could potentially introduce biases in our estimates if the referrals from primary care physicians to surgeons are also associated with the severity of the patient's illness. However, such bias is less likely to occur with non-elective procedures because of the quasi-randomisation of assigning patients to on-call surgeons. Secondly, we are unable to account for members of the health care team beyond the operating surgeon, for example, anesthesiologists, residents, nurses, and other healthcare providers. Thirdly, we analysed the data for Medicare fee-for-service beneficiaries aged 65 years and older who underwent a common surgical procedure; therefore, our findings may not be generalizable to younger populations, Medicare advantage beneficiaries, patients who receive less common procedures, or patients in other countries.

Conclusions

In this large study using national data for Medicare fee-for-service beneficiaries aged 65 and older who underwent common surgical procedures, we found that post-operative mortality was similar among the four types of patient-surgeon gender dyads. The associations were heterogeneous across different types of surgical procedures, with no significant findings observed for non-elective surgeries. Understanding the underlying mechanisms of this observation allows the opportunity to improve processes and patterns of care for all patients. Ongoing qualitative and quantitative research will better delineate how surgeon and patient gender, along with race and other aspects of shared identity, affect quality of care and outcomes after surgery.

What is already known on this topic

- Evidence is limited regarding the association between patient-surgeon gender concordance and patient health outcomes

- One study conducted in Ontario, Canada reported that patient-surgeon gender concordance was associated with better outcomes among female patients, but no difference for male patients

- No study has investigated the effect of patient-surgeon gender concordance on patient mortality in the US

What this study adds

- Among Medicare fee-for-service beneficiaries who underwent a common surgical procedure, mortality after surgery was similar among the four types of patient-surgeon gender dyads

- The association between patient-surgeon gender concordance and mortality after surgery was heterogeneous across different types of surgical procedures

AUTHOR AFFILIATIONS

1 Division of Urology, Department of Surgery, University of Toronto, Toronto, ON, Canada

2 Division of Urology, Department of Surgery, Mount Sinai Hospital, Toronto, ON, Canada

3 Division of Urology, Department of Surgery, University Health Network, Toronto, ON, Canada

4 Department of Anesthesia, Sunnybrook Health Sciences Center, Toronto, ON, Canada

5 Division of General Internal Medicine and Health Services Research, David Geffen School of Medicine at UCLA, Los Angeles, CA, USA

6 Department of Epidemiology, UCLA Fielding School of Public Health, Los Angeles, CA, USA

7 Department of Urology, Houston Methodist Hospital, Houston, TX, USA

8 Center for Outcomes Research, Houston Methodist Hospital, Houston, TX, USA

9 Department of Health Policy and Management, School of Public Health, Texas A&M University, College Station, TX, USA

10 Department of Surgery, University of Michigan, Ann Arbor, MI, USA

11 Division of General Internal Medicine and Primary Care, Brigham and Women's Hospital, Boston, MA, USA

12 Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, MA, USA

13 Department of Surgery, University of California Los Angeles, Los Angeles, CA, USA

14 Department of Medicine, Stanford University School of Medicine, Palo Alto, CA, USA

15 Division of Urology, Medical College of Georgia-Augusta University, Augusta, GA, USA

16 Department of Surgery, Sunnybrook Health Sciences Center, Toronto, ON, Canada

17 Institute for Health Policy, Management and Evaluation, University of Toronto, Toronto, ON, Canada

18 George Washington University, School of Medicine and Health Sciences, Washington, DC, USA

19 Department of Medicine, University of Toronto, Toronto, ON, Canada

20 Department of Medicine, Mount Sinai Hospital and University Health Network, Toronto, ON, Canada

21 Department of Health Policy and Management, UCLA Fielding School of Public Health, Los Angeles, CA, USA

1   Shrime MG, Sleemi A, Ravilla TD. Charitable platforms in global surgery: a systematic review of their effectiveness, cost-effectiveness, sustainability, and role training. *World J Surg* 2015;39:-20. doi: 10.1007/s00268-014-2516-0 pmid: 24682278

2   Shrime MG, Bickler SW, Alkire BC, Mock C. Global burden of surgical disease: an estimation from the provider perspective. *Lancet Glob Health* 2015;3(Suppl 2):-9. doi: 10.1016/S2214-109X(14)70384-5 pmid: 25926322

3   Birkmeyer JD, Siewers AE, Finlayson EV, etal. Hospital volume and surgical mortality in the United States. *N Engl J Med* 2002;346:-37. doi: 10.1056/NEJMsa012337 pmid: 11948273

4   Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. *N Engl J Med* 2003;349:-27. doi: 10.1056/NEJMsa035205 pmid: 14645640

5   Wallis CJD, Jerath A, Coburn N, etal. Association of Surgeon-Patient Sex Concordance With Postoperative Outcomes. *JAMA Surg* 2022;157:-56. doi: 10.1001/jamasurg.2021.6339 pmid: 34878511

6   Wallis CJ, Ravi B, Coburn N, Nam RK, Detsky AS, Satkunasivam R. Comparison of postoperative outcomes among patients treated by male and female surgeons: a population based matched cohort study. *BMJ* 2017;359:. doi: 10.1136/bmj.j4366 pmid: 29018008

7   Satkunasivam R, Klaassen Z, Ravi B, etal. Relation between surgeon age and postoperative outcomes: a population-based cohort study. *CMAJ* 2020;192:-92. doi: 10.1503/cmaj.190820 pmid: 32392499

8   Smith-Lovin L, Brody C. Interruptions in group discussions: the effects of gender and group composition. *Am Sociol Rev* 1989;54:-35doi: 10.2307/2095614.

