Queen's UNIVERSITY

DEPARTMENT OF ANESTHESIOLOGY

JOURNAL CLUB

Thursday, 19 October, 2023
1800 HOURS

LOCATION:
Curry Original
175 Bagot St, Kingston, ON
K7L 3E9

PRESENTING ARTICLES:
Dr. Joel Parlow & Dr. Matt Machina

SUGGESTED GUIDELINES FOR CRITICAL APPRAISAL OF PAPERS
ANESTHESIOLOGY JOURNAL CLUB
QUEEN'S UNIVERSITY

Two presenters will be assigned to choose and present summaries of their papers. Ideally the two papers will represent similar topics but contrasting research methodologies. The focus remains on critical appraisal of the research and manuscript, more than on the actual contents of the article. Each presenter will then lead an open discussion about the article, based around the guidelines below. The object is to open up the appraisal to wide discussion involving all participants.

GENERAL

1. Title of paper: Does it seem like an important problem? Does it reflect the purpose/results?
2. Authors, institution and country of origin

INTRODUCTION

1. What is the problem being addressed?
2. What is the current state of knowledge of the problem studied?
3. What is the hypothesis being tested?
4. How does testing the hypothesis help solve the stated problem?

METHODOLOGY

1. Study design:
    a) Clinical trial vs. systematic review/meta-analysis
    b) Prospective vs. retrospective
    c) Observational vs. Experimental
    d) Randomized or not
    e) Blinded or not

2. Population studied:
    a) Human, animal, other
    b) Justification
    c) Control groups: experimental vs. historical
    d) Is the sample size/power calculated, and how?
    e) Is the population similar to your own practice?
    f) Single vs. multi-centre

3. Is the study ethically sound?
    a) Clinical equipoise
    b) Does treatment meet standard of care (esp controls)?
    c) Appropriate consent and institutional ethics approval

4. Exclusions: what groups are excluded and why?

5. Experimental protocol
    a) Is it designed to test the hypothesis?

b) Is it detailed enough to be reproducible?
c) Is the methodology validated?
d) Are the drugs/equipment used detailed?
e) How does the randomization take place?

6. What are the primary endpoints?
7. Is power sufficient to justify secondary endpoints?
8. Is the protocol clinically relevant?
9. Data collection and analysis
10. Statistical analysis: Is it appropriate? Are results

RESULTS

1. Are the groups comparable?
2. Were any subjects/data eliminated?
3. Analyzed by intent to treat?
4. Are adequate details of results provided? - data, graphs, tables

DISCUSSION

1. What is the main conclusion of the study?
2. Do the results support this conclusion?
3. Do the results address the stated purpose/hypothesis of the study?
4. How do the authors explain the results obtained?
5. Are there any alternative interpretations to the data?
6. Are the results clinically as well statistically relevant?
7. How do the results compare with those of previous studies?
8. What do the results add to the existing literature?
9. What are the limitations of the methods or analysis used?
10. What are the unanswered questions for future work?

APPLICABILITY OF THE PAPER

1. Have you learned something important from reading this paper?
2. Will the results of this study alter your clinical practice?

ORIGINAL CLINICAL RESEARCH REPORT

Development, Implementation, and Evaluation of a Telemedicine Preoperative Evaluation Initiative at a Major Academic Medical Center

Nirav V. Kamdar, MD, MPP, MBA,* Ari Huverserian, MD,* Laleh Jalilian, MD,* William Thi, BS,* Victor Duval, MD,* Lauren Beck, MD,* Lindsay Brooker, MPP,† Tristan Grogan, MS,* Anne Lin, MD,‡ and Maxime Cannesson, MD, PhD*

BACKGROUND: With health care practice consolidation, the increasing geographic scope of health care systems, and the advancement of mobile telecommunications, there is increasing interest in telemedicine-based health care consultations. Anesthesiology has had experience with telemedicine consultation for preoperative evaluation since 2004, but the majority of studies have been conducted in rural settings. There is a paucity of literature of use in metropolitan areas. In this article, we describe the implementation of a telemedicine-based anesthesia preoperative evaluation and report the program's patient satisfaction, clinical case cancellation rate outcomes, and cost savings in a large metropolitan area (Los Angeles, CA).

METHODS: This is a descriptive study of a telemedicine-based preoperative anesthesia evaluation process in an academic medical center within a large metropolitan area. In a 2-year period, we evaluated 419 patients scheduled for surgery by telemedicine and 1785 patients who were evaluated in-person.

RESULTS: Day-of-surgery case cancellations were 2.95% and 3.23% in the telemedicine and the in-person cohort, respectively. Telemedicine patients avoided a median round trip driving distance of 63 miles (Q1 24; Q3 119) and a median time saved of 137 (Q1 95; Q3 195) and 130 (Q1 91; Q3 237) minutes during morning and afternoon traffic conditions, respectively. Patients experienced time-based savings, particularly from traveling across a metropolitan area, which amounted to $67 of direct and opportunity cost savings. From patient satisfaction surveys, 98% (129 patients out of 131 completed surveys) of patients who were consulted via telemedicine were satisfied with their experience.

CONCLUSIONS: This study demonstrates the implementation of a telemedicine-based preoperative anesthesia evaluation from an academic medical center in a metropolitan area with high patient satisfaction, cost savings, and without increase in day-of-procedure case cancellations. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

- **Question:** Can telemedicine for preoperative consultations be accomplished in a metropolitan area?
- **Findings:** Preoperative telemedicine consultations can be accomplished in a metropolitan academic medical center with low case cancellation rate, high patient satisfaction, and patient cost savings.
- **Meaning:** Preoperative telemedicine consultations can be used successfully as an adjunct to in-person consultations before surgery.

GLOSSARY

ASA = American Society of Anesthesiologists; **COVID-19** = coronavirus disease 2019; **DRG** = diagnosis-related group; **EHR** = xxx; **EMR** = electronic medical record; **HIPAA** = Health Insurance Portability and Accountability Act; **IRB** = institutional review board; **PEPC** = preoperative evaluation and planning center; **RRMC** = Ronald Reagan Medical Center; **SD** = standard deviation; **SMH** = Santa Monica Hospital; **UCLA** = University of California, Los Angeles

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Conflicts of Interest: See Disclosures at the end of the article.

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Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (www.anesthesia-analgesia.org).

Prior presentations: Huverserian A, Kamdar N. Telemedicine Preoperative Optimization Initiative at a Major Academic Medical Center. American Society for Anesthesiology Annual Conference. October 21, 2019 (selected for oral presentation and featured conference abstract); Thi WJ, Huverserian A, Maloney NJ, Kamdar NV. Savings Advantage of a Telemedicine-based Preoperative Evaluation in an Academic Anesthesia Program. American Society for Anesthesiology Annual Conference. October 21, 2019 (selected for oral presentation).

Telemedicine-based patient evaluation has reached an inflection point in modern medicine. The economic pressures on health care systems have influenced practice consolidation and, consequently, increased the geographic scope of patient care.[1,2] Major health systems now host patients spread across a large geographic scope, and, as a result, patients are accessing their health care systems from distant locations, particularly for highly specialized surgical care. Thus, preoperative anesthetic planning, assessment, and optimization must also be accomplished over greater distances. Health care systems recognize the importance of patient-centered care, the value of the patient experience, the importance of "on-demand" delivery of health care, and the fact that future patient demographics are accustomed to accessing goods and services (including health care) via mobile platforms.[3] While health care systems have incrementally incorporated telemedicine visits across specialties,[4] the coronavirus disease 2019 (COVID-19) pandemic forced the platform over the tipping point of acceptance for health systems, physicians, and even implementation skeptics.[5–7] At a time when state "shelter in place" policies made direct patient evaluation near impossible, telemedicine for perioperative care becomes even more relevant.

Despite preoperative evaluations reducing postoperative mortality,[8] anesthesiology had limited experience utilizing telemedicine for preoperative care,[9] and even more limited experience with this technology in large, urban health care systems. Therefore, the aims of this article are to (1) describe our telemedicine implementation experience, including descriptions of the technological platforms that we use; (2) highlight the patient experience best practices that we have learned and implemented during the maintenance of the program; (3) demonstrate patient-centered benefits from using telemedicine evaluations for preoperative anesthetic evaluations; and (4) elucidate implementation barriers and future questions.

A recent narrative review summarizes the collective experience with preoperative telemedicine evaluations from earlier studies.[10] Much of the original research comprised pilot studies in rural locations that demonstrated technological feasibility[11,12] and showed high acceptability for using telemedicine. Applegate et al[13] performed a randomized controlled trial of 82 telemedicine visits in an academic medical center, compared results to in-person visits in their preanesthesia assessment center, and showed low case cancellations (1/82) and high patient satisfaction. Mullen-Fortino et al[14] used telemedicine consultations in series and in conjunction with in-person consultation to reduce the consultation time of patients who presented to their preanesthesia assessment center.

Due to the dearth of experience with telemedicine and overall low adoption of telemedicine in anesthesiology as a specialty,[15] anesthesiologists must share telemedicine implementation experiences, challenges, and strategies to aid future implementation. Our group at the University of California, Los Angeles Health (UCLA) initiated a telemedicine-enabled preoperative evaluation initiative in August 2017, and, in this article, we describe its implementation and early results.

METHODS

The UCLA Health telemedicine preoperative anesthesia evaluation was initiated on August 1, 2017, within our division's preoperative evaluation and planning center (PEPC). In this article, we report on the period from its implementation until October 31, 2019. Institutional review board (IRB) approval was obtained but given exempt status for the purposes of analyzing and retrospectively reporting our results to facilitate improvements in the patient experience at UCLA Health; hence, patient consent was waived (IRB # 19-000554).

