BMJ Open

The impact of physician sex/gender on processes of care, and clinical outcomes in cardiac operative care: A systematic review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-037139
Article Type:	Original research
Date Submitted by the Author:	21-Jan-2020
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Keywords:	EPIDEMIOLOGY, Cardiac surgery < SURGERY, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Title: The impact of physician sex/gender on processes of care, and clinical outcomes in cardiac operative care: A systematic review

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Word count: 2401

ABSTRACT

Objectives: This systematic review aimed to assess the role of physician sex and gender in relation to processes of care and/or clinical outcomes within the context of cardiac operative care.

Design: Systematic review.

Data sources: Searches were conducted in PsycINFO, Embase, and Medline from inception to September 6, 2018. The reference lists of relevant systematic reviews and included studies were also searched.

Eligibility criteria for selecting studies: Quantitative studies of any design were included if they were published in English or French, involved patients of any age undergoing a cardiac surgical procedure, and specifically assessed differences in processes of care or clinical patient outcomes by physician sex or gender. Studies were screened in duplicate by two pairs of independent reviewers.

Outcome measures: Processes of care, patient morbidity, patient mortality.

Results: The search yielded 2095 publications after duplicate removal, of which two were ultimately included. These studies involved various types of surgery, including cardiac. One study found that patients treated by female surgeons compared to male surgeons had a lower 30-day mortality. The other study, however, found no differences in patient outcomes by surgeon sex. There were no studies that investigated anaesthesiologist sex/gender. There were also no studies investing physician sex or gender exclusively in the cardiac OR.

Conclusions: The limited data surrounding the impact of physician sex/gender on the outcomes of cardiac surgery inhibits drawing a robust conclusion at this time. Results highlight the need for primary research to determine how these factors may influence cardiac operative practice, in order to optimize provider performance and improve outcomes in this high-risk patient group.

Key words: cardiac surgical procedures; perioperative care; operating rooms; physicians, women; surgeons; anesthetics; sex; gender

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first systematic review to assess the impact of physician sex and gender on patient outcomes in cardiac surgery.
- The robust search strategy and screening process identified two indirectly relevant articles, which included cardiac surgery as one of many specialties assessed.
- A potential limitation of this study is that only articles published in English or French were included; however, we address two potentially relevant studies published in other languages in our discussion.
- Findings highlight an important knowledge gap related to physician sex/gender in the cardiac operating room, and in particular, as it relates to anaesthesiologists' practice as the included studies only studied surgeons.

INTRODUCTION

Approximately two million cardiac surgical procedures are performed globally every year [1]. Complication rates after cardiac surgery vary from two to 60%, depending on the outcome examined [2–6]. Importantly, many of these complications are preventable, and are related to ineffective teamwork in the operating room (OR) [7–16]. Effective teamwork encompasses both observable behaviours and clinicians' perceptions of interpersonal processes [17,18]. Though all team members play an important role, the relationship between the surgeon-anaesthesiologist dyad, who "sometimes share, yield, or compete for leadership", most critically influences overall OR team performance [19]. Research has identified tension between anaesthesiologists and surgeons as potentially arising from misperceptions of each other and discrepant views on which their quality of collaboration and communication was built [19–24]. Though power struggles in the OR have often been attributed to differences in professional training or values [15], research increasingly suggests that sex (i.e. biological, anatomical, and physiological characteristics) and gender (i.e. identity, behaviour, roles, and relations) shape team interactions in healthcare, as well as the different practice patterns observed among female and male physicians [25–34].

Cohesive teamwork and effective communication are especially important in the cardiac OR given the high acuity of cases, frequent and sudden events of hemodynamic instability, critical moments of cardiopulmonary bypass initiation and separation, and the need for precise blood pressure control during key stages of operation. Moreover, the high-risk nature of cardiac surgery and the predominance of male physicians in the cardiac OR compared to other surgical specialties [35] make effective teamwork and communication even more critical in this operative setting. For example, studies on non-cardiac OR teams show that women providers may be challenged more often than men and may also be less likely to speak up when an incorrect clinical decision is made [32,34]. Cooperation and communication have also been observed to decrease when more than half of the providers in an OR are male [33].

Sex and gender may also be relevant to the performance of individual physicians in the cardiac OR. Recent findings also suggest that male anaesthesiologists spend a greater proportion of time and may thus be more experienced with the care of complex cardiac and/or vascular patients, than their female counterparts [36]. This remains true despite the increasing number of female providers entering the specialty. Meanwhile, the broader surgical education literature suggests that male and female residents may benefit from different approaches to training (e.g. one-on-one training, instructor feedback are better received by female residents), but this finding has not been implemented in any postgraduate training programs [27].

Although physician sex and gender have been shown to influence processes of care and outcomes in non-cardiac medical and surgical care as well as in primary cardiac care [25,26,37–42], the role of these factors within the cardiac OR remains unclear. As such, it is necessary to quantify the effect of physician sex and gender on clinical processes of care and adverse patient outcomes for the cardiac OR. To this end, we conducted a systematic review to analyze the role of anaesthesiologists' and surgeons' sex and gender in relation to processes of care and/or clinical outcomes within the context of cardiac operative care.

METHODS

This review was conducted and reported in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [43]. The protocol was published on the University of Ottawa's research repository [44].

Eligibility criteria

Studies were included if they involved surgical patients of any age who underwent a cardiac surgical procedure requiring anaesthetic care, as long as there were specific investigations on the impact of medical provider (e.g., cardiac surgeon and cardiac anaesthesiologist) sex and/or gender on primary outcomes of process of care or patient outcome. Processes of care include but are not limited to hemostatic practices, antibiotic prophylaxis, selection of coronary artery bypass conduits, and harvesting of these conduits (i.e., pedicled vs skeletonized). Patient perioperative outcomes include postoperative 30-day mortality and complications (e.g. chylothorax, sternal wound infection, acute kidney injury, venous thrombosis, stroke, improvement of left ventricular function, blood loss, and length of hospital stay). Studies that did not specifically investigate the impact of provider sex/gender on process of care within the cardiac OR or patient outcomes, or that focused on patient sex/gender differences without considering provider sex/gender, were excluded. Studies that only explored the implications of surgeon sex and/or gender in non-cardiac procedures were omitted. Both comparative interventional (e.g., randomized control trials) and non-interventional (e.g., cohort) studies of any design were eligible for inclusion if they were published in a peer-reviewed journal. Letters, editorials, opinion pieces, conference abstracts, and reviews were excluded. Grey literature produced outside of conventional scientific publishing and distribution was not considered for this review.

Search strategy and information sources

The search strategy was developed in collaboration with an experienced information specialist (AD) (Appendix 1). The strategy was then reviewed by a second information specialist as per PRESS guidelines [45]. Searches were conducted in the electronic databases PsycINFO, Embase, Medline, and Medline in Process (via OVID) from inception to September 6th, 2018. Date and language restrictions were not applied; however, we planned to extract data from only those studies published in English or French. We also planned to search reference lists of included articles and to submit the final list of included studies to a group of experts (researchers, anaesthesiologists, and surgeons involved in cardiac care) to verify relevance and accuracy.

Study selection

DistillerSR systematic review software (Evidence Partners, Ottawa, Canada) was used to facilitate the study screening and selection process. Screening forms were developed and piloted by members of the review team prior to undertaking full screening (AJ, FM, HS, KZ). Titles and abstracts were screened for eligibility in duplicate by two pairs of independent reviewers (AJ, FM, HS, KZ). The full texts of titles and abstracts deemed potentially relevant by two reviewers were then reviewed. At each level of screening, disagreements were resolved through consensus or discussion with a third reviewer, if necessary.

Data items and abstraction

Data abstraction was conducted in duplicate by two pairs of independent reviewers using an electronic form in DistillerSR. The form included publication details (e.g. first author, year, country of data collection), clinical context (e.g. type of procedure, type of anaesthesia, urgent or elective procedure), population demographics (e.g. sex/gender of patients/providers, patient comorbidities, patient age), study details (e.g. research question/objective, methods used), outcomes assessed (i.e. process of care or patient outcomes studied, definition, timing), and study results (i.e. the reported impact of provider/patient sex/gender on process of care/patient outcomes). Furthermore, we planned to assess risk of bias in duplicate using one of three tools, depending on each study design. The NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies was used to assess risk of bias [46]. Reviewers assessed risk of bias independently and in duplicate, using consensus or third reviewer consultation to resolve disagreements (MD, FM).

Patient and public involvement

No patients were involved.

RESULTS

Study selection

The search yielded 3296 publications. After removal of duplicates, 2095 underwent title and abstract screening, and 2076 were removed due to failure to meet our eligibility criteria of assessing the impact of health care provider sex/gender on processes of care and patient outcomes in the setting of cardiac surgery. Nineteen studies proceeded to full-text screening. After full-text review, 17 were excluded based on our predetermined inclusion and exclusion criteria. The study PRISMA flow diagram is shown in Figure 1. A list of studies excluded at level two (with reasons) is provided in Appendix 2.

Study characteristics and synthesis

There were two eligible English studies indirectly assessing the impact of healthcare provider sex or gender in cardiac surgery in this systematic review. These studies are described below and summarized in Table 1.