9   Hall JA, Irish JT, Roter DL, Ehrlich CM, Miller LH. Gender in medical encounters: an analysis of physician and patient communication in a primary care setting. *Health Psychol* 1994;13:-92. doi: 10.1037/0278-6133.13.5.384 pmid: 7805632

10   Christen RN, Alder J, Bitzer J. Gender differences in physicians' communicative skills and their influence on patient satisfaction in gynaecological outpatient consultations. *Soc Sci Med* 2008;66:-83. doi: 10.1016/j.socscimed.2007.12.011 pmid: 18222586

11   Janssen SM, Lagro-Janssen AL. Physician's gender, communication style, patient preferences and patient satisfaction in gynecology and obstetrics: a systematic review. *Patient Educ Couns* 2012;89:-6. doi: 10.1016/j.pec.2012.06.034 pmid: 22819711

12   Brewer MB. In-group bias in the minimal intergroup situation: A cognitivemotivational analysis. *Psychol Bull* 1979;86:-24doi: 10.1037/0033-2909.86.2.307.

13   Gross R, McNeill R, Davis P, Lay-Yee R, Jatrana S, Crampton P. The association of gender concordance and primary care physicians' perceptions of their patients. *Women Health* 2008;48:-44. doi: 10.1080/03630240802313464 pmid: 19042213

14   Malhotra J, Rotter D, Tsui J, Llanos AAM, Balasubramanian BA, Demissie K. Impact of patient-provider race, ethnicity, and gender concordance on cancer screening: findings from medical expenditure panel survey. *Cancer Epidemiol Biomarkers Prev* 2017;26:-11. doi: 10.1158/1055-9965.EPI-17-0660 pmid: 29021217

15   Jerant A, Bertakis KD, Fenton JJ, Tancredi DJ, Franks P. Patient-provider sex and race/ethnicity concordance: a national study of healthcare and outcomes. *Med Care* 2011;49:-20. doi: 10.1097/MLR.0b013e31823688ee pmid: 22002644

16   Cooper-Patrick L, Gallo JJ, Gonzales JJ, etal. Race, gender, and partnership in the patient-physician relationship. *JAMA* 1999;282:-9. doi: 10.1001/jama.282.6.583 pmid: 10450723

17   Lurie N, Slater J, McGovern P, Ekstrum J, Quam L, Margolis K. Preventive care for women. Does the sex of the physician matter?*N Engl J Med* 1993;329:-82. doi: 10.1056/NEJM199308123290707 pmid: 8332153

18   Beran MS, Cunningham W, Landon BE, Wilson IB, Wong MD. Clinician gender is more important than gender concordance in quality of HIV care. *Gend Med* 2007;4:-84. doi: 10.1016/S1550-8579(07)80010-6 pmid: 17584629

19   Greenwood BN, Carnahan S, Huang L. Patient-physician gender concordance and increased mortality among female heart attack patients. *Proc Natl Acad Sci U S A* 2018;115:-74. doi: 10.1073/pnas.1800097115 pmid: 30082406

20   Tsugawa Y, Jena AB, Orav EJ, etal. Age and sex of surgeons and mortality of older surgical patients: observational study. *BMJ* 2018;361:. doi: 10.1136/bmj.k1343 pmid: 29695473

21   von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JPSTROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med* 2007;147:-7. doi: 10.7326/0003-4819-147-8-200710160-00010 pmid: 17938396

22   Benchimol EI, Smeeth L, Guttmann A, etalRECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. *PLoS Med* 2015;12:e1001885. doi: 10.1371/journal.pmed.1001885 pmid: 26440803

23   Sahni NR, Dalton M, Cutler DM, Birkmeyer JD, Chandra A. Surgeon specialization and operative mortality in United States: retrospective analysis. *BMJ* 2016;354:. doi: 10.1136/bmj.i3571 pmid: 27444190

24   Waljee JF, Greenfield LJ, Dimick JB, Birkmeyer JD. Surgeon age and operative mortality in the United States. *Ann Surg* 2006;244:-62. doi: 10.1097/01.sla.0000234803.11991.6d pmid: 16926561

25   Finks JF, Osborne NH, Birkmeyer JD. Trends in hospital volume and operative mortality for high-risk surgery. *N Engl J Med* 2011;364:-37. doi: 10.1056/NEJMsa1010705 pmid: 21631325

26   Miller ME, Welch WP, Welch HG. The impact of practicing in multiple hospitals on physician profiles. *Med Care* 1996;34:-62. doi: 10.1097/00005650-199605000-00007 pmid: 8614167

27   Research Data Assistance Centre. Medicare Data on Provider Practice and Specialty (MD-PPAS). https://resdac.org/cms-data/files/md-ppas.