Setting: UCLA Health Department of Anesthesiology and Perioperative Medicine

As of October 31, 2019, the Department of Anesthesiology and Perioperative Medicine at UCLA Health comprises 121 faculty, 100 residents, 21 fellows, and 44 certified nurse anesthetists. The department serves 2 main hospitals: Ronald Reagan Medical Center (RRMC), located in Westwood, and Santa Monica Hospital (SMH), located in Santa Monica; 3 affiliated hospitals (Olive View Medical Center, Martin Luther King Hospital, and Harbor UCLA); and a growing community practice, including outpatient surgery. These hospitals serve UCLA Health patients through a distributed network of 170 UCLA Health medical clinic locations throughout the Southern California region. On a daily basis, the department provides anesthesia services to more than 90 operating sites and performs over 60,000 procedures annually. As UCLA Health is expanding its community medical practice to increase its foothold in Southern California and to engage in population health management, the 2 main hospitals (RRMC and SMH) serve a growing surgical patient population and frequently patients must travel from outside of the Los Angeles metropolitan area. Therefore, in-person preoperative evaluations pose a challenge for many surgical patients, especially those who have multiple comorbidities and need specialist consultations.

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While the UCLA Health PEPC evaluates nearly 36,000 cases via telephone interview and chart review, we physically see ~1000 patients in clinic annually (2.78%). We established the PEPC telemedicine program on August 1, 2017, to improve our consultation access to surgical patients when geographic distance and time constraints limit patient access to the PEPC clinic. The video component improved patient experience with face-to-face, digital, interactions with an anesthesiologist.

Intake for a preanesthesia evaluation is represented graphically in Figure 1. Many low-risk patients are evaluated with a chart review and short phone interview with our preoperative nursing staff. When surgeons or proceduralists deem anesthesiologist consultation necessary or preferable, they triage the patient to the PEPC clinic for an in-person or telemedicine visit by an anesthesiologist. Our single nurse navigator at the clinic site monitors that each patient's unique preoperative requirements from the consult are met before the day of surgery, conducts follow-up interactions, and helps schedule subsequent telemedicine visits if the anesthesiologist or the patient requests an additional appointment.

The PEPC team is made up of physicians (1 faculty in clinic per day from a group of 7 faculty), 4 nurse practitioners, 20 registered nurses, and 3 support staff. The clinic has 7 examination rooms equipped with an examination bed and a computer for electronic medical record (EMR) access (Epic, Verona, WI). A separate, private, physician workroom accommodates an attending anesthesiologist, 1 anesthesia resident, and either a nurse practitioner or a perioperative fellow. Each computer workstation in the workroom is equipped with a computer that has a built-in camera for telemedicine encounters. All telemedicine visits are conducted from the PEPC clinic located at RRMC in Westwood, CA.

Planning, Execution, and Capital Expenditures

Implementation was facilitated by the UCLA Telehealth implementation team in the Department of Information Technology before the June 2017 launch in our PEPC. The implementation team consisted of a medical director, administrative director, and 2 implementation managers. Time spent for the initial, nonintegrated, workflow is estimated to 40 hours by the implementation team. Technical infrastructure to integrate the video visit platform into our electronic health record system required an estimate of 1338 hours for all departments. Implementation of the platform to go-live is estimated at 269 hours for the health system, which included the development of a training plan, tip sheets, eLearning, and training for long-term support staff. Administrative and clinical champions from each service line were asked to complete an 8-week program to define the project scope, build the charter, establish use cases and video visit–specific outcome measures, and determine hardware requirements which accounted for approximately 10 hours of administrative time dedicated to the anesthesia service line.

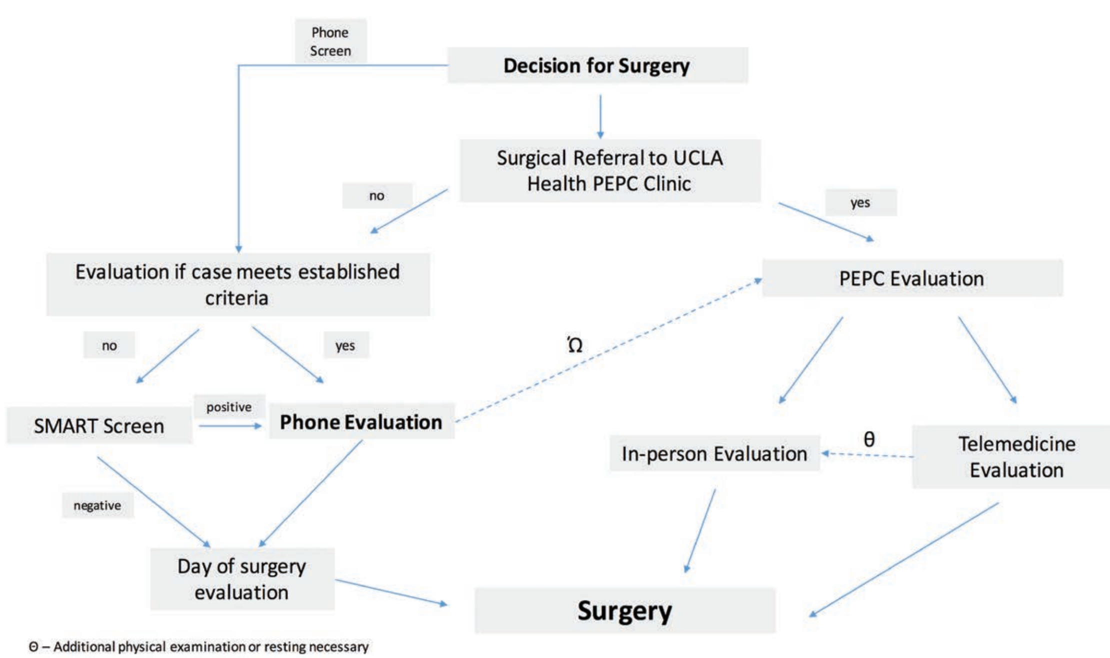

Figure 1. UCLA Health PEPC Screening Process for evaluation of preoperative patients suitable for a telemedicine visit. Dotted arrows indicate possible flow if clinical decision is made. PEPC indicates preoperative evaluation and planning center; UCLA, University of California, Los Angeles.

Telemedicine Visits

Once a patient or surgeon chooses a telemedicine consultation, PEPC staff assign an appointment date and time for their telemedicine preoperative consultation. As a care team, an attending anesthesiologist and anesthesia resident conduct the consultation via a video visit for 30 minutes. Consults include a verbal informed consent, a review of the goal of the visit, review of medications, and a full medical and anesthetic history with a brief examination of airway anatomy. The details of the anesthetic visit are seen in our document of best practices and workflow and given to each practitioner as a consult checklist before each telemedicine consultation (Supplemental Digital Content, Figure 1, http://links.lww.com/AA/D195).

Telemedicine Platform

During the period of this study, UCLA Health transitioned through 2 telemedicine platforms. From August 1, 2017 to June 8, 2018, PEPC telemedicine consultations were conducted via Zoom (Zoom Video Communications Inc, San Jose, CA). Zoom offers a Health Insurance Portability and Accountability Act (HIPAA) compliant platform with point-to-point encryption for video conferencing that was approved by our Office of Compliance Services for patient privacy through a Business Associate Agreement with the UC System. The PEPC scheduler confirms the appointment with the patient and then sends an individual meeting link directly to the patient via e-mail. Each link is unique to the individual meeting to ensure patient privacy. This platform was useful to start our initiative because it offered basic video conferencing tools and a stable login portal for both patients and clinicians. However, 1 difficulty with Zoom as a platform includes the inability to easily use photo capture to embed airway photos into the telemedicine assessment documentation. Additionally, appointments need to be made via patient e-mail rather than within the EMR. From June 8, 2018, UCLA Health transitioned to a video visit tool from Vidyo (Vidyo, Inc, Hackensack, NJ) that practices and health systems can license and integrate within Epic and use directly within the EMR system. At the time of this study, UCLA maintained a contract of 25 Vidyo licenses. Subsequent to transitioning to Vidyo, PEPC administrative staff scheduled patients directly within the Epic scheduling software; anesthesiologists logged into the video visit from the EMR-based clinic schedule. Patients logged into the myUCLA Health patient portal via the Epic MyChart application (Epic Systems Corporation, Verona, WI) on their smartphone or tablet. Their telemedicine appointment would be located within their appointments tab with a "Begin Visit" button allowing them to join directly in the app without any additional downloads. Due to the complexity of the website application for video visits, UCLA Health made an enterprise-wide operational decision to use a mobile-only option for patients as a way to optimize the user experience and avoid most technical problems. Within the video visit tool, an image capture tool was used to photograph the airway for the preanesthetic evaluation documentation for the day-of-surgery anesthesia care team. The interfaces for both patient and provider can be seen in Figure 2. Over the course of this study, these 2 different telemedicine platforms were implemented into our telemedicine program, and during the transition periods, there were a few technical failures.

Patient Satisfaction

To measure patient satisfaction, after completion of a telemedicine video visit, the UCLA Connected Health team issues each patient a patient experience survey via e-mail, as seen in Supplemental Digital Content, Figure 2, http://links.lww.com/AA/D195. Patients had the option to opt out of the experience survey. Eleven questions in 5-point Likert scale format are included in the survey, including a section for a free-text comment about the experience with the providers and the technological platform. Survey questions include items on interactions with the telemedicine team, technical ease of use, patient satisfaction, and future interest in telemedicine services. All responses are included in this analysis.

Case Cancellation Rate Analysis

We retrospectively compared the case cancellation rate of our telemedicine cohort to the current standard in-person clinic cohort. We extracted the total cases seen in the PEPC clinic using a digital extraction method from UCLA's DataMart[16] between January 1, 2017 and October 31, 2019. The total scheduled telemedicine and in-person visits were N = 419 and N = 1785, respectively. Case cancellations were tabulated if surgical cases were canceled on the day of surgery within 1 year of a presurgical anesthesia visit. Therefore, multiple surgical cases were possible for the same patient, thus accounting for 645 surgical cases among the telemedicine cohort and 3006 cases within the in-person cohort.