A retrospective matched cohort study by Wallis et al [29] explored the adverse postoperative outcomes (death, readmission, or complications) among 104 603 patients seen by female and male surgeons in Ontario, Canada. Overall, patients treated by female surgeons had a small but statistically significantly lower risk of 30 day mortality ($p = 0.04$) and comparable surgical outcomes (length of stay, complications, and readmission), compared with those treated by male surgeons. Among patients of female (n = 4023) and male (n = 4039) cardiothoracic surgeons, there was a trend towards more favorable outcomes by female surgeons, with an odds ratio of 0.91 (95% CI 0.82 -1.01) for postoperative adverse events.

An observational study by Tsugawa et al [47] done in acute care hospitals across the United States evaluated the age and sex of surgeons on operative mortality of 892 187 patients over 65 years old undergoing one of 20 major non-elective surgeries, four of which were common cardiovascular procedures (i.e.carotid endarterectomy, heart valve procedures, coronary artery bypass grafting, and abdominal aortic aneurysm repair. Among 45 826 surgeons across the scope of surgical disciplines between 2011-2014, 30 day mortality did not differ significantly between male and female surgeons (OR 0.97, 95% CI 0.93 - 1.01). No sub-group analysis was conducted for cardiothoracic procedures.

Risk of bias assessment

The included studies were evaluated using the NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies. The overall quality rating for each study was relatively high (Table 2).

DISCUSSION

Summary of main results

The novelty of this systematic review lies in its aim to assess the impact of both anaesthesiologists' and surgeons' sex and/or gender on perioperative cardiac processes of care and/or clinical outcomes. Out of 2093 references that were initially screened, we identified two English articles that briefly refer to cardiac surgery in the discussion of this topic in surgical specialties at large. These articles referred only to the sex of surgeons but not to that of anaesthesiologists.

Our inclusion criteria pre-specified publications in English and French, however, we identified two articles published in other languages (one in Japanese and one in Spanish) that may be relevant. We screened the English-language abstract of the article published in Japanese [48], which discusses the implications of coronary artery bypass grafting in female patients. The English language translation of the full Spanish article was provided by a scientific colleague who is a native Spanish speaker. This article discusses patient sex differences in valvular surgery outcomes [49]. Neither of these foreign language articles made clear references to provider sex or gender.

Explanation of the findings

Sex and gender are key determinants of healthcare practices and their outcomes, including in patients who undergo non-cardiac surgery [50–53]. Two recently published observational studies (29, 31) remotely investigated patient outcomes between female and male cardiac surgeons, however primary statistical analyses were conducted to include data across all surgical specialties. Anaesthesiologist sex was also not considered. The fact that there are no published studies that explicitly explore the impact of physician sex and gender for both surgeons and anaesthesiologists in the context of cardiac surgery was an unexpected finding. Given the high-stake nature of cardiac surgery and the crucial importance of teamwork in this context, our finding draws attention to potentially missed opportunities to optimize team and individual performance, as well as patient outcomes. Growing evidence in cardiac medical care and in non-cardiac surgery has shown that physicians' sex and gender significantly impact care. For example, OR teamwork is integral to preventing and treating many intra- and postoperative complications and can also be shaped by the sex composition of the team as well as gender roles and norms [11,54]. In addition, there is considerable imbalance of physician sex in cardiac surgery as compared to other surgical specialties, such that cardiac surgery has traditionally been viewed as a field dominated by male physicians [35]. Therefore, an in-depth understanding of how physician sex and gender influence team dynamics, in addition to individual performance, may inform future team-based interventions and ultimately mitigate preventable adverse events in cardiac surgery [55–58]. Research in this domain might also inform an integrated clinical practice approach that moves beyond medical knowledge and experience, to individual and social factors. For example, educational interventions could be tailored based on provider sex or cardiac OR scheduling apps could be designed to optimize OR team sex composition. Such an approach will shift the paradigm in patient safety research towards the personalization of provider characteristics, to provide all-around personalized medical care.

Future directions

Future research should consider physician sex and gender when examining physician-related factors influencing surgical cardiac care. At minimum, studies should report the sex and/or gender characteristics of both the healthcare providers and patients involved so that future meta-analyses may be possible [59]. In addition, sex and gender are not the only physician characteristics relevant to performance and their salience may depend on other factors such as age, level of experience, region of training, or cultural background [60–63]. Thus, studies that integrate sex and gender variables may also consider how they intersect with additional categories of social identity.

Limitations of the study

While this review has identified a critical knowledge gap in cardiac surgical care, there are some limitations of this review that are to be noted. First, we included only studies published in English or French. Two other non-English/French studies were identified and were determined not to be relevant. Second, it is possible that studies examined physician sex and/or gender as control variables but may have been excluded during title and abstract screening based on the failure of the study to specify this as a primary aim. Given our findings, combined with other systematic reviews showing the paucity of sex/gender analyses in medicine [64], we believe it is unlikely that any relevant studies were missed by our search strategy or screening process.

Within the two studies included in this review, neither specifically explored the impact of surgeon and anaesthesiologist sex or gender in the context of cardiac surgery in detail, nor did they include the processes of care as an outcome. Furthermore, the magnitude of reduction in adverse events and the methodology of propensity score matching used were at times unclear within the two observational studies presented in this review (29,31).

Conclusions

This systematic review found no English or French language publication directly assessing the role of physician sex and/or gender in cardiac operative care. Two observational studies investigated the impact of surgeon sex on patient outcomes across the full scope of surgical specialties. These findings highlight the need for primary research to determine how these factors may influence cardiac surgical practice, in order to optimize provider performance and improve outcomes in this high-risk patient group.

FUNDING STATEMENT
Dr. Boet was supported by The Ottawa Hospital Anesthesia Alternate Funds Association. Dr. Sun is supported by the Ottawa Heart Institute Research Corporation. DSR licenses were funded by the Department of Anesthesiology and Pain Medicine of The Ottawa Hospital.

ACKNOWLEDGEMENTS

We would like to thank Alexandra Davis, BA, MLIS for her help in the development and review of the search strategies.

CONTRIBUTOR'S STATEMENT

SB, NE, MD, LS: Contributed substantially to conception and design, or analysis and interpretation of data, drafted the article, revised article critically for important intellectual content, gave final approval of the version to be published, agreed to act as guarantor of the work (ensuring that questions related to any part of the work are appropriately investigated and resolved).

AJ, FM, HS, KZ: Contributed substantially to acquisition of data, revised the article critically for important intellectual content, gave final approval of the version to be published, agreed to act as guarantor of the work (ensuring that questions related to any part of the work are appropriately investigated and resolved).

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

DATA STATEMENT

All relevant data is included in the manuscript.

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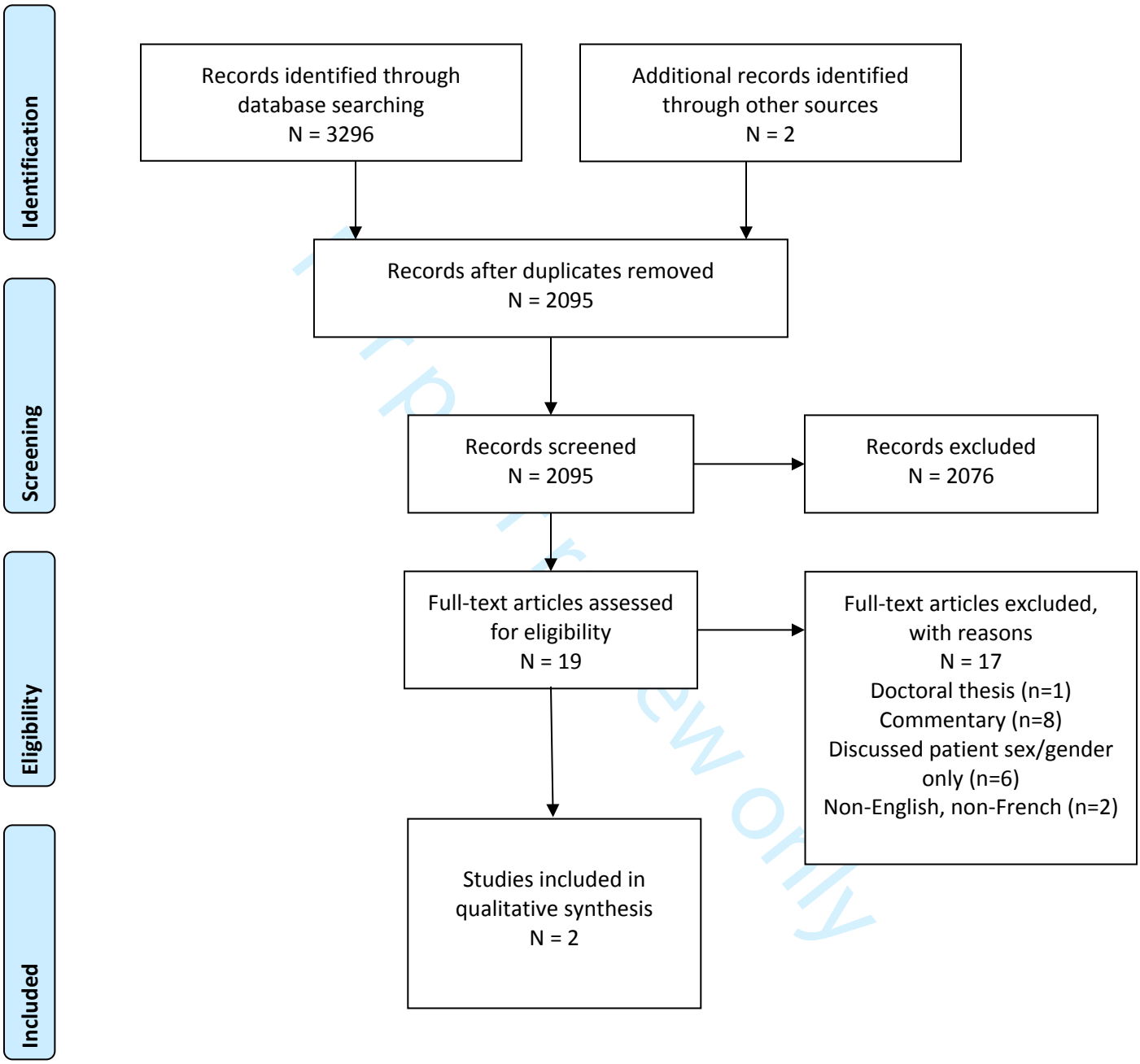
Table 1. Characteristics and results of included studies (n=2)

