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Original Article

Association between anaesthesia–surgery team sex diversity and major morbidity

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Abstract

Background: Team diversity is recognized not only as an equity issue but also a catalyst for improved performance through diversity in knowledge and practices. However, team diversity data in healthcare are limited and it is not known whether it may affect outcomes in surgery. This study examined the association between anaesthesia–surgery team sex diversity and postoperative outcomes.

Methods: This was a population-based retrospective cohort study of adults undergoing major inpatient procedures between 2009 and 2019. The exposure was the hospital percentage of female anaesthetists and surgeons in the year of surgery. The outcome was 90-day major morbidity. Restricted cubic splines were used to identify a clinically meaningful dichotomization of team sex diversity, with over 35% female anaesthetists and surgeons representing higher diversity. The association with outcomes was examined using multivariable logistic regression.

Results: Of 709 899 index operations performed at 88 hospitals, 90-day major morbidity occurred in 14.4%. The median proportion of female anaesthetists and surgeons was 28 (interquartile range 25–31)% per hospital per year. Care in hospitals with higher sex diversity (over 35% female) was associated with reduced odds of 90-day major morbidity (OR 0.97, 95% c.i. 0.95 to 0.99; $P = 0.02$) after adjustment. The magnitude of this association was greater for patients treated by female anaesthetists (OR 0.92, 0.88 to 0.97; $P = 0.002$) and female surgeons (OR 0.83, 0.76 to 0.90; $P < 0.001$).

Conclusion: Care in hospitals with greater anaesthesia–surgery team sex diversity was associated with better postoperative outcomes. Care in a hospital reaching a critical mass with over 35% female anaesthetists and surgeons, representing higher team sex-diversity, was associated with a 3% lower odds of 90-day major morbidity.

Introduction

The need for team diversity is an evolving conversation, initially rooted in notions of representation and social justice[1–4]. Diversity is not solely a social and ethical imperative, but can also be a catalyst for improved performance[1–3]. In various sectors, such as business, finance, industry, technology, education, and music, gender and sex diversity is a strategic resource that enriches the output of teams through a multiplicity of experiences and viewpoints[4–13]. However, there is limited evidence for the value of sex diversity of teams in healthcare, with published reports[14–20] to date focusing on individual's characteristics and their

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associations with outcomes. There is a paucity of data regarding the role of the team's sex diversity[6,21]. Because the performance of a team is known to surpass that of individuals, it is crucial to understand the relationship between sex diversity and patient outcomes at the team level[4,22]. Given the distinct nature of healthcare, healthcare-specific data are needed[3,6]. Understanding the influence of team sex diversity on patient outcomes is needed to support further efforts to increase diversity in the operating room. Indeed, despite increasing sex diversity in medical schools, anaesthesia and surgery still grapple with diversity in hiring, promotion, and retention[23–26]. Therefore, the aim of the study was to determine the association between anaesthesia–surgery team sex diversity and postoperative major morbidity after major inpatient surgery.

Methods

Study design, setting, and data sources

This was a population-based retrospective cohort study using administrative healthcare data in Ontario, Canada, where 14 million residents receive health services through a government-administered single-payer system[27]. The use of these data was authorized under section 45 and approved by ICES' Privacy and Legal Office. Reporting followed the RECORD statement[28]. Data sets were linked using unique encoded identifiers and analysed at ICES (formerly known as the Institute for Clinical Evaluative Sciences). Data sets are further detailed in *Table S1*.

Study population

Patients aged at least 18 years undergoing major elective inpatient surgery (*Table S2*) between 2009 and 2019 were identified. Commonly performed procedures associated with higher morbidity risk were included given the higher potential for association with perioperative team diversity. Where a patient underwent more than one procedure, unique procedures more than 90 days apart were included.

Exposure

The exposure was anaesthesia–surgery team sex diversity, defined as the percentage of female anaesthetists and surgeons among all anaesthetists and surgeons working in the hospital in the year of the index surgery (*Table S3*). Because of data availability, biological sex information was captured but not the construct of gender.