Calculation of Patient Cost Savings

We examined cost savings from the perspective of the surgical patient. In a metropolitan area, patients experience cost savings from both transportation to our clinic as well as time-based savings. The total direct cost to the patient included the total fuel cost, parking cost, and time-based savings (Supplemental Digital Content, Figure 3, http://links.lww.com/AA/D195). We used the median values for fuel costs and fuel economy among California vehicles ($3.36[17] and 24.90[18] mi/gal, respectively). Day parking at UCLA is $12. We

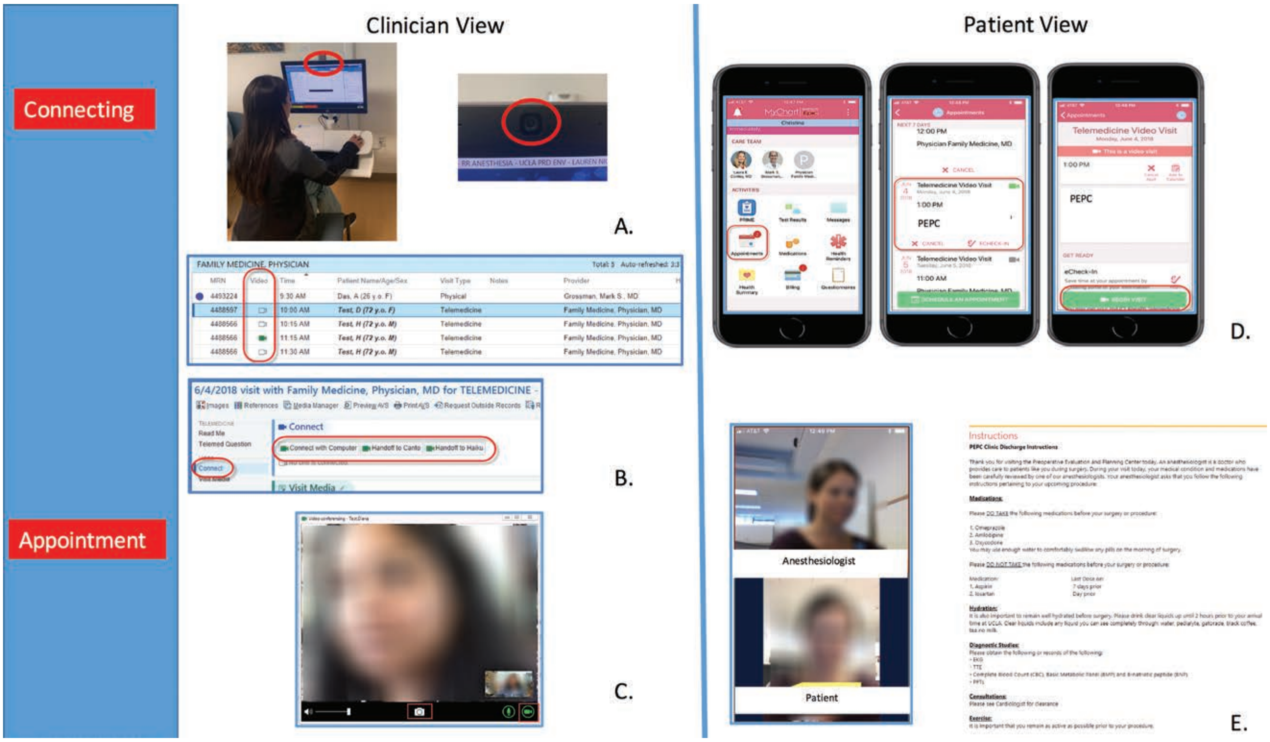

Figure 2. IT infrastructure. A, The computer console with the provider and video camera (left) on the upper panel of the computer monitor (right). B, Epic display that shows when the patient is active and ready for a telemedicine visit and is waiting for their provider to log into the encounter. The provider can connect either via the desktop computer monitor or from their mobile smartphone. C, The telemedicine encounter utilizes a window to display the patient with a smaller image to show the provider(s). D, The display from Epic smartphone mobile app so that patients can identify their video visit time and provider. E, The smartphone video encounter utilizes the phone's cameras to display both patient and provider on the single screen. The patient can obtain the after-visit recommendations within their phone directly from their anesthesia provider. ©Epic Systems Corporation. Used with permission.

conducted sensitivity analyses by varying the fuel cost ($3.15–4.00/gal), the median round trip distance (5–200 miles), and the fuel economy (15–60 MPG) to help characterize the range of total costs. The time-based savings were calculated by measuring the travel time from each subject's originating zip code to the UCLA PEPC clinic using Google Maps' Distance Matrix API (Google, Mountain View, CA). The methods were used and reported in previous literature involving telemedicine.[19] In our patient cohort, 14 zip codes were not entered into the EMR; hence, our time savings analysis was based on 405 subjects. We estimated the travel time with traffic by assuming morning telemedicine encounters occurring at 10 AM and afternoon encounters beginning at 1 PM. We used the median hourly wage in California ($20.40[20]) to calculate time-based savings for traveling to UCLA and conducted sensitivity analyses by varying originating distance and hourly wage to estimate the time-based savings of the subject cohort.

Statistical Analyses

Patient characteristics and study variables were summarized between the telemedicine and in-person cohorts using mean (standard deviation [SD]) or frequency (%) unless otherwise noted.

RESULTS

Demographics

In a 2-year period, we conducted N = 419 telemedicine preoperative consultations and N = 1785 in-person consults. On average, the population who used the UCLA PEPC telemedicine program was predominantly Caucasian and younger. Patient demographic characteristics are presented in Table 1.

Patient Satisfaction Data

Out of 419 patients evaluated by telemedicine, 131 (31%) of the patients completed the patient experience survey, 11 patients (3%) opted out from taking the survey, and 277 patients (66%) did not complete the survey. The majority of patients who responded to the survey (>90%) either agreed or strongly agreed with statements regarding what to expect from the video visit, confidence heading into it, clarity of video, meeting patient needs, overall satisfaction, and having more in the future (Table 2). Fewer patients (83% agree or strongly agree) found the technical process of joining to be easy, although still a clear majority. We present the results of the patient experience survey in Table 2.

Table 1. Demographic Characteristics of Patients Who Had a Telemedicine Encounter for a PEPC Video Visit Between August 2017 and October 2019 (Mean and 95% Confidence Intervals, Median, and Interquartile Range)

Variables	Telemedicine (N = 419)	In-Person (N = 1785)
Age		
Mean	56.1 (15.8)	61.1 (15.7)
Median	57 (45–68)	64 (51–73)
Sex		
Male	160 (38.2%)	699 (39.2%)
Female	259 (61.8%)	1086 (60.8%)
Race		
Native American	1 (0.2%)	9 (0.5%)
Asian	20 (4.8%)	153 (8.6%)
African American	28 (6.7%)	163 (9.1%)
Declined	4 (1.0%)	29 (1.6%)
LatinX	41 (9.8%)	301 (16.9%)
Other	48 (11.5%)	272 (15.2%)
Pacific Islander	0 (0.0%)	7 (0.4%)
Unknown	2 (0.5%)	9 (0.5%)
Caucasian	275 (65.6%)	842 (47.2%)
ASA physical status		
I	8 (1.9%)	21 (1.2%)
II	149 (35.6%)	484 (27.1%)
III	170 (40.6%)	885 (49.6%)
IV	16 (3.8%)	76 (4.3%)
Null	76 (18.1%)	319 (17.9%)

Abbreviations: ASA, American Society of Anesthesiologists; PEPC, preoperative evaluation and planning center.

Case Cancellation Rate Outcomes

Day-of-surgery case cancellations among evaluated patients occurred in 19 patients (2.96%) in the telemedicine cohort and 97 patients (3.23%) in the in-person cohort.

Travel Distance and Time Saved

The median round trip travel distance saved among telemedicine patients, as calculated from the patients' home zip codes to the UCLA PEPC Clinic, was estimated as 63 miles (Q1 24.7; Q3 119). When travel time and traffic conditions were factored, an estimated median of 137 minutes for a morning appointment (Q1 95; Q3 195) and 130 minutes for an afternoon appointment (Q1 91; Q3 237) based on traffic conditions were observed respectively. Figure 3 presents the geographical distribution of patients who participated in a telemedicine video visit with the PEPC clinic.

Patient Cost Savings With Telemedicine

The median round trip driving distance for patients in California who underwent a PEPC telemedicine visit was 63 miles. Direct savings per patient was estimated at $20 per visit (Q1 $15; Q3 $28). We conducted several sensitivity analyses and varied the round trip driving distance, fuel economy, and fuel prices per gallon. Savings for the patient ranged from $12 to $44 when round trip distances were 200 miles (Supplemental Digital Content, Figures 4–5, http://links.lww.com/AA/D195). The time-based savings based on initial assumptions was $46 (Q1 $32; Q3 $66). Sensitivity analyses were conducted to reflect the value of a telemedicine encounter based on wage (Supplemental Digital Content, Figure 6, http://links.lww.com/AA/D195). Therefore, the estimated median savings by using telemedicine for preoperative evaluation totaled $67 (Q1 $47; Q3 $94).

DISCUSSION

This retrospective study represents the largest published case series of telemedicine for preoperative evaluation in a metropolitan, urban, health system. Whereas we used telemedicine in place of in-person visits, in a comparable study, Mullen-Fortino et al[14] used telemedicine consultations in series and in conjunction with in-person consultation. Additionally, we discuss issues related to patient savings, satisfaction, and cancellation.