First author, year	Study design, objective(s)	Type of procedure(s)	N providers (% female, male), profession	N patients (% female, male)	Outcome (definition, timing)	Statistical results
Tsugawa, 2018	**Design:** Observational study **Objective:** To investigate whether patients' mortality differs according to the age and sex of surgeons.	Hip and femur fracture, colorectal resection, cholecystectomy and common duct procedures, laminectomy, excision of peritoneal adhesions, fracture or dislocation of lower extremity other than hip or femur, lung resection, hysterectomy, amputation of lower extremity, nephrectomy, appendectomy, small bowel resection, pancreatic resection, gastrectomy, splenectomy, and esophageal resection, carotid endarterectomy, heart valve procedures, coronary artery bypass grafting, and abdominal aortic aneurysm repair	N = 45826 surgeons Female = 4634 (10.1%) Male = 41192 (89.9%)	N = 892,187 Female = 551,628 (61.8%) Male = 340,559 (38.2%)	Operative mortality rate of patients, defined as death during hospital admission or within 30 days of the operative procedure	No evidence that adjusted operative mortality differed between patients treated by female versus male surgeons (adjusted mortality 6.3% for female surgeons versus 6.5% for male surgeons; adjusted odds ratio 0.97 (95% CI 0.93 to 1.01). **Subgroup analysis for cardiac surgery was not performed.**
Wallis, 2017	**Design:** Population based, retrospective, matched cohort study **Objective:** To examine the effect of surgeon sex on postoperative outcomes of patients undergoing common surgical procedures.	Coronary artery bypass grafting, femoral-popliteal bypass, abdominal aortic aneurysm repair, appendectomy, cholecystectomy, gastric bypass, colon resection, liver resection, hysterectomy, anterior or posterior spinal decompression, anterior or posterior spinal arthrodesis, craniotomy for brain tumour, total knee replacement, total hip replacement, open repair of femoral neck or shaft fracture, total thyroidectomy, neck dissection, lung resection, radical cystectomy, radical prostatectomy, transurethral resection of prostate, carpal tunnel release, and breast reduction	N = 3314 surgeons Female = 774 (23.4%) Male = 2540 (76.6%)	Before matching: N = 1,159,687 Female = 695,747 (60.0%) Male = 463,940 (40.0%) After matching: N = 104,630 Female = 52315 (50%) Male = 52315 (50%)	Composite of death, complications, or readmission (to any hospital in the province of Ontario) in the 30 days after surgery	Fewer patients treated by female surgeons died, were readmitted to hospital, or had complications within 30 days (5810 of 52 315, 11.1%, 95% CI 10.9% to 11.4%) than those treated by male surgeons (6046 of 52 315, 11.6%, 95% CI 11.3% to 11.8%; adjusted odds ratio 0.96, 95% CI 0.92 to 0.99, P = 0.02). Patients treated by female surgeons were less likely to die within 30 days (adjusted odds ratio 0.88; 95% CI 0.79 to 0.99, P = 0.04), but there was no significant difference in readmissions or complications. **In the subgroup analysis for cardiothoracic surgery**, there was OR of 0.91 (CI 95% 0.82 to 1.01) for composite outcomes among patients treated by female and male surgeons, when stratified by physician, patient, and hospital factors

Table 2. Risk of bias for included studies: NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies

First author, year	Quality rating (/14)
Tsugawa, 2018	11
Wallis, 2017	12

Figure 1. PRISMA Flow Diagram



Appendix 1: Search strategy

Database: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily <1946 to September 06, 2018>
Search Strategy:

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1 exp cardiac surgical procedures/ (200938)
2 exp Heart Diseases/su [Surgery] (156583)
3 Heart Neoplasms/su [Surgery] (4760)
4 ((cardiac or heart or coronary or cardiovascular) adj2 surg*).tw. (67075)
5 (cardiac surg* or heart surg*).kw. (7445)
6 ((cardiothoracic or cardio thoracic) adj2 (surg* or resection)).tw. (3248)
7 (cardiothoracic surg* or cardi-thoracic surg*).kw. (151)
8 ((cardiac or heart) adj2 transplant*).tw. (31061)
9 exp Heart Valves/su [Surgery] (28200)
10 exp Heart Defects, Congenital/su [Surgery] (45282)
11 (valv* adj2 (repair or replacement or implant* or annuloplasty)).tw. (39378)
12 (coronary artery bypass graft* or coronary artery bypass surgery or CABG).tw,kw. (38366)
13 (aortocoronary adj2 (bypass or graft*)).tw. (2745)
14 pericardectom*.tw,kw. (300)
15 cardiomyoplast*.tw,kw. (842)
16 myectom*.tw,kw. (1504)
17 or/1-16 (343953)
18 ((sex or gender) adj2 (difference* or disparit*)).tw. (70531)
19 (gender difference* or gender based or gender specific).tw,kw. (39305)
20 (sex or gender or women or men or female or male).ti. (548983)
21 Physicians, Women/ (5625)
22 ((female or women or male) adj3 (surgeon* or physician* or an?esthesiologist* or an?esthetist*)).tw. (5058)
23 female gender.tw. (14006)
24 male gender.tw. (13788)
25 or/18-24 (616019)
26 perioperative care/ or perioperative period/ or intraoperative period/ or postoperative period/ or preoperative period/ (75044)
27 (preoperative* or pre-operative* or perioperative* or peri-operative* or intraoperative* or intra-operative* or postoperative* or post-operative*).tw,kw. (773968)
28 (postoperative* or post-operative* or postsurg* or post-surg*).tw,kw. (552307)
29 Postoperative Complications/ (336691)
30 or/26-29 (1009987)
31 17 and 25 and 30 (1185)
32 ((post or following or after) adj3 (cardiac surg* or heart surg* or coronary surg* or cardiovascular surg* or cardiothoracic surg* or cardio-thoracic surg* or cardiac transplant* or heart transplant* or CABG or myectom* or cardiomyoplast* or pericardectom* or coronary artery bypass surg* or coronary artery bypass graft*)).tw. (33888)
33 25 and 32 (643)
34 31 or 33 (1432)
35 animals/ not humans/ (4462509)
36 34 not 35 (1429)
37 case reports.pt. (1895280)
38 36 not 37 (1367)

Database: Embase Classic+Embase <1947 to 2018 September 6>
Search Strategy:

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1 exp *heart surgery/ (185030)
2 ((cardiac or heart or coronary or cardiovascular) adj2 surg*).tw. (95608)
3 ((cardiothoracic or cardio thoracic) adj2 (surg* or resection)).tw. (10404)
4 ((cardiac or heart) adj2 transplant*).tw. (48320)
5 (valv* adj2 (repair or replacement or implant* or annuloplasty)).tw. (59368)
6 (coronary artery bypass graft* or coronary artery bypass surgery or CABG).tw. (55469)
7 (aortocoronary adj2 (bypass or graft*)).tw. (3137)
8 pericardectom*.tw. (485)
9 cardiomyoplast*.tw. (993)
10 myectom*.tw. (2067)
11 or/1-10 (306709)
12 *sex difference/ (36769)
13 ((sex or gender) adj2 (difference* or disparit*)).tw. (93875)
14 (gender difference* or gender based or gender specific).tw. (51324)
15 (sex or gender or women or men or female or male).ti. (686782)
16 female physician/ (4639)
17 ((female or women or male) adj3 (surgeon* or physician* or an?esthesiologist* or an?esthetist*)).tw. (6274)
18 (female gender or male gender).tw. (45514)
19 or/12-18 (789727)
20 perioperative period/ (41769)
21 preoperative period/ or preoperative care/ (85168)
22 intraoperative period/ (35068)
23 postoperative period/ (189526)
24 (preoperative* or pre-operative* or perioperative* or peri-operative* or intraoperative* or intra-operative* or postoperative* or post-operative*).tw. (1088663)
25 (postoperative* or post-operative* or postsurg* or post-surg*).tw. (783471)
26 *postoperative complication/ (64743)
27 or/20-26 (1247931)
28 11 and 19 and 27 (1414)
29 ((post or following or after) adj3 (cardiac surg* or heart surg* or coronary surg* or cardiovascular surg* or cardiothoracic surg* or cardio-thoracic surg* or cardiac transplant* or heart transplant* or CABG or myectom* or cardiomyoplast* or pericardectom* or coronary artery bypass surg* or coronary artery bypass graft*)).tw. (49291)
30 19 and 29 (1026)
31 28 or 30 (1899)
32 case report/ (2364953)
33 31 not 32 (1835)
34 animals/ not humans/ (1320229)
35 33 not 34 (1833)