Outcome

The primary outcome was 90-day major morbidity (*Table S3*) defined as complications with a Clavien–Dindo grade of III–V[29–32]. Patients were followed until 90 days after surgery, date of death, date of last clinical contact with the healthcare system, or end of study (31 March 2020).

Co-variates

For each index procedure, clinical and demographic characteristics were measured at the time of surgery (*Table S3*). Patient age, sex, rural residence, socioeconomic status, and co-morbidity burden were captured. Operations were grouped by specialty and morbidity risk profile. Surgeon, anaesthetist, and hospital annual volume of procedures of interest, and hospital setting (academic *versus* community) were also captured[33,34].

Statistical analysis

Descriptive statistics were calculated with numbers and percentages for categorical variables and median (i.q.r.) for continuous variables. Linear and non-linear relationships between anaesthesia–surgery team sex diversity and outcome were explored. Informed by these relationships, the association between team sex diversity and the outcome was described using the exposure as a binary variable. Index operations were divided into groups according to whether the patient had received care in a hospital with lower or higher team sex diversity. Groups were compared using standardized mean differences, with a difference below 10% considered non-significant[35,36]. Multivariable logistic regression models were used to adjust for potential confounders of patient age, sex, and co-morbidity burden, annual hospital, surgeon and anaesthetist volumes, type of surgery, and year of surgery. Finally, sensitivity analyses were conducted (*Table S4*).

Because anaesthetist and surgeon sex have been associated with postoperative outcomes, effect modification by individual anaesthetist and surgeon sex was examined with interaction terms between the exposure and individual physician sex[17]. Where such interaction terms were statistically significant, effect estimates of team sex diversity were reported for each surgeon and each anaesthetist sex category to reflect the potentially differing effect.

There were no missing data on the co-variates, exposure, or outcomes used for the multivariable analysis. Statistical tests were two-sided and $P < 0.050$ was considered statistically significant. All analyses were conducted using SAS® Enterprise Guide 7.1 (SAS Institute, Cary, NC, USA).

Results

A total of 709 899 index procedures were included (*Fig. S1*). Characteristics of these operations are summarized in *Table 1*. The 90-day postoperative major morbidity rate was 14.4% (10 240 patients). The median percentage of females (team sex diversity) for anaesthetists and surgeons was 28 (i.q.r. 25–31)% per hospital per year. Restricted cubic splines demonstrated an inflection point at 35% (*Fig. S2*). This was chosen as the cut-off point, and the distribution of characteristics of index procedures was divided into groups with higher and lower team sex diversity (*Table 1*).

The adjusted association between anaesthesia–surgery team sex diversity and 90-day postoperative major morbidity is shown in *Fig. 1*. Care in a hospital with higher team sex diversity was independently associated with a lower odds of 90-day postoperative major morbidity (adjusted OR 0.97, 95% c.i. 0.95 to 0.99; $P = 0.02$) (*Fig. 2* and *Table S5*).

Overall, 47 874 index operations (6.7%) were performed by female surgeons and 192 144 (27.0%) were undertaken with female anaesthetists. Interaction terms for differential associations by surgeon sex and by anaesthetist sex were significant (both $P < 0.01$) (*Fig. 2*). Care by a female surgeon increased the association of higher team sex diversity with outcomes, whereas this was not observed for care by a male surgeon. This indicates that having higher team sex diversity and care by a female surgeon had a greater association with outcomes than the sum of each. The same was observed for care by female anaesthetists.

The association between higher team sex diversity and 90-day postoperative major morbidity persisted in sensitivity analyses (*Table S6*).

Discussion

In this population-based study, care in a hospital with more than 35% female anaesthetists and surgeons was independently associated with a 3% reduction in the odds of 90-day postoperative major morbidity. This association was greater

Table 1 Distribution of characteristics of index operations, stratified according to sex diversity of anaesthesia–surgery team