Patient Satisfaction

Similarly to other studies,[9,12,13] patients rated telemedicine consultations favorably. Mullen-Fortino et al[14] showed that 97.5% of patients preferred telemedicine-based applications for anesthesia presurgical evaluation. Of the 131 respondents, 129 of 131 participants (98%) "agreed" or "strongly agreed" that they were satisfied with a video preoperative consultation, with 120 of 131 patients (92%) reporting that they "agreed" or "strongly agreed" that they preferred these visits in the future. That said, 12 of 131 patients (9%) either "disagreed" or "strongly disagreed" that the technological link process was easy. Compared to other health centers with EMR-based video visits,[14] our group did not have a telemedicine coordinator review the download, login, or connection quality. Lack of an organized orientation program for patients may explain some patient dissatisfaction, particularly among our older demographic.

Case Cancellation Rate

Without a full physical examination, case cancellations or case delays are of concern in telemedicine consultations. We found the case cancellation rate among evaluated patients was similar between our telemedicine cohort (n = 19 patients, 2.96% case cancellation rate) and in-person cohort (n = 97 patients, 3.25% cancellation rate). Although our in-person cohort had a slightly higher American Society of Anesthesiologists (ASA) physical status, the results of our data demonstrate that, despite a limited physical examination, we can successfully use telemedicine on ASA physical status of I–IV patients without increasing case cancellation, as similarly reported at other institutions.[9,12,13]

Table 2. UCLA Health Telemedicine Patient Satisfaction Survey Results (n = 131/419 [31%] Patients)

Survey Question	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
The care team adequately explained what to expect during my video visit session	55	37	7	2	1
I felt confident in meeting with my provider via video visit	63	31	5	1	1
The technical process of joining the video visit was easy	50	33	8	5	5
I could clearly see and hear my provider during the video visit session	63	29	6	2	1
The video visit met my expectation for the needs of my appointment	67	30	2	1	1
Overall, I was satisfied with my video visit	70	28	1	1	1
Given the option, I would choose to have other appointments via video visit in the future	63	28	7	2	0

Abbreviation: UCLA, University of California, Los Angeles.

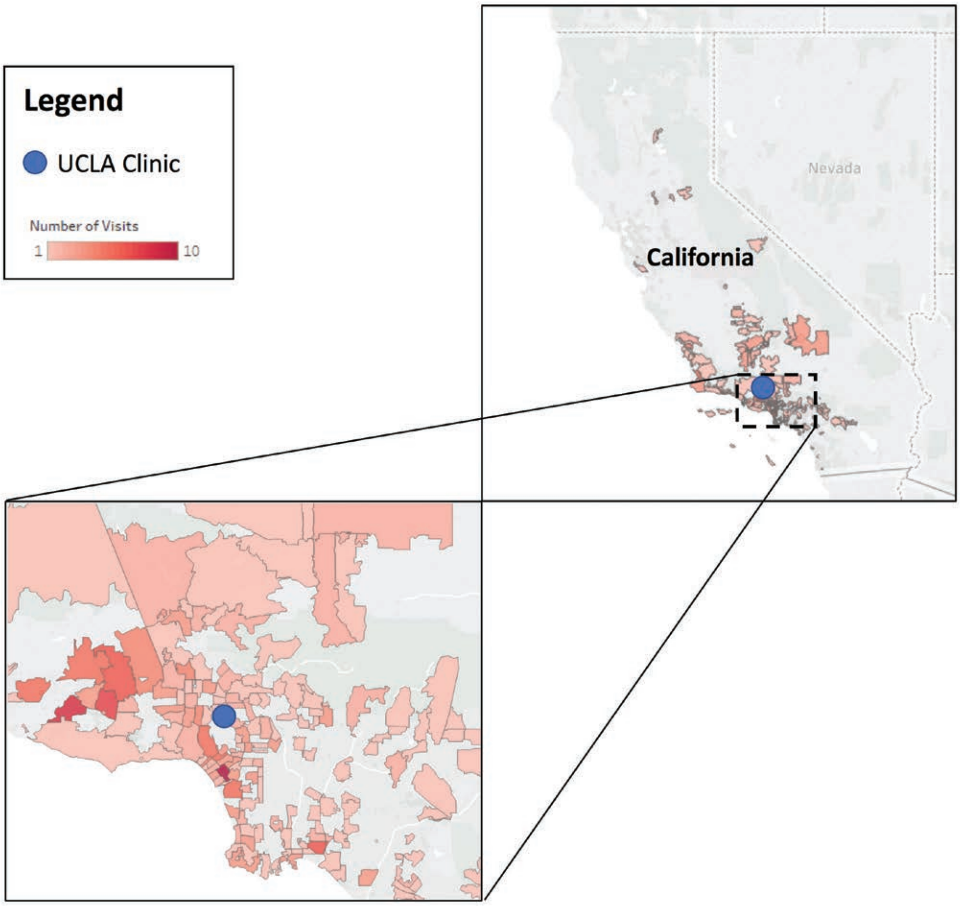

Figure 3. Geographical distribution of patients who had a UCLA Health PEPC telemedicine encounter. PEPC indicates preoperative evaluation and planning center; UCLA, University of California, Los Angeles.

Patient Savings

Telemedicine patients experienced direct savings in fuel and parking at the university campus. We conducted sensitivity analyses by varying fuel costs, distance, and fuel economy. Our results show that patients directly saved a median of $20. This savings becomes greater as driving distance increases. The time-based savings adds significant value to patients distant from the main consultation area, those on high-traffic routes, and those who experience opportunity costs from missed work. We provide a hypothetical clinical vignette demonstrating the cost savings for an individual patient (Figure 4). Reflecting a median wage of $20, the time-based opportunity savings is $46, bringing the total savings to greater than $65 per patient—greater than $43 previously published.[22] While studies from management consulting firms show time savings value scales particularly when the patient's socioeconomic status is high,[23] we found some savings across all socioeconomic statuses. Within the free-text feedback in the patient experience survey, participants rated eliminating transport highly. However, our analysis was limited, neglecting the unemployed, full-time students, retired, etc, who may reflect a $0/h opportunity cost. Future studies should investigate the consumer value and willingness to pay for telemedicine.

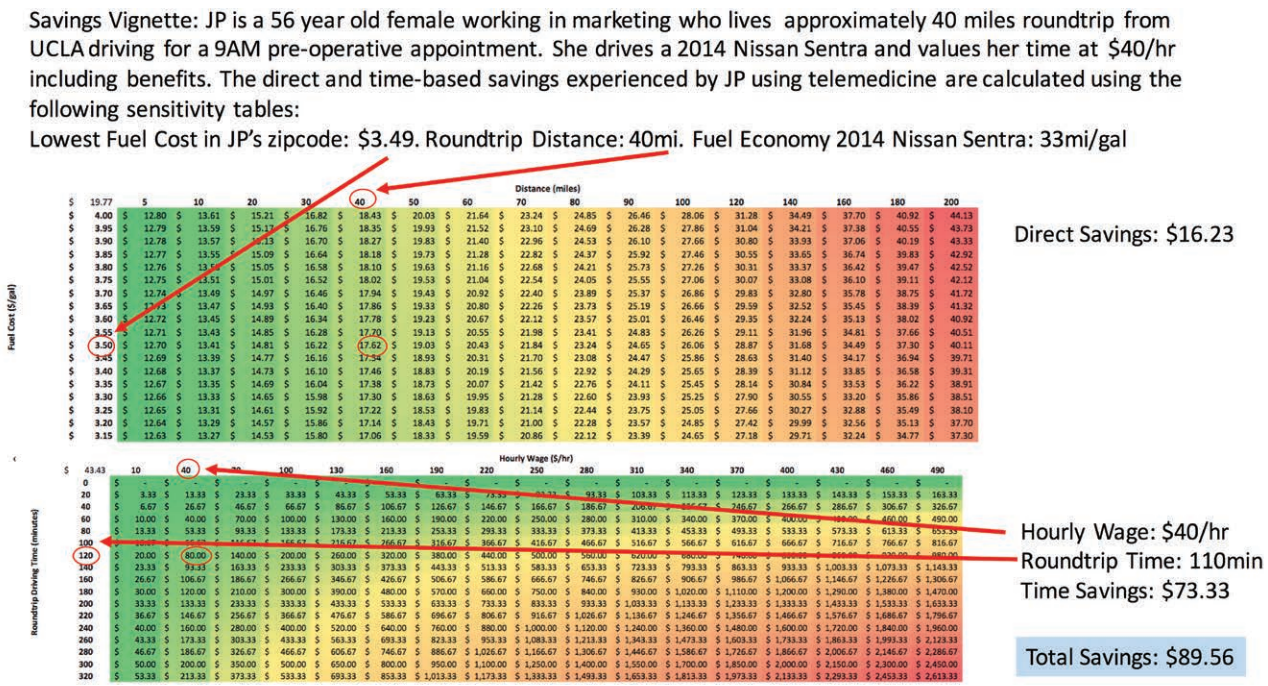

Figure 4. Savings vignette from a hypothetical patient to show readers how to navigate the sensitivity analyses presented in Table 3. UCLA indicates University of California, Los Angeles.

Geography

As a referral center in Southern California, UCLA Health treats patients inside and outside the metropolitan area; for residents of Los Angeles County, traveling short distances can take significant time due to traffic. Figure 3 shows the geographical reach of patients who received a telemedicine preoperative consultation. While some patients were in Northern California and the Central Valley, a vast majority of patients within neighboring counties to UCLA opted for a telemedicine visit. Because Los Angeles has high traffic congestion,[24] patients significantly value time saved with video visits from home or work. Compared to other studies conducting telemedicine consultations with patients in rural areas, our data show that there is high demand for telemedicine preoperative consultations even within metropolitan areas over shorter distances.

Organizational Learning and Telemedicine Best Practices

Our case series of 419 telemedicine preoperative consultations gave our group insight into telemedicine best practices. Our PEPC Clinic keeps a best practices checklist within each room where telemedicine consults occur (Supplemental Digital Content, Figure 1, http://links.lww.com/AA/D195), outlining necessary communication points about telemedicine consent, limited physical examination, and necessity to capture still airway images for EHR documentation. The largest participants in telemedicine emerge from a younger demographic accustomed to "on-demand" services. Therefore, we aimed for punctual telemedicine consults. To facilitate patient satisfaction and workflow of our in-person anesthesiology clinic, telemedicine encounters were kept to 30 minutes.