Database: PsycINFO <1806 to September Week 1 2018>
Search Strategy:

---

1 Heart Surgery/ (1440)
2 ((cardiac or heart or coronary or cardiovascular) adj2 surg*).tw. (1427)
3 ((cardiothoracic or cardio thoracic) adj2 (surg* or resection)).tw. (51)
4 ((cardiac or heart) adj2 transplant*).tw. (450)
5 (valv* adj2 (repair or replacement or implant* or annuloplasty)).tw. (118)
6 (coronary artery bypass graft* or coronary artery bypass surgery or CABG).tw,kw. (837)
7 (aortocoronary adj2 (bypass or graft*)).tw. (9)
8 pericardectom*.tw,kw. (0)
9 cardiomyoplast*.tw,kw. (0)
10 myectom*.tw,kw. (1)
11 or/1-10 (2726)
12 Human Sex Differences/ (107002)
13 ((sex or gender) adj2 (difference* or disparit*)).tw. (77653)
14 (gender difference* or gender based or gender specific).tw,kw. (48241)
15 HUMAN FEMALES/ (87482)
16 (sex or gender or women or men or female or male).ti. (219801)
17 ((female or women or male) adj3 (surgeon* or physician* or an?esthesiologist* or an?esthetist*)).tw. (1337)
18 female gender.tw. (3363)
19 male gender.tw. (2936)
20 or/12-19 (328932)
21 11 and 20 (174)
22 Surgical Patients/ or Surgery/ (14030)
23 (preoperative* or pre-operative* or perioperative* or peri-operative* or intraoperative* or intra-operative* or postoperative* or post-operative*).tw,kw. (12886)
24 (postoperative* or post-operative* or postsurg* or post-surg*).tw,kw. (11666)
25 Postsurgical Complications/ (825)
26 or/22-25 (23936)
27 21 and 26 (74)
28 ((post or following or after) adj3 (cardiac surg* or heart surg* or coronary surg* or cardiovascular surg* or cardiothoracic surg* or cardio-thoracic surg* or cardiac transplant* or heart transplant* or CABG or myectom* or cardiomyoplast* or pericardectom* or coronary artery bypass surg* or coronary artery bypass graft*)).tw. (870)
29 21 and 28 (59)
30 27 or 29 (96)

Appendix 2: Reason for exclusion for references screened at Level 2

First author, year	Reference	Reason for exclusion
Kobayashi H. et al, 1988	Coronary artery bypass grafting in women: analyses of preoperative and intraoperative factors. *Nihon Kyobu Geka Gakkai Zasshi.* 1988 Aug;36(8):1285-91	Japanese, non-English
Hanet C. et al., 1990	Angiographic evaluation of vasomotor properties of internal mammary arteries before and after coronary artery bypass grafting in men. *The American Journal of Cardiology*. 1990;65(13):918–21.	Studied patient sex only
Meyer SA., 1993	The relationship of nutritional status, personality hardiness, and social support of the older adult to treatment outcomes following non-emergent cardiac surgery. *Thesis (D.P.H.) University of Hawaii at Manoa*	Doctorate thesis
Vallejo JL. et al, 1994	Influence of sex in the technique and results of valvular surgery. *Rev Esp Cardiol*. 1994;47 Suppl 3:68–75.	Spanish, non-English
Bryan CF. et al., 1996	Influence of donor gender on patient mortality after heart transplantation. *Transplant Protocol*. 1996 Feb;28(1):149-51.	Studied recipient and donor patient sex only
Aidala E. et al., 1999	Gender and coronary artery bypass mortality. *Ann Thorac Surg.* 1999 Aug;68(2):625–6.	Commentary
TH. Lee., 2001	Heart lines. Neurological complications more common in women after heart surgery. *Harvard Heart Letter*. 2001 Dec;12(4):1-7	Commentary
Herd JA. et al., 2003	Heart rate and blood pressure responses to mental stress and clinical cardiovascular events in men and women after coronary artery bypass grafting: The Post Coronary Artery Bypass Graft (Post-CABG) biobehavioral study. *American Heart Journal*. 2003;146(2):273–9.	Studied patient sex only

Koch CG. et al., 2003	Is it gender, methodology, or something else? *Journal of Thoracic and Cardiovascular Surgery*. 2003;126(4):932–5.	Commentary
Habib RH. et al., 2004	Sex differences in mortality after coronary artery bypass graft surgery. *JAMA*. 2004 Jul 7;292(1):40–1.	Commentary
Habib RH. et al., 2004	Worse early outcomes in women after coronary artery bypass grafting: Is it simply a matter of size? *The Journal of Thoracic and Cardiovascular Surgery*. 2004;128(3):487–8.	Commentary
Cheng TO., 2005	In China women uphold half of the sky. *International Journal of Cardiology*. 2005;102(1):159–159.	Commentary
Jonker G. et al., 2006	Increased mortality among women after coronary artery bypass grafting seems mainly to be explained by infections. 2006.	Commentary
Dixon B. et al., 2014	The operating surgeon is an independent predictor of chest tube drainage following cardiac surgery. *J Cardiothorac Vasc Anesth.* 2014;28(2):242–6.	Studied patient gender only
Lopes CT. et al., 2015	Excessive bleeding predictors after cardiac surgery in adults: integrative review. J Clin Nurs. 2015;24(21–22):3046–62.	Studied patient sex only
Mattioli AV. et al., 2018	Combined Rehabilitation and Nutritional Coaching After Cardiac Surgery: Sex Differences. *The Annals of Thoracic Surgery*. 2018;106(4):1265.	Commentary

Section/topic	#	Checklist item	Rep on
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	App 2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	4

Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A

BMJ Open

The impact of physician sex/gender on processes of care, and clinical outcomes in cardiac operative care: A systematic review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-037139.R1
Article Type:	Original research
Date Submitted by the Author:	30-Jul-2020
Complete List of Authors:	Etherington, Nicole; Ottawa Hospital Research Institute, Deng, Mimi; University of Ottawa, Faculty of Medicine Boet, S; University of Ottawa, Department of Anesthesiology and Pain Medicine; Ottawa Hospital Research Institute, Clinical Epidemiology Program Johnston, Amy; University of Ottawa, School of Epidemiology and Public Health; University of Ottawa Heart Institute, Brain and Heart Research Nexus Program Mansour, Fadi; University of Ottawa, Faculty of Medicine Said, Hussein; University of Ottawa, Faculty of Medicine Zheng, Katina; University of Ottawa, Faculty of Medicine; University of Ottawa Heart Institute, Division of Cardiac Anesthesiology, Department of Anaesthesiology and Pain Medicine Sun, Louise; University of Ottawa Heart Institute, Division of Cardiac Anesthesiology, Department of Anesthesiology and Pain Medicine; University of Ottawa, School of Epidemiology and Public Health
Primary Subject Heading:	Cardiovascular medicine
Secondary Subject Heading:	Epidemiology
Keywords:	EPIDEMIOLOGY, Cardiac surgery < SURGERY, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Title: The impact of physician sex/gender on processes of care, and clinical outcomes in cardiac operative care: A systematic review

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Word count: 2401

ABSTRACT

Objectives: This systematic review aimed to assess the role of physician sex and gender in relation to processes of care and/or clinical outcomes within the context of cardiac operative care.

Design: Systematic review.

Data sources: Searches were conducted in PsycINFO, Embase, and Medline from inception to September 6, 2018. The reference lists of relevant systematic reviews and included studies were also searched.

Eligibility criteria for selecting studies: Quantitative studies of any design were included if they were published in English or French, involved patients of any age undergoing a cardiac surgical procedure, and specifically assessed differences in processes of care or clinical patient outcomes by physician sex or gender. Studies were screened in duplicate by two pairs of independent reviewers.

Outcome measures: Processes of care, patient morbidity, patient mortality.

Results: The search yielded 2095 publications after duplicate removal, of which two were ultimately included. These studies involved various types of surgery, including cardiac. One study found that patients treated by female surgeons compared to male surgeons had a lower 30-day mortality. The other study, however, found no differences in patient outcomes by surgeon sex. There were no studies that investigated anaesthesiologist sex/gender. There were also no studies investing physician sex or gender exclusively in the cardiac OR.

Conclusions: The limited data surrounding the impact of physician sex/gender on the outcomes of cardiac surgery inhibits drawing a robust conclusion at this time. Results highlight the need for primary research to determine how these factors may influence cardiac operative practice, in order to optimize provider performance and improve outcomes in this high-risk patient group.