	All index operations (*n* = 709 899)	Lower team sex diversity (≤ 35%) (*n* = 652 892)	Higher team sex diversity (> 35%) (*n* = 57 007)	Standardized difference
Age at surgery (years), median (i.q.r.)	67 (59–74)	67 (59–74)	67 (59–74)	0.02
Sex				
Female	375 267 (52.9)	345 086 (92.0)	30 181 (8.0)	0
Male	334 632 (47.1)	307 806 (92.0)	26 826 (8.0)	0
High co-morbidity burden (Elixhauser sum ≥ 4)	66 519 (9.4)	61 278 (92.1)	5241 (7.9)	0.01
Preoperative frailty (pFI > 0.21)	37 059 (5.2)	34 442 (92.9)	2617 (7.1)	0.03
Rural residence	85 130 (12.0)	77 143 (90.6)	7987 (9.4)	0.07
Material deprivation				
1st quintile (least deprived)	149 095 (21.0)	132 176 (88.7)	16 919 (11.3)	0.22
2nd quintile	146 902 (20.7)	134 412 (91.5)	12 490 (8.5)	0.03
3rd quintile	142 369 (20.1)	131 542 (92.4)	10 827 (7.6)	0.03
4th quintile	138 656 (19.5)	130 250 (93.9)	8406 (6.1)	0.14
5th quintile (most deprived)	127 575 (18.0)	119 658 (93.8)	7917 (6.2)	0.12
Missing	5302 (0.7)	4854 (91.6)	448 (8.4)	0
Type of surgery				
Cardiac	14 328 (2.0)	14 089 (98.3)	239 (1.7)	0.15
High-risk gastrointestinal	13 728 (1.9)	12 473 (90.9)	1255 (9.1)	0.02
Low-risk gastrointestinal	84 252 (11.9)	78 795 (93.5)	5457 (6.5)	0.08
Genitourinary	51 584 (7.3)	46 667 (90.5)	4917 (9.5)	0.05
Gynaecological oncology	16 584 (2.3)	15 026 (90.6)	1558 (9.4)	0.03
Head and neck	3253 (0.5)	2899 (89.1)	354 (10.9)	0.02
Neurosurgery	13 140 (1.9)	11 785 (89.7)	1355 (10.3)	0.04
Orthopaedic	413 708 (58.3)	379 481 (91.7)	34 227 (8.3)	0.04
Spinal	49 738 (7.0)	46 062 (92.6)	3676 (7.4)	0.02
Thoracic (lung)	25 803 (3.6)	23 206 (89.9)	2597 (10.1)	0.05
Vascular	23 781 (3.3)	22 409 (94.2)	1372 (5.8)	0.06
Hospital status				
Community	424 997 (59.9)	400 720 (94.3)	24 277 (5.7)	0.38
Teaching	284 902 (40.1)	252 172 (88.5)	32 730 (11.5)	0.38
Annual clinical volumes (procedures/year), median (i.q.r.)				
Hospital	494 (253–879)	486 (249–847)	761 (297–1113)	0.29
Surgeon	108 (48–179)	120 (48–223)	109 (48–184)	0.17
Anaesthetist	31 (14–57)	31 (14–57)	33 (12–68)	0.07

Values are *n* (%) unless otherwise stated; percentages calculated by column for all procedures and by row for diversity subgroups. Standardized differences above 0.1 considered significant. pFI, preoperative frailty index.

when operations involved a female surgeon or female anaesthetist, indicating a different association depending on the sex of the physicians involved. These findings are important for optimizing patient outcomes and quality care by building intentionally diverse teams.

Team sex and gender diversity correlate with enhanced performance across business, industry, and education sectors[6,22]. Within healthcare, one study has reported conflicts arising with increasing racial diversity, whereas others have associated team diversity in the healthcare workforce with improved patient adherence and satisfaction[6,37,38]. In the perioperative field, studies of diversity have focused on individual clinicians, and reported associations between individual surgeon and anaesthetist female sex and better postoperative outcomes, and between clinician–patient sex concordance and better postoperative outcome[17,20,39–42]. The present work provides novel information by shifting understanding of the benefits of diversity in perioperative performance from individual clinicians towards teams. This team-level analysis challenges the binary approach comparing female and male clinicians, and supports team sex diversity as a potential asset in enhancing care quality. Although the observed difference in outcomes may appear small, the sample size was large and the widths of the confidence intervals were narrow, so one can be confident that the results represent a meaningful statistical difference. The authors believe that this difference is also clinically meaningful; indeed, the magnitude of the effect estimate is aligned with that identified in other work that focused on the sex of individual physicians[14,18,39,42]. The present results are also dependent on the existing team sex diversity in the cohort; it is possible that with more hospital-years with higher team sex diversity and more operations performed by individual female anaesthetists or surgeons, a larger difference may be observed.