Future Challenges

Telemedicine among anesthesiologists is nascent; thus, many questions remain unanswered and many challenges remain. From a financial perspective, telemedicine reimbursement remains regulated on a state-by-state basis; individual state health plans have individual stipulations for reimbursement, and these regulations need to be understood by anesthesiology departments in their respective state of practice. While, typically, Medicare does not reimburse for telemedicine visits, Congress lifted those provisions for the COVID-19 pandemic. We hope the telemedicine parity laws within 30 states, mandating commercial insurance companies to reimburse services for telemedicine visits, will expand nationwide. These policies are evolving, and we expect more US states and commercial insurers will provide reimbursement for telemedicine services, broadening the use of telemedicine for outpatient encounters. At UCLA, PEPC telemedicine visits were bundled within the surgical diagnosis-related group (DRG) both to aid both adoption of telemedicine visits before the day of surgery and as a value-add to preoperative optimization.

Limitations

This study has several limitations. First, this is a retrospective, nonrandomized implementation study for telemedicine preoperative consultation. Although we present cancellation results in telemedicine and in-person consultation workflow, we did not randomize the patient population to test if telemedicine consultations were noninferior to in-person consultation and do not make direct statistical comparison. Rather, this study demonstrated feasibility of telemedicine implementation in opposition to a brick and mortar preanesthesia evaluation center. Second, we did not make statistical comparisons between the in-person and telemedicine cohorts to compare demographic and case cancellation data, which would require controls for confounding bias. Finally, our patient satisfaction scores were measured only in the telemedicine group and our technological platform changed from Zoom to an Epic-bundled product midway during our retrospective analysis. Therefore, change in satisfaction could have resulted from the change in platform itself. However, we did not see a significant change in satisfaction scores before and after a change to our platform.

CONCLUSIONS

This study examines a 419 patient case series of telemedicine for preoperative consultation in patients across surgical service lines in a large, tertiary, metropolitan health center. We describe telemedicine implementation among ASA physical status of I–IV patients as the cornerstone of our preoperative evaluation enterprise at our academic medical center, low levels of case cancellations or delays, and high patient satisfaction with the technology and platform. We show direct patient savings from transportation costs and illustrate that larger savings could be realized due to opportunity cost savings. Our article illustrates that anesthesiologists can use telemedicine safely, efficiently, and with high patient satisfaction with savings benefits within metropolitan areas where patients may be geographically near but temporally far from health care institutions. We conclude that the UCLA PEPC telemedicine program may be an effective and appropriate substitute for face-to-face PEPC visits in an urban metropolitan area, and our experience illustrates that anesthesiologists can use telemedicine as a capstone technology and platform with which to interact and consult with patients in the perioperative environment. Implementation of telemedicine in anesthesia practices across the United States should be further explored, and the impact on departmental revenue should be quantified.

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DISCLOSURES

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Contribution: This author created the study and helped author the primary manuscript.
Conflicts of Interest: Dr Kamdar is a seed preferred shareholder and medical advisor to HAI Solutions LLC and a medical advisor to Heartcloud Inc.
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Contribution: This author collected the data, conducted data analyses, and helped author the primary manuscript.
Conflicts of Interest: None.
Name: Laleh Jalilian, MD.
Contribution: This author helped write and review the final manuscript.
Conflicts of Interest: None.
Name: William Thi, BS.
Contribution: This author helped collect and analyze data for the manuscript.
Conflicts of Interest: None.
Name: Victor Duval, MD.
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Contribution: This author helped collect the data for the manuscript.
Conflicts of Interest: None.
Name: Lindsay Brooker, MPP.
Contribution: This author helped maintain the technical infrastructure of the program and write and edit the final manuscript.
Conflicts of Interest: None.
Name: Tristan Grogan, MS.
Contribution: This author helped conduct all the statistical analyses and write the methodological sections of the manuscript.
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Name: Anne Lin, MD.
Contribution: This author implemented the infrastructure for the study and reviewed the final manuscript.
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Name: Maxime Cannesson, MD, PhD.
Contribution: This author helped write and review the final manuscript.
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Clinical Investigation

CLINICAL INVESTIGATION

Association of preoperative anaesthesia consultation prior to elective noncardiac surgery with patient and health system outcomes: a population-based study

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☆The study protocol was developed and published in the Open Science Framework registry (https://osf.io/8r23d/).

Abstract

Background: Surgical volumes and use of preoperative anaesthesia consultations are increasing. However, contemporary data estimating the association between preoperative anaesthesia consultation and patient (days alive and at home [DAH_{30}], mortality) and system (costs, length of stay, and readmissions) outcomes are not available.

Methods: We conducted a population-based comparative effectiveness study using linked health administrative data among patients aged ≥40 yr who underwent intermediate-risk to high-risk elective, inpatient, noncardiac surgery in Ontario, Canada (2009–17). Our primary outcome was DAH_{30}. Secondary outcomes included DAH_{90}, 30-day and 1-yr mortality, 30-day health system costs, length of index admission, and 30-day readmissions. Propensity score overlap weights were used to adjust for confounders. Prespecified effect modifier analyses focused on high-risk subgroups.

Results: Among 364 149 patients, 274 365 (75.3%) received a preoperative anaesthesia consultation. No adjusted association was found (22.5 days *vs* 22.5 days; adjusted ratio of means 1.00, 95% CI 1.00–1.00) between consultation and DAH_{30} in the full population. We identified significant effect modification (significantly more DAH_{30}) among patients with ischaemic heart disease, ASA physical status ≥4, frailty index score ≥0.21, and who underwent vascular surgery. Secondary outcomes were associated with preoperative consultation, including greater DAH_{90}, decreased length of stay, lower 30-day and 1-yr mortality, and reduced 30-day costs.

Conclusions: Preoperative anaesthesia consultation was not associated with greater DAH_{30} across the overall study population. However, important potential benefits were observed among high-risk subgroups. Research is needed to identify optimal patient populations and consultation processes.

Keywords: epidemiology; economics; patient-centred outcomes; preoperative assessment; propensity score

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Editor's key points

- Previous studies demonstrate increasing use of preoperative anaesthesia consultation in response to greater demand for surgical services and complexity of perioperative populations. However, the patient benefits of this approach remain unclear.
- In a population-based cohort of patients having elective major noncardiac surgery, anaesthesia consultations were not associated with more days alive and at home within 30 days of surgery. However, for high-risk patients, potential patient and health system benefits were observed.
- Further research is needed to define the patient groups who most benefit from preoperative anaesthesia consultation, and the health system impacts of this approach.

Worldwide, more than 300 million surgeries occur annually. The majority are performed on a scheduled (also referred to as elective) basis.[1] After scheduled surgery, serious complication rates are 10–20%.[2] Among those who experience a complication, the risk of subsequent mortality is doubled and resource use is substantially increased (up to $100 000 increase in costs).[3–5] One approach to reducing adverse postoperative events is to ensure that patients' risk profiles are understood and optimised before surgery. Preoperative anaesthesia consultations could support such an approach through clinical and diagnostic assessment of patients' health status to guide personalised perioperative optimisation, resulting in reduced healthcare resource use and improved patient outcomes postoperatively.[6,7] In some settings, their utilisation has doubled over the past 15 yr.[8]

Despite the increasing use of preoperative anaesthesia consultation,[8,9] the effectiveness of anaesthesia consultations in improving patient- and system-relevant outcomes remains uncertain. A systematic review of prospective observational studies, along with a population-based comparative effectiveness study of encounters prior to 2005, demonstrate an association between preoperative consultation and reduced hospital length of stay (typically 0.5–1 day).[9,10] Consultations may also act to improve resource use and patient flow by avoiding day-of-surgery cancellations, which are reportedly reduced in those who receive a consultation.[10] However, the association between preoperative anaesthesia consultation and costs appears mixed.[11–13] Available data do not support a substantive impact on postoperative mortality,[9] while patient-centred outcome data are lacking.

As demand for surgical services grows from an increasingly complex perioperative population,[14,15] clinicians and health system leaders require a contemporary understanding of what preoperative interventions may improve outcomes, while also considering the value added by such interventions. These data may justify the economic costs of establishing preoperative anaesthesia clinics and the transfer of anaesthetists away from the operating room. Concurrently, a greater focus on patient-centred outcomes is required to ensure that interventions' impacts are understood in a patient-oriented manner. Therefore, our objective was to perform a population-based comparative effectiveness study to estimate the association between preoperative anaesthesia consultation and patient-centred outcomes (days alive and at home, 30-day and 1-yr mortality) and perioperative healthcare resource utilisation (costs, length of stay, and readmissions) for adults who underwent intermediate-to high-risk, elective, inpatient, noncardiac surgery. We further aimed to describe recent trends in rates of preoperative anaesthesia consultations over time.

Methods

Design, setting, and protocol

We conducted a population-based cohort study using linked health administrative data from the Canadian province of Ontario (approximately 15 million people). Findings were reported in accordance with the STROBE and RECORD statements.[16] The study protocol was developed and published *a priori* in the Open Science Framework registry (https://osf.io/8r23d/). Protocol amendments are described in Supplementary Appendix 1.

Data sources

Ontario residents are provided universal health insurance for hospital and physician services. Health administrative data are collected and stored in a standardised fashion at ICES, an independent research institute. We developed our analytic data set using the following databases: Discharge Abstract Database (DAD; surgeries, present on admission diagnoses, in-hospital resource use); the Registered Persons Database (RDPB; demographic data and non-hospital deaths); the Ontario Drug Benefit Database (ODB; outpatient prescription drugs for people aged ≥65 yr); the National Ambulatory Care Reporting System (NACRS; emergency room [ER] visits); Ontario Health Insurance Plan (OHIP; all physician service claims, baseline healthcare utilisation); Continuing Care Reporting System (CCRS; complex and continuing care); and Home Care Database (HCD; home-based healthcare receipt). Given that the data set was derived from data that are routinely collected and anonymised, Ontario's Personal Health Information Privacy Legislation exempted this study from research ethics board review.