Key words: cardiac surgical procedures; perioperative care; operating rooms; physicians, women; surgeons; anesthetics; sex; gender

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first systematic review to assess the impact of physician sex and gender on patient outcomes in cardiac surgery.
- The robust search strategy and screening process identified two indirectly relevant articles, which included cardiac surgery as one of many specialties assessed.
- A potential limitation of this study is that only articles published in English or French were included; however, we address two potentially relevant studies published in other languages in our discussion.
- Findings highlight an important knowledge gap related to physician sex/gender in the cardiac operating room, and in particular, as it relates to anaesthesiologists' practice as the included studies only studied surgeons.

INTRODUCTION

Approximately two million cardiac surgical procedures are performed globally every year [1]. Complication rates after cardiac surgery vary from two to 60%, depending on the outcome examined [2–6]. Importantly, many of these complications are preventable, and are related to ineffective teamwork in the operating room (OR) [7–16]. Effective teamwork encompasses both observable behaviours and clinicians' perceptions of interpersonal processes [17,18]. Though all team members play an important role, the relationship between the surgeon-anaesthesiologist dyad, who "sometimes share, yield, or compete for leadership", most critically influences overall OR team performance [19]. Research has identified tension between anaesthesiologists and surgeons as potentially arising from misperceptions of each other and discrepant views on which their quality of collaboration and communication was built [19–24]. Though power struggles in the OR have often been attributed to differences in professional training or values [15], research increasingly suggests that sex (i.e. biological, anatomical, and physiological characteristics) and gender (i.e. identity, behaviour, roles, and relations) shape team interactions in healthcare, as well as the different practice patterns observed among female and male physicians [25–34].

Cohesive teamwork and effective communication are especially important in the cardiac OR given the high acuity of cases, frequent and sudden events of hemodynamic instability, critical moments of cardiopulmonary bypass initiation and separation, and the need for precise blood pressure control during key stages of operation. Moreover, the high-risk nature of cardiac surgery makes effective teamwork and communication even more critical in this operative setting. The predominance of male physicians in the cardiac OR compared to other surgical specialties [35] may carry implications for operative communication and teamwork related to gendered hiearchies. For example, studies on non-cardiac OR teams show that female staff anaesthsiologists are challenged more often by the respiratory therapist than their male colleagues when an incorrect clinical decision is made [32,34]. This suggests that there are implicit gender hierarchies within the OR and a potential reduction in the professional hierarchy gradient associated with female leadership. Another study found that if the attending surgeon's gender differed from the primary gender composition of the overall surgical team, cooperation increased, and conflict decreased [33]. Specifically, cooperation and communication were observed to decrease when more than half of the providers in an OR were male [33]. The highest percentage of conflict interactions was observed in the cardiothoracic OR, where over 95% of staff surgeons were male [33]. With increasing gender diversity in surgery, however, it is likely that team dynamics will also evolve.

Sex and gender may also be relevant to the performance of individual physicians in the cardiac OR. Recent findings also suggest that male anaesthesiologists spend a greater proportion of time and may thus be more experienced with the care of complex cardiac and/or vascular patients, than their female counterparts [36]. This remains true despite the increasing number of female providers entering the specialty.

Although physician sex and gender have been shown to influence processes of care and outcomes in non-cardiac medical and surgical care as well as in primary cardiac care [25,26,37–42], the role of these factors within the cardiac OR remains unclear. As such, it is necessary to quantify the effect of physician sex and gender on clinical processes of care and adverse patient

outcomes for the cardiac OR. To this end, we conducted a systematic review to analyze the role of anaesthesiologists' and surgeons' sex and gender in relation to processes of care and/or clinical outcomes within the context of cardiac operative care.

METHODS

This review was conducted and reported in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [43]. The protocol was published on the University of Ottawa's research repository [44].

Eligibility criteria

Studies were included if they involved surgical patients of any age who underwent a cardiac surgical procedure requiring anaesthetic care, as long as there were specific investigations on the impact of medical provider (e.g., cardiac surgeon and cardiac anaesthesiologist) sex and/or gender on primary outcomes of process of care or patient outcome. Processes of care include but are not limited to hemostatic practices, antibiotic prophylaxis, selection of coronary artery bypass conduits, and harvesting of these conduits (i.e., pedicled vs skeletonized). Patient perioperative outcomes include postoperative 30-day mortality and complications (e.g. chylothorax, sternal wound infection, acute kidney injury, venous thrombosis, stroke, improvement of left ventricular function, blood loss, and length of hospital stay). Studies that did not specifically investigate the impact of provider sex/gender on process of care within the cardiac OR or patient outcomes, or that focused on patient sex/gender differences without considering provider sex/gender, were excluded. Studies that explored the implications of surgeon sex and/or gender in a variety of surgical specialties met inclusion criteria as long as cardiac procedures were included. Both comparative interventional (e.g., randomized control trials) and non-interventional (e.g., cohort) studies of any design were eligible for inclusion if they were published in a peer-reviewed journal. Letters, editorials, opinion pieces, conference abstracts, and reviews were excluded. Grey literature produced outside of conventional scientific publishing and distribution was not considered for this review.

Search strategy and information sources

The search strategy was developed in collaboration with an experienced information specialist (AD) (Appendix 1). The strategy was then reviewed by a second information specialist as per PRESS guidelines [45]. Searches were conducted in the electronic databases PsycINFO, Embase, Medline, and Medline in Process (via OVID) from inception to September 6th, 2018. Date and language restrictions were not applied; however, we planned to extract data from only those studies published in English or French. We also planned to search reference lists of included articles and to submit the final list of included studies to a group of experts (researchers, anaesthesiologists, and surgeons involved in cardiac care) to verify relevance and accuracy.

Study selection

DistillerSR systematic review software (Evidence Partners, Ottawa, Canada) was used to facilitate the study screening and selection process. Screening forms were developed and piloted by members of the review team prior to undertaking full screening (AJ, FM, HS, KZ). Titles and abstracts were screened for eligibility in duplicate by two pairs of independent reviewers (AJ, FM, HS, KZ). The full texts of titles and abstracts deemed potentially relevant by two reviewers were then reviewed. At each level of screening, disagreements were resolved through consensus or discussion with a third reviewer, if necessary.

Data items and abstraction

Data abstraction was conducted in duplicate by two pairs of independent reviewers using an electronic form in DistillerSR. The form included publication details (e.g. first author, year, country of data collection), clinical context (e.g. type of procedure, type of anaesthesia, urgent or elective procedure), population demographics (e.g. sex/gender of patients/providers, patient comorbidities, patient age), study details (e.g. research question/objective, methods used), outcomes assessed (i.e. process of care or patient outcomes studied, definition, timing), and study results (i.e. the reported impact of provider/patient sex/gender on process of care/patient outcomes). To ensure that the study was inclusive of all eligible papers, we wanted to avoid limiting the inclusion criteria by outcomes defined a priori. Meta-analysis was not conducted, as it may not be suitable in capturing the breadth of the clinical outcomes that arise in eligible studies.

Risk of bias

The NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies was used to assess risk of bias [46]. This tool includes 14 dichotomous items (i.e. yes or no), such as clarity of the research question, specification of the study population, sample size justification, and measurement of confounding variables. Studies are assigned a score of "1" if the criterion is present, for a total possible score of 14 (high quality). Reviewers assessed risk of bias independently and in duplicate, using consensus or third reviewer consultation to resolve disagreements (MD, FM).

Patient and public involvement

No patients were involved.

RESULTS

Study selection

The search yielded 3296 publications. After removal of duplicates, 2095 underwent title and abstract screening, and 2076 were removed due to failure to meet our eligibility criteria of assessing the impact of health care provider sex/gender on processes of care and patient outcomes in the setting of cardiac surgery. Nineteen studies proceeded to full-text screening by satisfying the inclusion criteria on abstract screening or the abstract did not provide information to confidently be excluded without full-text review. After full-text review, 17 were excluded based on our predetermined inclusion and exclusion criteria. The study PRISMA flow diagram is shown in Figure 1. A list of studies excluded at level two (with reasons) is provided in Appendix 2.

Figure 1. PRISMA Flow Diagram

Study characteristics and synthesis

There were two eligible English studies indirectly assessing the impact of healthcare provider sex or gender in cardiac surgery in this systematic review. These studies are described below and summarized in Table 1.

An observational study by Tsugawa et al [47] done in acute care hospitals across the United States evaluated the age and sex of surgeons on operative mortality of 892 187 patients over 65 years old undergoing one of 20 major non-elective surgeries from 2011 - 2014, four of which were common cardiovascular procedures (i.e.carotid endarterectomy, heart valve procedures, coronary artery bypass grafting, and abdominal aortic aneurysm repair. Among 45 826 surgeons across the scope of surgical disciplines, 30-day mortality did not differ significantly between male (n = 41 192) and female (n = 4 634) surgeons (OR 0.97, 95% CI 0.93 to 1.01). No sub-group analysis was conducted for cardiothoracic procedures.