28   Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects.*Stata J* 2012;12:-31doi: 10.1177/1536867X1201200209.

29   Robert Graham Center - Policy Studies in Family Medicine & Primary Care. Social deprivation index (SDI). 2018https://www.graham-center.org/maps-data-tools/social-deprivation-index.html.

30   Kim DH, Schneeweiss S, Glynn RJ, Lipsitz LA, Rockwood K, Avorn J. Measuring frailty in medicare data: development and validation of a claims-based frailty index. *J Gerontol A Biol Sci Med Sci* 2018;73:-7. doi: 10.1093/gerona/glx229 pmid: 29244057

31   Silliman RA, Demissie S, Troyan SL. The care of older women with early-stage breast cancer: what is the role of surgeon gender?*Med Care* 1999;37:-67. doi: 10.1097/00005650-199910000-00009 pmid: 10524372

32   Hershman DL, Buono D, McBride RB, etal. Surgeon characteristics and receipt of adjuvant radiotherapy in women with breast cancer. *J Natl Cancer Inst* 2008;100:-206. doi: 10.1093/jnci/djm320 pmid: 18230795

33   Arrington AK, Jarosek SL, Virnig BA, Habermann EB, Tuttle TM. Patient and surgeon characteristics associated with increased use of contralateral prophylactic mastectomy in patients with breast cancer. *Ann Surg Oncol* 2009;16:-704. doi: 10.1245/s10434-009-0641-z pmid: 19653045

34   Gilligan MA, Neuner J, Sparapani R, Laud PW, Nattinger AB. Surgeon characteristics and variations in treatment for early-stage breast cancer. *Arch Surg* 2007;142:-22. doi: 10.1001/archsurg.142.1.17 pmid: 17224496

35   Eckel CC, Grossman PJ. Men, women and risk aversion: experimental evidence. Handbook of experimental economics results. 2008;1:1061-73.

36   Mittal M, Vyas R. A study of psychological reasons for gender differences in preferences for risk and investment decision making. *IUP Journal of Behavioral Finance*. 2011;8:.

37   AAMC. Physician Specialty Data Report. 2019. https://www.aamc.org/data-reports/workforce/interactive-data/active-physicians-sex-and-specialty-2019.

38   Newman TH, Parry MG, Zakeri R, etal. Gender diversity in UK surgical specialties: a national observational study. *BMJ Open* 2022;12:e055516.

39   Schmidt LE, Cooper CA, Guo WA. Factors influencing US medical students' decision to pursue surgery. *J Surg Res* 2016;203:-74. doi: 10.1016/j.jss.2016.03.054 pmid: 27338536

40   Giantini Larsen AM, Pories S, Parangi S, Robertson FC. Barriers to Pursuing a Career in Surgery: An Institutional Survey of Harvard Medical School Students. *Ann Surg* 2021;273:-6. doi: 10.1097/SLA.0000000000003618 pmid: 31599803

41   Wichmann MW, Inthorn D, Andress HJ, Schildberg FW. Incidence and mortality of severe sepsis in surgical intensive care patients: the influence of patient gender on disease process and outcome. *Intensive Care Med* 2000;26:-72. doi: 10.1007/s001340050041 pmid: 10784304

42   Schattner A, Sabbah A, Dubin I. Mind the caretaker: ED referrals of community-dwelling older adult patients by their primary caregivers are accurate. *Am J Emerg Med* 2021;44:-4. doi: 10.1016/j.ajem.2021.02.008 pmid: 33582614

43   Franks P, Clancy CM. Referrals of adult patients from primary care: demographic disparities and their relationship to HMO insurance. *J Fam Pract* 1997;45:-53.pmid: 9228914

44   Foote DC, Burke CR, Pandian B, etal. Gender disparity in referral for definitive care of malignant pleural effusions. *J Surg Res* 2019;244:-16. doi: 10.1016/j.jss.2019.06.068 pmid: 31325663

45   Feldman DE, Huynh T, Des Lauriers J, etal. Gender and other disparities in referral to specialized heart failure clinics following emergency department visits. *J Womens Health (Larchmt)* 2013;22:-31. doi: 10.1089/jwh.2012.4107 pmid: 23751166

46   Chen YW, Orlas C, Chang DC, Kelleher CM. Gender homophily in interphysician referrals to surgeons. *J Surg Res* 2023;283:-5. doi: 10.1016/j.jss.2022.10.021 pmid: 36372029

47   Dossa F, Zeltzer D, Sutradhar R, Simpson AN, Baxter NN. Sex differences in the pattern of patient referrals to male and female surgeons. *JAMA Surg* 2022;157:-103. doi: 10.1001/jamasurg.2021.5784 pmid: 34757424