Cohort

We identified all Ontario residents aged ≥40 yr who underwent elective, inpatient surgery between 2009 and 2017 (meaning that 1-yr follow up data were captured up to 2018). Eligible surgeries were intermediate-to high-risk procedures that can be accurately identified, and whose processes and outcomes have been previously evaluated: vascular (aortic surgery, major peripheral vascular, carotid endarterectomy), orthopaedic (hip and knee replacement), general (large bowel, liver, pancreaticoduodenectomy), urologic (cystectomy, nephrectomy), and thoracic (lung and oesophageal resection) surgeries were included.[9,17,18] All had an elective admission status to exclude emergency surgeries. A patient-level data set was constructed by including only the first qualifying surgery for any individual in the study period.

Patient and public involvement

Our research did not formally involve patients or the public in the study design, conduct, or reporting.

Exposure

Our primary exposure was the receipt of a preoperative anaesthesia consultation in the 60 days preceding surgery, which is a previously described time interval for consultation.[9,19] We identified those who had a preoperative anaesthesia consultation using validated OHIP physician billing codes specific to the provision of non-inpatient anaesthesia consultation (A015) by a specialist physician anaesthetist. Physician billing codes in Ontario, where anaesthetists are paid in a fee for service model, are highly accurate (88–95% inter-rater agreement) and have been used previously for research purposes.[20] Although fee for service billing in Ontario is standardised, the clinical process of anaesthesia consultation (e.g. who requires a consultation, what processes are conducted during a consultation) is not standardised across the province, but instead tends to vary at each hospital.

Covariates

As the association of preoperative anaesthesia consultations and outcomes are likely subject to indication and confounding biases, we collected variables that we postulated were associated with the receipt of a preoperative anaesthesia consultation and outcome. These included age, sex, year of surgery, hospital type, neighbourhood income quintile (a marker of socioeconomic status), surgery type (based on the full procedural code), all Elixhauser comorbidities (using a 3-yr lookback),[21] American Society of Anesthesiologists (ASA) physical status score, a validated frailty index,[22] receipt of concurrent preoperative medical consultation within 60 days of surgery,[23] and invasive haemodynamic monitoring.

Outcomes

Our primary outcome was days alive at home in the 30 days after surgery (DAH_{30}), a validated and patient-centred measure that combines the effects of complications and other adverse events, acute hospitalisation, non-home discharge, institutionalisation, readmissions, and mortality. This outcome has an established minimally important difference of 3 days and was calculated by subtracting the total number of days in an acute care hospital, rehabilitation, or long-term care facility from the number of days an individual survived in the 30 days after surgery.[24,25] Secondary outcomes included days alive at home in the 90 days after surgery (DAH_{90}), total health system costs (calculated using a validated patient-level costing algorithm that accounts for direct and indirect costs, as well as resource intensity weights from the perspective of the provincial health insurer, from 60 days preceding surgery to end of follow-up window),[26] 30-day and 1-yr mortality, 30-day readmission rates, and index hospitalisation length of stay. We identified baseline preventative healthcare utilisation within 2 yr of surgery (screening mammogram and colon cancer screening [faecal occult blood testing and colonoscopy]) to assess whether potential unmeasured confounding variables were likely to exist related to health behaviours.

Analysis

All analyses used Stata (Stata Corporation, College Station, TX, USA). Descriptive data were compared between exposed and unexposed groups using absolute standardised differences, with values >0.1 suggesting substantive differences.[27] Trends in anaesthesia consultations by year were calculated as proportions by year with corresponding 95% confidence intervals. A linear test for trend was estimated.

The unadjusted and adjusted associations between receipt of a preoperative anaesthesia consultation and outcomes were estimated. Adjustment for postulated confounders was accomplished using propensity score (PS) overlap weights.[28] First, a PS for receipt of a preoperative anaesthesia consultation was calculated using logistic regression with all listed covariates included as predictors (see Supplementary Appendix 2 for parametrisation of each variable); clustering by hospital was accounted for using a fixed effect for each centre in estimating the PS. The PS model was iteratively refined to ensure that all standardised differences were ≤0.1. Next, overlap weights were applied (1-PS for exposed; PS for unexposed) in regression analyses using generalised linear regression models appropriate for each outcome type (negative binomial for days alive at home, log-gamma for costs and length of stay, logistic for binary outcomes) to estimate adjusted relative effect sizes. We further calculated E-values, which is a form of quantitative bias analysis that estimates the effect size of a potential unmeasured confounder that would be needed to attenuate our estimated effect to the null (Supplementary Appendix 3).[29]

Sample size and missing data

Assuming a mean number of days alive at home of 24 (SD 4), a sample size of 86 was required to identify a minimally important difference of 3 days using a two-sided Wilcoxon test; a 1-day difference required 712.[25] As our approach also required a stable multivariable regression model, with log-transformation of the dependent variable and 30 parameters, a stable model with an explained variance (Cox-Snell R^2) of 0.2 required 1119 participants.[30] Being a population-based study, we included all eligible participants, meaning that we had adequate power for our planned analyses. A prespecified approach to missing data was included in our protocol. As exposure and outcome data were complete, we proceeded with a complete case analysis (income quintile data were missing for 0.2% of the study population; therefore, our complete case analysis included 99.8% of included participants). A sensitivity analysis centrally imputing missing income quintile to assess any possible impact on results was conducted. Although the analyses were prespecified, we did not apply any formal adjustment for multiple testing. Therefore, the significance of our results, especially for secondary analyses, should be interpreted cautiously and will require verification in future, purpose-designed studies.[31]

Sensitivity and effect modifier analyses

To test the robustness of our primary analyses, we re-ran our primary analysis using a multilevel regression framework to control for measured confounders and random intercepts to account for clustering by hospital. We further investigated possible unmeasured differences in health behaviours at baseline by comparing adjusted rates of cancer screening between exposure groups in the 2 yr preceding surgery.

To estimate whether certain characteristics might act as effect modifiers in the anaesthesia consultation–outcome association, we tested for effect modification between exposure and primary outcome by introducing a multiplicative interaction term between our exposure variable and the following postulated effect modifiers (separate, adjusted models for each effect modifier): ischaemic heart disease (IHD; see Supplementary Appendix 4 for diagnostic and procedure codes),[21] ASA physical status (≤2; 3; ≥4), frailty index score (<0.21 *vs* ≥0.21),[22] and surgery type. These variables were chosen *a priori* as they are well-established risk factors for adverse postoperative outcomes and are core constructs used to risk stratify patients and inform process selection prior to surgery.

Processes of care analyses

Given that preoperative consultation was expected to impact rates of diagnostic testing, we also identified processes of care within 60 days of surgery (pulmonary function testing, chest radiography, coronary angiogram, transthoracic echocardiogram [TTE], cardiac stress testing, and coronary revascularisation).[19] Unadjusted and adjusted associations between anaesthesia consultation and receipt of preoperative diagnostic tests and procedures were estimated.

Results

Among 364 149 patients included in the study, 274 365 (75.3%) received a preoperative anaesthesia consultation. Rates increased from 70.3% to 78.2% between 2009 and 2017 (mean increase per year 0.9%; ratio of means [RoM] 1.01, 95% CI 1.01–1.01) (Fig. 1). We included 364 149 (99.8%) of eligible participants in the primary analyses as they had complete data (Table 1). Patients who received a consultation were older, lived with greater frailty, had higher ASA physical status, had more comorbidities, and were more likely to have received a preoperative general internal medicine consultation. Abdominal aortic aneurysm (AAA) repair and pneumonectomy/lobectomy were more common among those who received a consultation, whereas large bowel resection was more common among those who did not. The distribution of consultations varied substantially across hospital types.

Primary outcome

On an unadjusted basis, the mean number of DAH_{30} was lower among patients who received a preoperative anaesthesia consultation than those who did not (22.4 days *vs* 22.9 days; unadjusted RoM 0.98, 95% CI 0.98–0.98; Supplementary Appendix 5). After adjustment for postulated confounders, receipt of consultation was not associated with a difference in mean DAH_{30} (22.5 days *vs* 22.5 days; adjusted RoM 1.00, 95% CI 1.00–1.00; Table 2).

Secondary outcomes

Prior to adjustment, patients who received a consultation experienced fewer DAH_{90} and shorter hospital length of stay; 1-yr mortality, 30-day readmission rates, and 30-day health system costs were higher in the consultation group (see Supplementary Appendix 5 for the unadjusted effect estimates). Following PS overlap weighted adjustment, receipt of preoperative anaesthesia consultation was associated with a significant increase in mean DAH_{90} (80.5 days *vs* 79.9 days; adjusted RoM 1.01, 95% CI 1.01–1.01). Preoperative consultation was also associated with a significantly reduced odds of 30-day (adjusted OR 0.85, 95% CI 0.75–0.95) and 1-yr (adjusted OR 0.86, 95% CI 0.82–0.90) mortality, as well as a reduced length of stay (5.3 days *vs* 5.9 days; adjusted RoM 0.90, 95% CI 0.89–0.92) and mean 30-day health system costs ($16 803 *vs* $16 962; adjusted RoM 0.99, 95% CI 0.98–0.997). Consultation status was not associated with a significant difference in 30-day readmission rates (adjusted OR 1.01, 95% CI 0.97–1.05; Table 2). E-values for the primary and secondary outcomes can be found in Supplementary Appendix 3.