The present data indicated a non-linear relationship between anaesthesia–surgery team sex diversity and outcomes. The observed 35% threshold echoes business findings in various countries including the USA, Italy, Australia, and Japan, which showed better performance with balanced teams[4,43,44]. This reflects Kanter's 1970 theory that highlighted the benefits of balanced teams over more uniform teams, whereby teams that are male-dominated have the same performance as those that are female-dominated, and both are overperformed by balanced teams[4,45]. The concept of critical mass is central to this pattern. Because minority team members often withhold diverse perspectives until adequate representation is achieved, below a critical mass the unique perspectives of those individuals are not fully leveraged[4–6,46].

Team sex diversity likely contributes to patient outcomes through the myriad of differences that male and female physicians bring to the workplace. The two sexes possess

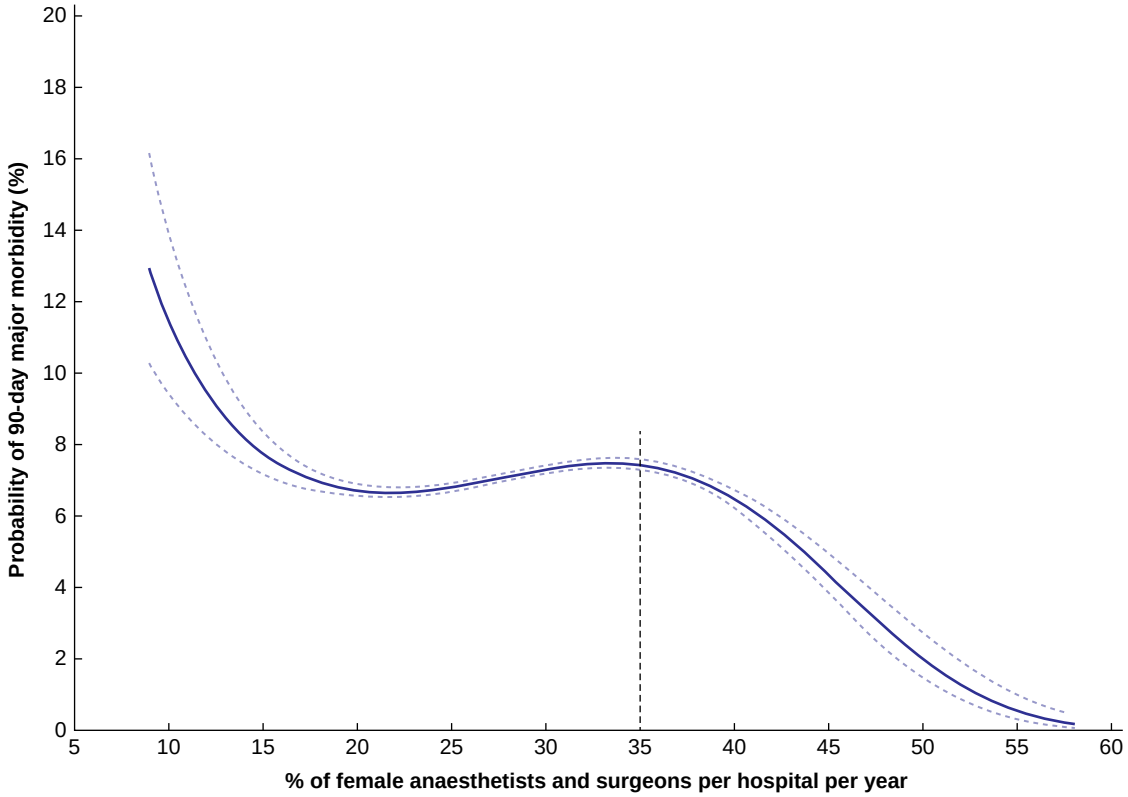

Fig. 1 Adjusted probability of 90-day postoperative major morbidity according to anaesthesia–surgery team sex diversity

Polynomial logistic regression with quadratic and cubic terms was used. The analysis was adjusted for patient age, sex, co-morbidity burden, hospital, anaesthetist, and surgeon procedure volumes, type of surgery, and year of surgery. Solid line represents the probability of 90-day major morbidity and dotted lines represent the 95% confidence interval.