A retrospective matched cohort study by Wallis et al [29] explored the adverse postoperative outcomes (death, readmission, or complications) among 104 603 patients seen by female and male surgeons in Ontario, Canada from 2007 – 2015, across 25 elective and non-elective procedures, including coronary artery bypass grafting. Overall, patients treated by female surgeons had a small but statistically significantly lower 30-day mortality (adjusted OR 0.88, 95% CI 0.79 to 0.99, p = 0.04) and comparable surgical outcomes (length of stay, complications, and readmission), compared with those treated by male surgeons. Among patients of female (n = 4023) and male (n = 4039) cardiothoracic surgeons, there is weak evidence towards more favorable outcomes by female surgeons, with an odds ratio of 0.91 (95% CI 0.82 to 1.01) for postoperative adverse events.

Table 1. Characteristics and results of included studies (n=2)

First author, year	Study design, objective(s)	Type of procedure(s)	N providers (% female, male), profession	N patients (% female, male)	Outcome (definition, timing)	Statistical results
Tsugawa, 2018	**Design:** Observational study **Objective:** To investigate whether patients' mortality differs according to the age and sex of surgeons.	Hip and femur fracture, colorectal resection, cholecystectomy and common duct procedures, laminectomy, excision of peritoneal adhesions, fracture or dislocation of lower extremity other than hip or femur, lung resection, hysterectomy, amputation of lower extremity, nephrectomy, appendectomy, small bowel resection, pancreatic resection, gastrectomy, splenectomy, and esophageal resection, carotid endarterectomy, heart valve procedures, coronary artery bypass grafting, and abdominal aortic aneurysm repair	N = 45826 surgeons Female = 4634 (10.1%) Male = 41192 (89.9%)	N = 892,187 Female = 551,628 (61.8%) Male = 340,559 (38.2%)	Operative mortality rate of patients, defined as death during hospital admission or within 30 days of the operative procedure	No evidence that adjusted operative mortality differed between patients treated by female versus male surgeons (adjusted mortality 6.3% for female surgeons versus 6.5% for male surgeons; adjusted odds ratio 0.97 (95% CI 0.93 to 1.01). **Subgroup analysis for cardiac surgery was not performed.**
Wallis, 2017	**Design:** Population based, retrospective, matched cohort study **Objective:** To examine the effect of surgeon sex on postoperative outcomes of patients undergoing common surgical procedures.	Coronary artery bypass grafting, femoral-popliteal bypass, abdominal aortic aneurysm repair, appendectomy, cholecystectomy, gastric bypass, colon resection, liver resection, hysterectomy, anterior or posterior spinal decompression, anterior or posterior spinal arthrodesis, craniotomy for brain tumour, total knee replacement, total hip replacement, open repair of femoral neck or shaft fracture, total thyroidectomy, neck dissection, lung resection, radical cystectomy, radical prostatectomy, transurethral resection of prostate, carpal tunnel release, and breast reduction	N = 3314 surgeons Female = 774 (23.4%) Male = 2540 (76.6%)	Before matching: N = 1,159,687 Female = 695,747 (60.0%) Male = 463,940 (40.0%) After matching: N = 104,630 Female = 52315 (50%) Male = 52315 (50%)	Composite of death, complications, or readmission (to any hospital in the province of Ontario) in the 30 days after surgery	Fewer patients treated by female surgeons died, were readmitted to hospital, or had complications within 30 days (5810 of 52 315, 11.1%, 95% CI 10.9% to 11.4%) than those treated by male surgeons (6046 of 52 315, 11.6%, 95% CI 11.3% to 11.8%; adjusted odds ratio 0.96, 95% CI 0.92 to 0.99, P = 0.02). Patients treated by female surgeons were less likely to die within 30 days (adjusted odds ratio 0.88; 95% CI 0.79 to 0.99, P = 0.04), but there was no significant difference in readmissions or complications. **In the subgroup analysis for cardiothoracic surgery**, there was OR of 0.91 (CI 95% 0.82 to 1.01) for composite outcomes among patients treated by female and male surgeons, when stratified by physician, patient, and hospital factors

Risk of bias assessment

The included studies were evaluated using the NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies. The overall quality rating for the internal validity of each study was relatively high (Table 2). Both studies mitigated risk of bias by having a well-defined research question, pre-specified eligibility criteria, justified duration of follow-up, consideration for key confounding variables, and insignificant loss to follow-up, among others. Two deductions in quality rating were due to the inability in examining different levels of exposure as related to the outcome and in assessing exposure more than once over time, as gender was determined to be binary and fixed in both studies. Tsugawa et al received an additional quality rating deduction for failure to provide sample size justification, power description, or variance and effect estimates. Detailed ratings for each study can be found in Appendix 3.

Table 2. Risk of bias for included studies: NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies

First author, year	Quality rating (/14)
Tsugawa, 2018	11
Wallis, 2017	12

DISCUSSION

Summary of main results

The novelty of this systematic review lies in its aim to assess the impact of both anaesthesiologists' and surgeons' sex and/or gender on perioperative cardiac processes of care and/or clinical outcomes. Out of 2093 references that were initially screened, we identified two English articles that briefly refer to cardiac surgery in the discussion of this topic in surgical specialties at large. These articles referred only to the sex of surgeons but not to that of anaesthesiologists.

Our inclusion criteria pre-specified publications in English and French, however, we identified two articles published in other languages (one in Japanese and one in Spanish) that may be relevant. We screened the English-language abstract of the article published in Japanese [48], which discusses the implications of coronary artery bypass grafting in female patients. The English language translation of the full Spanish article was provided by a scientific colleague who is a native Spanish speaker. This article discusses patient sex differences in valvular surgery outcomes [49]. Neither of these foreign language articles made clear references to provider sex or gender.

Explanation of the findings

Sex and gender are key determinants of healthcare practices and their outcomes, including in patients who undergo non-cardiac surgery [50–53]. Two recently published observational studies (29, 31) remotely investigated patient outcomes between female and male cardiac surgeons, however primary statistical analyses were conducted to include data across all surgical specialties. Tsugawa et al. included Medicare beneficiaries over 65 years of age undergoing a variety of non-elective procedures. In this study, only 10.1% of surgeons were female and it is unclear how many specialized in cardiac surgery [47]. Hence, sex and gender analysis may have been underpowered in the arena of cardiac surgery practices. Wallis et al. provided greater generalizability by considering all adult patients undergoing 25 common elective and non-elective procedures, with complete tracking of mortality and postoperative complications. Interestingly, Wallis et al. noted some degree of evidence (OR 0.91, CI 95% 0.82 to 1.01) for superior composite outcome of postoperative death, readmission, or complications in patients under the care of female cardiothoracic surgeons compared to male cardiothoracic surgeons. They attributed this finding to female surgeons' tendency to adhere to guidelines, provide patient-centred care, and attention to communication and teamwork [54,55]. Alternatively, this observation could also have be a consequence of effect modification, as female surgeons were more heavily involved elective surgeries, which were in themselves associated better postoperative outcomes as compared to urgent or emergent procedures [29]. Overall, the study by Tsugawa and colleagues did not provide subgroup analysis for cardiac surgery, while both the Tsugawa and Wallis studies failed to specify the proportion of male and female surgeons within each specialty. These studies were also limited by shorter lengths of postoperative follow-up (i.e., 30 days), as well as unmeasured confounders such as complexity of the operation and underlying disease severity.

Anaesthesiologist sex was not considered in either studies. The fact that there are no published studies that explicitly explore the impact of physician sex and gender for both surgeons and

anaesthesiologists in the context of cardiac surgery was an unexpected finding. Given the high-stake nature of cardiac surgery and the crucial importance of teamwork in this context, our finding draws attention to potentially missed opportunities to optimize team and individual performance, as well as patient outcomes. Growing evidence in cardiac medical care and in non-cardiac surgery has shown that physicians' sex and gender significantly impact care. For example, OR teamwork is integral to preventing and treating many intra- and postoperative complications and can also be shaped by the sex composition of the team as well as gender roles and norms [11,56]. In addition, there is considerable imbalance of physician sex in cardiac surgery as compared to other surgical specialties, such that cardiac surgery has traditionally been viewed as a field dominated by male physicians [35]. Therefore, an in-depth understanding of how physician sex and gender influence team dynamics, in addition to individual performance, may inform future team-based interventions and ultimately mitigate preventable adverse events in cardiac surgery [57–60]. Research in this domain might also inform an integrated clinical practice approach that moves beyond medical knowledge and experience, to individual and social factors. For example, educational interventions could be tailored based on provider sex or cardiac OR scheduling apps could be designed to optimize OR team sex composition. Such an approach will shift the paradigm in patient safety research towards the personalization of provider characteristics, to provide all-around personalized medical care.

Future directions

Future research should consider physician sex and gender when examining physician-related factors influencing surgical cardiac care. At minimum, studies should report the sex and/or gender characteristics of both the healthcare providers and patients involved so that future meta-analyses may be possible [61]. In addition, sex and gender are not the only physician characteristics relevant to performance and their salience may depend on other factors such as age, level of experience, region of training, or cultural background [62–65]. Thus, studies that integrate sex and gender variables may also consider how they intersect with additional categories of social identity. Attention to anesthesiologist sex/gender, in particular, would be warranted given the lack of literature in this area in addition to the potential interaction between anesthesiologist and surgeon sex/gender.