Processes of care

Unadjusted ORs for process of care measures can be found in Supplementary Appendix 6. In the adjusted analyses, preoperative anaesthesia consultation was associated with higher rates of preoperative TTE (adjusted OR 1.14, 95% CI 1.10–1.17), cardiac stress testing (adjusted OR 1.19, 95% CI 1.14–1.24), pulmonary function testing (adjusted OR 1.28, 95% CI 1.22–1.34), and chest radiography (adjusted OR 1.51, 95% CI

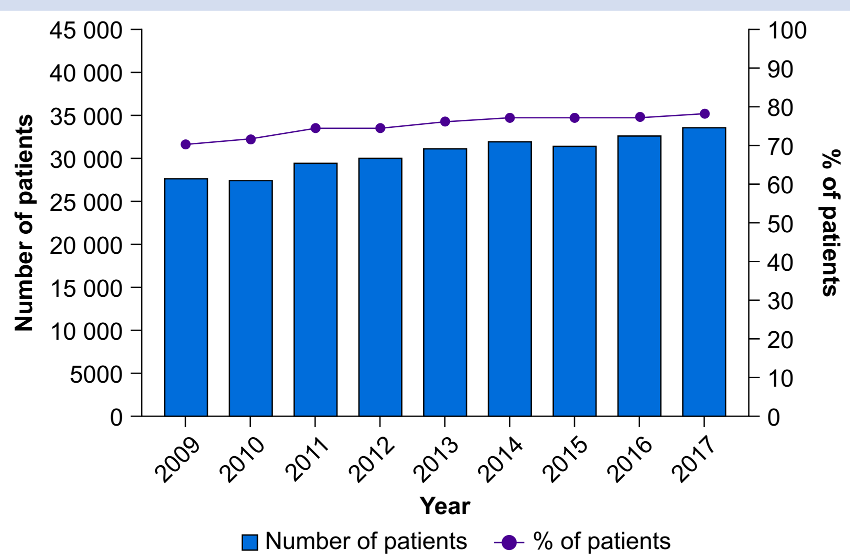

Fig 1. Annual trend of receipt of preoperative anaesthesia consultation.

Table 1 Unadjusted and propensity-weighted baseline cohort characteristics by preoperative anaesthesia consultation status. AAA, abdominal aortic aneurysm; ASA, American Society of Anesthesiologists; ASD, absolute standardised differences; SD, standard deviation. *All are *n* (%), unless otherwise indicated. †ASD >0.10 represent a substantive difference. ‡Medical consultations were within 60 days of surgery.

	Unadjusted cohort			Propensity-weighted cohort		
Baseline characteristics*	Preoperative anaesthesia consultation (*n*=274 365; 75.3%)	No preoperative anaesthesia consultation (*n*=89 784; 24.7%)	ASD†	Preoperative anaesthesia consultation (*n*=273 739; 75.4%)	No preoperative anaesthesia consultation (*n*=89 548; 24.6%)	ASD†
Age, mean (SD)	67 (10.4)	66 (10.8)	0.13	66 (10.7)	66 (10.9)	0
Male sex	130,246 (47.5)	42,682 (47.5)	0.00	181,320 (47.4)	70,250 (47.4)	0
ASA physical status						
2	59,717 (21.8)	33,658 (37.5)	0.35	82,950 (30.3)	27,135 (30.3)	0
3	166,006 (60.5)	46,698 (52.0)	0.17	152,484 (55.7)	49,882 (55.7)	0
4	48,236 (17.6)	9250 (10.3)	0.21	37,661 (13.8)	12,320 (13.8)	0
5	406 (0.1)	178 (0.2)	0.01	644 (0.2)	211 (0.2)	0
Frailty index score, mean (SD)	0.14 (0.06)	0.13 (0.06)	0.18	0.13 (0.06)	0.13 (0.06)	0
Income quintile						
1 (lowest)	49,087 (17.9)	15,822 (17.6)	0.01	48,33 (17.8)	15,975 (17.8)	0
2	55,324 (20.2)	17,775 (19.8)	0.01	54,708 (20.0)	17,897 (20.0)	0
3	54,997 (20.1)	18,487 (20.6)	0.01	55,294 (20.2)	18,088 (20.2)	0
4	55,573 (20.3)	18,680 (20.8)	0.01	56,194 (20.5)	18,383 (20.5)	0
5 (highest)	58,758 (21.4)	18,784 (20.9)	0.01	58,709 (21.5)	19,206 (21.5)	0
Hospital type						
Teaching	98,900 (36.1)	28,494 (31.7)	0.09	107,565 (39.3)	35,188 (39.3)	0
High-volume non-teaching	42,801 (15.6)	34,228 (38.1)	0.53	61,698 (22.5)	29,183 (22.5)	0
Mid-volume non-teaching	62,539 (22.8)	14,621 (16.3)	0.16	51,729 (18.9)	16,922 (18.9)	0
Low-volume non-teaching	70,125 (25.6)	12,441 (13.9)	0.30	52,747 (19.3)	17,255 (19.3)	0
Surgery type						
AAA repair	8886 (3.2)	1104 (1.2)	0.14	5616 (2.1)	1837 (2.1)	0
Carotid endarterectomy	5381 (2.0)	1180 (1.3)	0.05	5702 (2.1)	1865 (2.1)	0
Peripheral vascular bypass	9041 (3.3)	2107 (2.4)	0.06	9305 (3.4)	3044 (3.4)	0
Total hip replacement	64,391 (23.5)	20,384 (22.7)	0.02	62,280 (22.8)	20,374 (22.8)	0
Total knee replacement	112,280 (40.9)	36,121 (40.2)	0.01	104,668 (38.2)	34,240 (38.2)	0
Large bowel resection	36,760 (13.4)	21,304 (23.7)	0.27	54,429 (19.9)	17,805 (19.9)	0
Gastrectomy or esophagectomy	5932 (2.2)	1322 (1.5)	0.05	5363 (2.0)	1754 (2.0)	0
Liver resection	3224 (1.2)	619 (0.7)	0.05	2895 (1.1)	947 (1.1)	0
Whipple procedure	2358 (0.9)	347 (0.4)	0.06	1761 (0.6)	576 (0.6)	0
Nephrectomy	12,808 (4.7)	3812 (4.2)	0.02	14,493 (5.3)	4741 (5.3)	0
Cystectomy	3496 (1.3)	524 (0.6)	0.07	2345 (0.9)	767 (0.9)	0
Pneumonectomy or lobectomy	9808 (3.6)	960 (1.1)	0.17	4882 (1.8)	1597 (1.8)	0
Comorbidities						
Coronary artery disease	31,515 (11.5)	7236 (8.1)	0.12	24,893 (9.1)	8143 (9.1)	0
Congestive heart failure	6977 (2.5)	1811 (2.0)	0.04	6276 (2.3)	2053 (2.3)	0
Cerebrovascular disease	4493 (1.6)	1140 (1.3)	0.03	4427 (1.6)	1448 (1.6)	0
Hypertension	87,272 (31.8)	20,941 (23.3)	0.19	75,021 (27.4)	24,541 (27.4)	0
Diabetes mellitus	53,688 (19.6)	14,168 (15.8)	0.10	46,397 (17.0)	15,178 (17.0)	0
Pulmonary disease	16,382 (6.0)	3857 (4.3)	0.08	13,797 (5.0)	4513 (5.0)	0
Dialysis or renal disease	3340 (1.2)	866 (1.0)	0.02	3319 (1.2)	1086 (1.2)	0
Malignant disease	66,624 (24.3)	21,740 (24.2)	0.00	69,265 (25.3)	22,659 (25.3)	0
Medical consultation‡						
General internal medicine	69,807 (25.4)	14,581 (16.2)	0.23	46,840 (17.1)	15,323 (17.1)	0
Cardiology	15,537 (5.7)	4896 (5.5)	0.01	15,541 (5.7)	5084 (5.7)	0
Intraoperative monitoring						
Arterial line	72,740 (26.5)	15,179 (16.9)	0.23	63,716 (23.3)	20,843 (23.3)	0
Central venous line	17,920 (6.5)	3024 (3.4)	0.15	13,394 (4.9)	4382 (4.9)	0
Pulmonary artery catheter	551 (0.2)	178 (0.2)	0.00	707 (0.3)	231 (0.3)	0

1.49–1.54) in the 60 days preceding surgery. Conversely, consultation was associated with lower rates of preoperative coronary angiogram (adjusted OR 0.60, 95% CI 0.53–0.68) and coronary revascularisation (adjusted OR 0.54, 95% CI 0.42–0.69) (Table 3).

Unadjusted and adjusted associations for baseline preventative healthcare screening tests can be found in Supplementary Appendix 7. Preoperative anaesthesia consultation was associated with increased rates of mammography (adjusted OR 1.04, 95% CI 1.01–1.06) but not colon cancer screening (adjusted OR 1.02, 95% CI 0.9996–1.04).

Sensitivity analyses

Using a multilevel regression model to adjust for confounders, we found an association between consultation and DAH_{30}

Table 2 Adjusted associations of preoperative anaesthesia consultation status with primary and secondary outcomes. CI, confidence interval; DAH_{30}, days alive at home in the 30 days after surgery; DAH_{90}, days alive at home in the 90 days after surgery; LOS, length of stay. *Event rate in the exposed arm (preoperative consultation) relative to the unexposed arm (no preoperative consultation). †Effect estimates adjusted for age, sex, year of surgery, hospital type, income quintile, surgery type, all Elixhauser comorbidities, ASA score, frailty index score, receipt of concurrent preoperative general internal medicine or cardiology consultation within 60 days of surgery, and intraoperative monitoring. ‡Adjusted effect estimate for DAH, length of stay, cost is a ratio of means (95% CI); for mortality, readmission is an odds ratio (95% CI). ¶Index hospitalisation LOS is presented in days. §Cost is presented in CAD $.