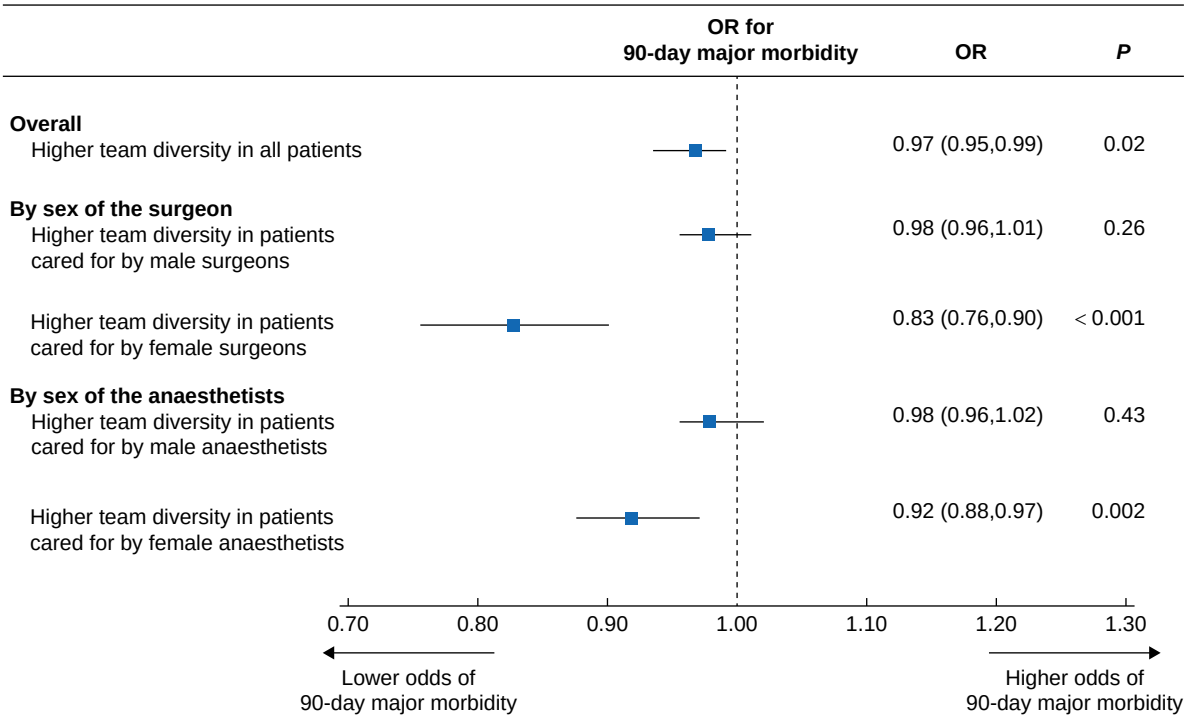

Fig. 2 Adjusted ORs showing associations between anaesthesia–surgery team sex diversity and 90-day postoperative major morbidity, including interactions with sex of the individual anaesthetist or surgeon performing the surgery

ORs are shown with 95% confidence intervals. Analyses were adjusted for patient age, sex, co-morbidity burden, hospital, anaesthetist, and surgeon procedure volumes, type of surgery, and year of surgery.

different skills, knowledge, experiences, beliefs, values, and leadership styles, all of which lead to different cognitive frames[3,7,8,47]. Despite the benefits of sex and gender diversity on team performance, inclusion of women in operating rooms remains challenging. This is evidenced in the present study by the slow rise in the median percentage of female anaesthetists and surgeons by only 5% over 10 years, with half of the hospitals studied having less than 35% women in 2019. Therefore, these results fill a gap in the literature to support further efforts to address under-representation of women in the operating room.