Limitations of the study

While this review has identified a critical knowledge gap in cardiac surgical care, there are some limitations of this review that are to be noted. First, we included only studies published in English or French. Two other non-English/French studies were identified and were determined not to be relevant. Second, it is possible that studies examined physician sex and/or gender as control variables but may have been excluded during title and abstract screening based on the failure of the study to specify this as a primary aim. Given our findings, combined with other systematic reviews showing the paucity of sex/gender analyses in medicine [66], we believe it is unlikely that any relevant studies were missed by our search strategy or screening process.

Neither of the two studies included in this review specifically explored the impact of surgeon and anaesthesiologist sex or gender in the context of cardiac surgery in detail, nor did they include the processes of care as an outcome. Furthermore, the magnitude of reduction in adverse events

and the methodology of propensity score matching used were at times unclear within the two observational studies presented in this review (29,31).

Conclusions

This systematic review found no English or French language publication directly assessing the role of physician sex and/or gender in cardiac operative care. Two observational studies investigated the impact of surgeon sex on patient outcomes across the full scope of surgical specialties. These findings highlight the need for primary research to determine how these factors may influence cardiac surgical practice, in order to optimize provider performance and improve outcomes in this high-risk patient group.

FUNDING STATEMENT
Dr. Boet was supported by The Ottawa Hospital Anesthesia Alternate Funds Association. Dr. Sun is supported by the Ottawa Heart Institute Research Corporation. DSR licenses were funded by the Department of Anesthesiology and Pain Medicine of The Ottawa Hospital.

ACKNOWLEDGEMENTS

We would like to thank Alexandra Davis, BA, MLIS for her help in the development and review of the search strategies.

CONTRIBUTOR'S STATEMENT

SB, NE, MD, LS: Contributed substantially to conception and design, or analysis and interpretation of data, drafted the article, revised article critically for important intellectual content, gave final approval of the version to be published, agreed to act as guarantor of the work (ensuring that questions related to any part of the work are appropriately investigated and resolved).

AJ, FM, HS, KZ: Contributed substantially to acquisition of data, revised the article critically for important intellectual content, gave final approval of the version to be published, agreed to act as guarantor of the work (ensuring that questions related to any part of the work are appropriately investigated and resolved).

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

DATA STATEMENT

All relevant data is included in the manuscript.

FIGURE & TABLE LEGEND

Table 1. Characteristics and results of included studies (n = 2)

Table 2. Risk of bias for included studies: NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies

Figure 1. PRISMA Flow Diagram

Appendix 1: Search strategy

Appendix 2: Reason for exclusion for references screened at Level 2

Appendix 3: Detailed risk of bias ratings

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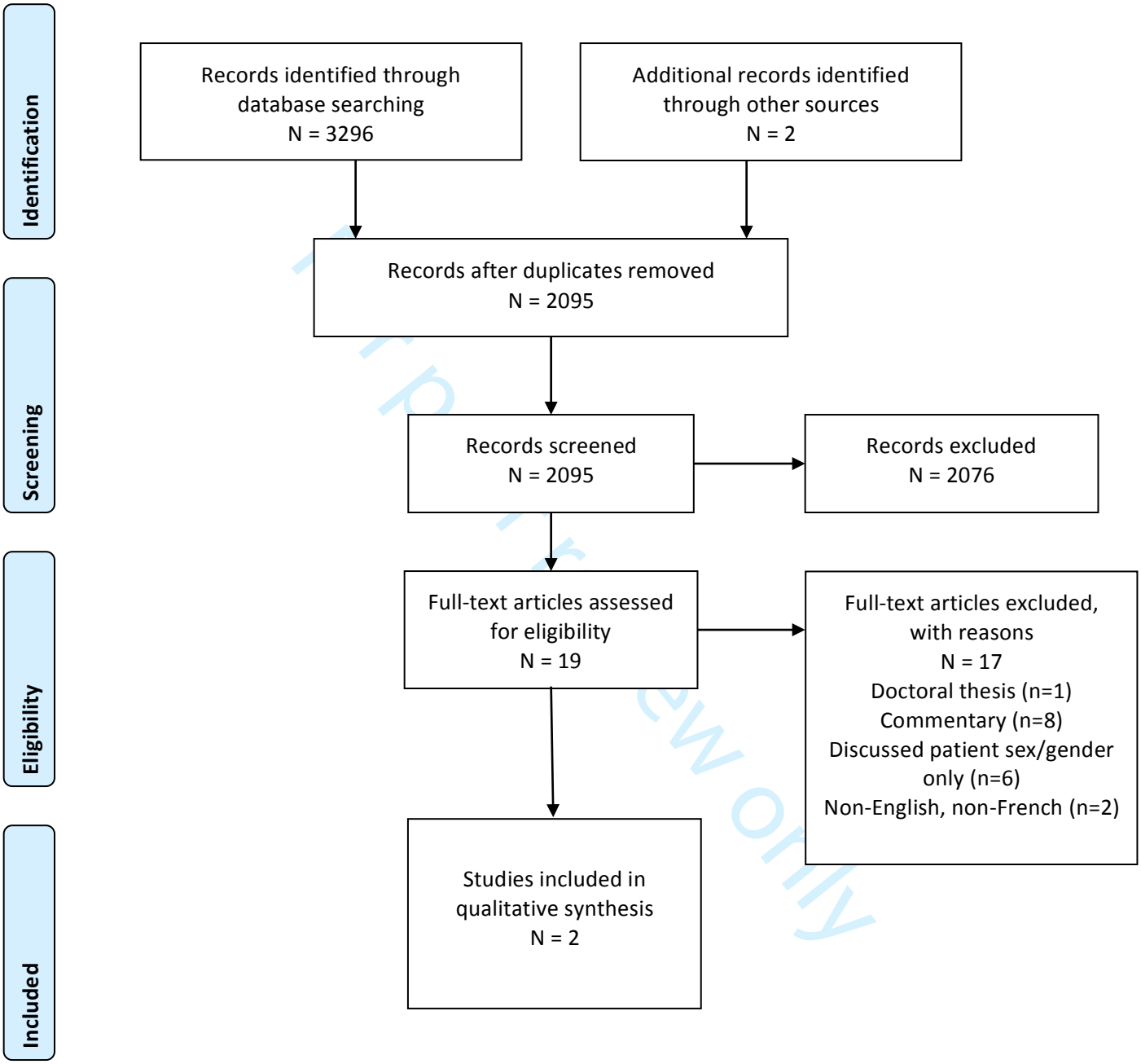
Figure 1. PRISMA Flow Diagram



Appendix 1: Search strategy

Database: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily <1946 to September 06, 2018>
Search Strategy:

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1 exp cardiac surgical procedures/ (200938)
2 exp Heart Diseases/su [Surgery] (156583)
3 Heart Neoplasms/su [Surgery] (4760)
4 ((cardiac or heart or coronary or cardiovascular) adj2 surg*).tw. (67075)
5 (cardiac surg* or heart surg*).kw. (7445)
6 ((cardiothoracic or cardio thoracic) adj2 (surg* or resection)).tw. (3248)
7 (cardiothoracic surg* or cardi-thoracic surg*).kw. (151)
8 ((cardiac or heart) adj2 transplant*).tw. (31061)
9 exp Heart Valves/su [Surgery] (28200)
10 exp Heart Defects, Congenital/su [Surgery] (45282)
11 (valv* adj2 (repair or replacement or implant* or annuloplasty)).tw. (39378)
12 (coronary artery bypass graft* or coronary artery bypass surgery or CABG).tw,kw. (38366)
13 (aortocoronary adj2 (bypass or graft*)).tw. (2745)
14 pericardectom*.tw,kw. (300)
15 cardiomyoplast*.tw,kw. (842)
16 myectom*.tw,kw. (1504)
17 or/1-16 (343953)
18 ((sex or gender) adj2 (difference* or disparit*)).tw. (70531)
19 (gender difference* or gender based or gender specific).tw,kw. (39305)
20 (sex or gender or women or men or female or male).ti. (548983)
21 Physicians, Women/ (5625)
22 ((female or women or male) adj3 (surgeon* or physician* or an?esthesiologist* or an?esthetist*)).tw. (5058)
23 female gender.tw. (14006)
24 male gender.tw. (13788)
25 or/18-24 (616019)
26 perioperative care/ or perioperative period/ or intraoperative period/ or postoperative period/ or preoperative period/ (75044)
27 (preoperative* or pre-operative* or perioperative* or peri-operative* or intraoperative* or intra-operative* or postoperative* or post-operative*).tw,kw. (773968)
28 (postoperative* or post-operative* or postsurg* or post-surg*).tw,kw. (552307)
29 Postoperative Complications/ (336691)
30 or/26-29 (1009987)
31 17 and 25 and 30 (1185)
32 ((post or following or after) adj3 (cardiac surg* or heart surg* or coronary surg* or cardiovascular surg* or cardiothoracic surg* or cardio-thoracic surg* or cardiac transplant* or heart transplant* or CABG or myectom* or cardiomyoplast* or pericardectom* or coronary artery bypass surg* or coronary artery bypass graft*)).tw. (33888)
33 25 and 32 (643)
34 31 or 33 (1432)
35 animals/ not humans/ (4462509)
36 34 not 35 (1429)
37 case reports.pt. (1895280)
38 36 not 37 (1367)

Database: Embase Classic+Embase <1947 to 2018 September 6>
Search Strategy:

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1 exp *heart surgery/ (185030)
2 ((cardiac or heart or coronary or cardiovascular) adj2 surg*).tw. (95608)
3 ((cardiothoracic or cardio thoracic) adj2 (surg* or resection)).tw. (10404)
4 ((cardiac or heart) adj2 transplant*).tw. (48320)
5 (valv* adj2 (repair or replacement or implant* or annuloplasty)).tw. (59368)
6 (coronary artery bypass graft* or coronary artery bypass surgery or CABG).tw. (55469)
7 (aortocoronary adj2 (bypass or graft*)).tw. (3137)
8 pericardectom*.tw. (485)
9 cardiomyoplast*.tw. (993)
10 myectom*.tw. (2067)
11 or/1-10 (306709)
12 *sex difference/ (36769)
13 ((sex or gender) adj2 (difference* or disparit*)).tw. (93875)
14 (gender difference* or gender based or gender specific).tw. (51324)
15 (sex or gender or women or men or female or male).ti. (686782)
16 female physician/ (4639)
17 ((female or women or male) adj3 (surgeon* or physician* or an?esthesiologist* or an?esthetist*)).tw. (6274)
18 (female gender or male gender).tw. (45514)
19 or/12-18 (789727)
20 perioperative period/ (41769)
21 preoperative period/ or preoperative care/ (85168)
22 intraoperative period/ (35068)
23 postoperative period/ (189526)
24 (preoperative* or pre-operative* or perioperative* or peri-operative* or intraoperative* or intra-operative* or postoperative* or post-operative*).tw. (1088663)
25 (postoperative* or post-operative* or postsurg* or post-surg*).tw. (783471)
26 *postoperative complication/ (64743)
27 or/20-26 (1247931)
28 11 and 19 and 27 (1414)
29 ((post or following or after) adj3 (cardiac surg* or heart surg* or coronary surg* or cardiovascular surg* or cardiothoracic surg* or cardio-thoracic surg* or cardiac transplant* or heart transplant* or CABG or myectom* or cardiomyoplast* or pericardectom* or coronary artery bypass surg* or coronary artery bypass graft*)).tw. (49291)
30 19 and 29 (1026)
31 28 or 30 (1899)
32 case report/ (2364953)
33 31 not 32 (1835)
34 animals/ not humans/ (1320229)
35 33 not 34 (1833)

Database: PsycINFO <1806 to September Week 1 2018>
Search Strategy:

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1 Heart Surgery/ (1440)
2 ((cardiac or heart or coronary or cardiovascular) adj2 surg*).tw. (1427)
3 ((cardiothoracic or cardio thoracic) adj2 (surg* or resection)).tw. (51)
4 ((cardiac or heart) adj2 transplant*).tw. (450)
5 (valv* adj2 (repair or replacement or implant* or annuloplasty)).tw. (118)
6 (coronary artery bypass graft* or coronary artery bypass surgery or CABG).tw,kw. (837)
7 (aortocoronary adj2 (bypass or graft*)).tw. (9)
8 pericardectom*.tw,kw. (0)
9 cardiomyoplast*.tw,kw. (0)
10 myectom*.tw,kw. (1)
11 or/1-10 (2726)
12 Human Sex Differences/ (107002)
13 ((sex or gender) adj2 (difference* or disparit*)).tw. (77653)
14 (gender difference* or gender based or gender specific).tw,kw. (48241)
15 HUMAN FEMALES/ (87482)
16 (sex or gender or women or men or female or male).ti. (219801)
17 ((female or women or male) adj3 (surgeon* or physician* or an?esthesiologist* or an?esthetist*)).tw. (1337)
18 female gender.tw. (3363)
19 male gender.tw. (2936)
20 or/12-19 (328932)
21 11 and 20 (174)
22 Surgical Patients/ or Surgery/ (14030)
23 (preoperative* or pre-operative* or perioperative* or peri-operative* or intraoperative* or intra-operative* or postoperative* or post-operative*).tw,kw. (12886)
24 (postoperative* or post-operative* or postsurg* or post-surg*).tw,kw. (11666)
25 Postsurgical Complications/ (825)
26 or/22-25 (23936)
27 21 and 26 (74)
28 ((post or following or after) adj3 (cardiac surg* or heart surg* or coronary surg* or cardiovascular surg* or cardiothoracic surg* or cardio-thoracic surg* or cardiac transplant* or heart transplant* or CABG or myectom* or cardiomyoplast* or pericardectom* or coronary artery bypass surg* or coronary artery bypass graft*)).tw. (870)
29 21 and 28 (59)
30 27 or 29 (96)

Appendix 2: Reason for exclusion for references screened at Level 2

First author, year	Reference	Reason for exclusion
Kobayashi H. et al, 1988	Coronary artery bypass grafting in women: analyses of preoperative and intraoperative factors. *Nihon Kyobu Geka Gakkai Zasshi.* 1988 Aug;36(8):1285-91	Japanese, non-English
Hanet C. et al., 1990	Angiographic evaluation of vasomotor properties of internal mammary arteries before and after coronary artery bypass grafting in men. *The American Journal of Cardiology*. 1990;65(13):918–21.	Studied patient sex only
Meyer SA., 1993	The relationship of nutritional status, personality hardiness, and social support of the older adult to treatment outcomes following non-emergent cardiac surgery. *Thesis (D.P.H.) University of Hawaii at Manoa*	Doctorate thesis
Vallejo JL. et al, 1994	Influence of sex in the technique and results of valvular surgery. *Rev Esp Cardiol*. 1994;47 Suppl 3:68–75.	Spanish, non-English
Bryan CF. et al., 1996	Influence of donor gender on patient mortality after heart transplantation. *Transplant Protocol*. 1996 Feb;28(1):149-51.	Studied recipient and donor patient sex only
Aidala E. et al., 1999	Gender and coronary artery bypass mortality. *Ann Thorac Surg.* 1999 Aug;68(2):625–6.	Commentary
TH. Lee., 2001	Heart lines. Neurological complications more common in women after heart surgery. *Harvard Heart Letter*. 2001 Dec;12(4):1-7	Commentary
Herd JA. et al., 2003	Heart rate and blood pressure responses to mental stress and clinical cardiovascular events in men and women after coronary artery bypass grafting: The Post Coronary Artery Bypass Graft (Post-CABG) biobehavioral study. *American Heart Journal*. 2003;146(2):273–9.	Studied patient sex only

Koch CG. et al., 2003	Is it gender, methodology, or something else? *Journal of Thoracic and Cardiovascular Surgery*. 2003;126(4):932–5.	Commentary
Habib RH. et al., 2004	Sex differences in mortality after coronary artery bypass graft surgery. *JAMA*. 2004 Jul 7;292(1):40–1.	Commentary
Habib RH. et al., 2004	Worse early outcomes in women after coronary artery bypass grafting: Is it simply a matter of size? *The Journal of Thoracic and Cardiovascular Surgery*. 2004;128(3):487–8.	Commentary
Cheng TO., 2005	In China women uphold half of the sky. *International Journal of Cardiology*. 2005;102(1):159–159.	Commentary
Jonker G. et al., 2006	Increased mortality among women after coronary artery bypass grafting seems mainly to be explained by infections. 2006.	Commentary
Dixon B. et al., 2014	The operating surgeon is an independent predictor of chest tube drainage following cardiac surgery. *J Cardiothorac Vasc Anesth.* 2014;28(2):242–6.	Studied patient gender only
Lopes CT. et al., 2015	Excessive bleeding predictors after cardiac surgery in adults: integrative review. J Clin Nurs. 2015;24(21–22):3046–62.	Studied patient sex only
Mattioli AV. et al., 2018	Combined Rehabilitation and Nutritional Coaching After Cardiac Surgery: Sex Differences. *The Annals of Thoracic Surgery*. 2018;106(4):1265.	Commentary

Commentary: qualitative analysis exclusively.

Appendix 3. Risk of bias for included studies: NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies

	NIH Quality Assessment Tool	Tsugawa, 2018	Wallis, 2017
1	Was the research question or objective in this paper clearly stated?	Y	Y
2	Was the study population clearly specified and defined?	Y	Y
3	Was the participation rate of eligible persons at least 50%?	Y	Y
4	Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	Y	Y
5	Was a sample size justification, power description, or variance and effect estimates provided?	N	Y
6	For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	Y	Y
7	Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Y	Y
8	For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	N	N
9	Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	Y
10	Was the exposure(s) assessed more than once over time?	N	N
11	Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	Y
12	Were the outcome assessors blinded to the exposure status of participants?	Y	Y
13	Was loss to follow-up after baseline 20% or less?	Y	Y
14	Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	Y	Y
	Total (/14)	**11**	**12**

Y: yes, N: no

Section/topic	#	Checklist item	Rep on
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	App 2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	4

Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A