Although the present findings require validation in other systems, they underscore the potential of anaesthesia–surgery team sex diversity to improve patient outcomes. The main takeaway for clinical practice and health policy is that increasing operating room teams' sex diversity is not a question of representation or social justice, but an important part of optimizing performance. Healthcare institutions should intentionally foster sex diversity in operating room teams to potentially reduce major morbidity, which, in turn, can enhance patient satisfaction and reduce costs[48–51]. Addressing the disparities in anaesthesia–surgery team sex diversity needs multifaceted solutions and commitment from all stakeholders. A fulsome discussion of inclusive leadership interventions falls beyond the scope of this work, but has been reviewed by others[52]. A few practical solutions may include the following: First, recognizing that team sex diversity is a key component of performance and the role of a critical mass, through dissemination and awareness of the literature on this topic[11,53]. Second, ensuring systematic recruitment, promotion, and retainment policies promoting diversity[3]. Third, implementing structural interventions such as minimum sex representation in operating teams, like those implemented in France, Germany, and Italy for boards, to work towards a critical mass[54]. This can be coupled with monitoring and reporting of the make-up of operating room teams as part of existing quality monitoring programmes to build accountability in achieving a critical mass.

This study has limitations. Owing to the retrospective design with use of administrative databases, the data used were not collected specifically to answer the research question. Some details that may have influenced the association between exposure and outcomes were lacking, such as organizational culture and norms, and unmeasured confounding cannot be ruled out. For instance, the authors could not account for changes in unconscious bias or workplace culture over time, but could only adjust for year of surgery. This study focused on one component of team diversity: biological sex. It is acknowledged that the behaviours and benefits of team diversity may also be related to the social construct of gender. Although the magnitude of the association may differ, the authors believe that the direction would remain if gender were examined. It is also recognized that diversity encompasses many other sociodemographic dimensions, such as race, ethnicity, and religion, and the intersection of these dimensions, and that the operating room team involves other key professionals. Based on the literature from other fields[2,22,55], it can be hypothesized that the findings would be similar if such other characteristics and groups were examined. It is also acknowledged that social norms and values regarding sex diversity may influence the results and vary across cultural settings, potentially influencing generalizability. Given consistent findings in other sectors across the Americas, Europe, and Asia-Pacific[4,43,44], the authors suspect that the present results could be replicated in other settings.

In conclusion, anaesthesia–surgery team sex diversity was associated with better postoperative outcomes. Care at a hospital reaching a critical mass of over 35% female anaesthetists and surgeons was associated with a 3% lower odds of 90-day major morbidity. This association was greater for patients treated by female surgeons and anaesthetists. These data suggest that there is a diversity bonus in outcomes with more sex-diverse anaesthesia–surgery teams.

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Author contributions

Julie Hallet (Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing—original draft, Writing—review & editing), Rinku Sutradhar (Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Validation, Visualization, Writing—review & editing), Alana Flexman (Conceptualization, Investigation, Methodology, Visualization, Writing—review & editing), Daniel McIsaac (Data curation, Investigation, Methodology, Validation, Writing—review & editing), Francois Martin Carrier (Data curation, Investigation, Methodology, Validation, Writing—review & editing), Alexis F. Turgeon (Investigation, Methodology, Validation, Writing—review & editing), Colin McCartney (Investigation, Methodology, Validation, Writing—review & editing), Wing C. Chan (Data curation, Formal analysis, Investigation, Validation, Writing—review & editing), Natalie Coburn (Data curation, Funding acquisition, Investigation, Methodology, Validation, Writing—review & editing), Antoine Eskander (Data curation, Investigation, Methodology, Validation, Writing—review & editing), Angela Jerath (Investigation, Methodology, Validation, Writing—review & editing), Pablo Perez d'Empaire (Funding acquisition, Investigation, Methodology, Validation, Writing—review & editing), and Gianni Lorello (Conceptualization, Data curation, Investigation, Methodology, Supervision, Validation, Writing—review & editing)

Disclosure

The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at *BJS* online.

Data availability

The data sets from this study are held securely in coded form at ICES. Although data-sharing agreements prohibit ICES from making the data sets publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at http://www.ices.on.ca/DAS. The data set creation plan and underlying analytical code are available from the authors upon reasonable request, on the understanding that the computer programs may rely on coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

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