Outcomes	Preoperative anaesthesia consultation (*n*=273,739; 75.4%)	No preoperative anaesthesia consultation (*n*=89,548; 24.6%)	Adjusted effect estimates*,†,‡
Primary outcome			
DAH_{30}, mean (SD)	22.5 (6.3)	22.5 (6.7)	1.00 (1.00–1.00)
Secondary outcomes			
DAH_{90}, mean (SD)	80.5 (13.6)	79.9 (15.3)	1.01 (1.01–1.01)
30-day mortality, *n* (%)	1625.6 (0.6)	627.3 (0.7)	0.85 (0.75–0.95)
1-yr mortality, *n* (%)	8684.7 (3.2)	3235.6 (3.6)	0.86 (0.82–0.90)
30-day readmission, *n* (%)	14,778.9 (5.4)	4789.9 (5.3)	1.01 (0.97–1.05)
Index hospitalisation LOS, mean (SD)¶	5.3 (8.7)	5.9 (11.8)	0.90 (0.89–0.92)
30-day health system costs, mean (SD)§	$16,803 (11,704)	$16,962 (12,380)	0.99 (0.98–0.997)

(adjusted RoM 1.004, 95% CI 1.002–1.007). After imputation of missing income quintiles, we found no association between consultation and DAH_{30} (adjusted RoM 1.00, 95% CI 1.00–1.00) in the PS overlap weighted analysis. After re-running the primary analysis accounting for clustering in the outcome model using a random intercept for each hospital, we observed no association between consultation receipt and DAH_{30} (RoM 1.00, 95% CI 0.98–1.03).

Effect modifiers

Adjusting for confounders, we found significant interaction on the relative scale between preoperative anaesthesia consultation and IHD, procedure type, ASA score, and frailty index score (all $P<0.001$). As shown in Figure 2 and Supplementary Appendix 8, significantly greater days at home were present for individuals with IHD (adjusted RoM 1.02, 95% CI 1.01–1.04), vascular surgery procedures (adjusted RoM 1.05, 95% CI 1.04–1.06), an ASA score ≥4 (adjusted RoM 1.09, 95% CI 1.07–1.10), or a frailty score ≥0.21 (adjusted RoM 1.07, 95% CI 1.05–1.09).

Discussion

In this population-based comparative effectiveness study of 364 149 adults who underwent intermediate-to high-risk elective major noncardiac surgery, receipt of a preoperative anaesthesia consultation was not associated with a greater number of days alive at home in the 30 days after surgery in the full population. However, among patients with higher ASA physical status, cardiac risk, procedural risk, and frailty, we observed a significant increase in the number of days alive at home among those who received a consultation. Furthermore, anaesthesia consultations were associated with an adjusted reduction in length of stay, 30-day and 1-yr mortality, health system costs, and a small increase in the number of days alive at home over 90 days after surgery. These potential benefits, especially among higher-risk patients, in addition to lower costs of care, support the possible value of anaesthesia consultations before surgery. As an observational study, our findings highlight the need for further prospective evaluation in randomised trials to identify optimal target populations and consultation processes.

Our population-based comparative effectiveness study should be interpreted based on its strengths and weaknesses. Strengths include protocol prespecification and use of a validated, patient-centred primary outcome that is impacted by multiple, prioritised clinical outcomes.[25] Although causal associations cannot be inferred from our observational analysis, measured confounders were adjusted for using PS overlap weights, and clustering by hospital was used to adjust for unmeasured between-centre differences. We also completed

Table 3 Adjusted processes of care measures. CI, confidence interval; OR, odds ratio. *All values are *n* (%). †Event rate in the exposed arm (preoperative consultation) relative to the unexposed arm (no preoperative consultation). ‡ORs were adjusted for age, sex, year of surgery, hospital type, income quintile, surgery type, all Elixhauser comorbidities, ASA score, frailty index score, receipt of concurrent preoperative general internal medicine or cardiology consultation within 60 days of surgery, and intraoperative monitoring.

Preoperative testing within 60 days of surgery*	Preoperative anaesthesia consultation (*n*=273,739; 75.4%)	No preoperative anaesthesia consultation (*n*=89,548; 24.6%)	Adjusted OR (95% CI)†,‡
Transthoracic echocardiogram	25,128 (9.2)	7316 (8.2)	1.14 (1.10–1.17)
Cardiac stress test	16,092 (5.9)	4468 (5.0)	1.19 (1.14–1.24)
Coronary angiogram	1107 (0.4)	600 (0.7)	0.60 (0.53–0.68)
Pulmonary function test	13,408 (4.9)	3467 (3.9)	1.28 (1.22–1.34)
Coronary revascularisation	273 (0.1)	166 (0.2)	0.54 (0.42–0.69)
Chest radiography	107,079 (39.1)	26,668 (29.8)	1.51 (1.49–1.54)

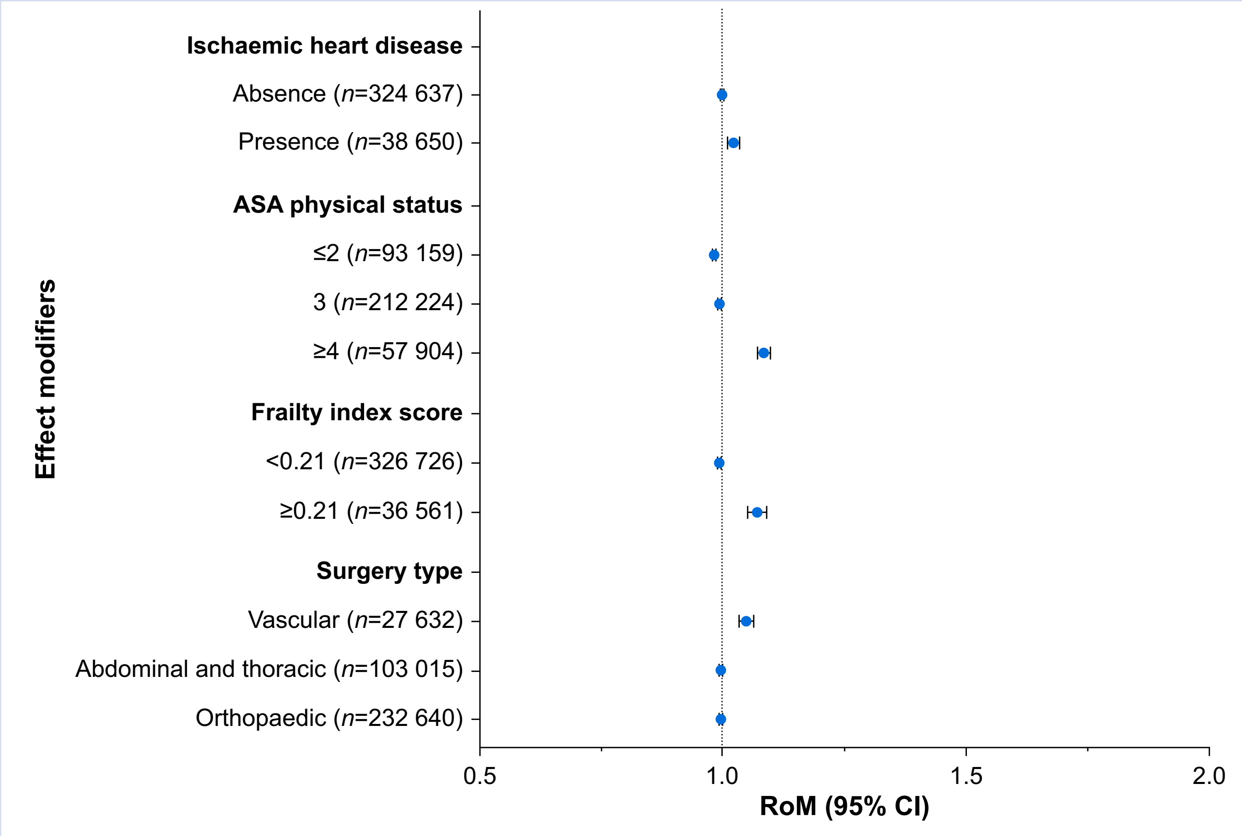

Fig 2. Effect modification analysis on the association of preoperative anaesthesia consultation status with days alive at home in the 30 days after surgery (DAH_{30}). Ratio of means (RoM; with 95% CI) to the right or left of the dotted line indicate significant association with receipt of consultation (significant increase in DAH_{30} to the right; significant decrease in DAH_{30} to the left). CI, confidence interval; RoM, ratio of means.

multiple sensitivity analyses that were either consistent with primary analyses or suggested a marginal, positive association for preoperative anaesthesia consultations.

Limitations were also present. First, the data were not collected for research purposes, which creates a potential for misclassification bias. Second, our results may not apply to populations outside of Ontario; however, Ontario has a diverse population, and various hospital types were included to improve generalisability. Third, unmeasured differences between exposure groups may have affected our results; analyses of E-values identified that missing confounders would require an association with mortality equivalent to an OR=1.3–1.5 to nullify mortality associations. Fourth, our binary evaluation of comorbidities may not capture disease severity (although we would expect this to have reduced the positive association of consultation as those who received consultation would be expected to have greater disease severity). Fifth, we were unable to estimate impacts on patient and system outcomes related to consultations resulting in patients choosing not to proceed to surgery or on surgeries cancelled after consultation. Sixth, although we assessed objective patient-centred outcomes, we could not capture use of care processes such as shared decision-making, or the association of consultations with patient-reported experience.

Preoperative anaesthesia consultations provide an opportunity for identification of perioperative risk factors, optimisation of health status, and planning for perioperative and anaesthetic care prior to surgery. Although use of anaesthesia consultations has increased significantly over time, including in our study, rigorous contemporary data evaluating their effectiveness on clinical outcomes are lacking.[8,9] As randomised trials comparing clinical outcomes with, versus without, preoperative anaesthesia consultations are not available, observational studies currently represent the highest level of evidence available to evaluate the possible effectiveness of anaesthesia consultations.

Similar to other observational studies,[9,10] we found a reduction in length of stay, approximately 0.6 days, which appears to be a stable association across time and different jurisdictions. Interestingly, this significant association with length of stay did not directly translate into greater number of days alive at home in the 30 days after surgery despite length of stay being estimated as the strongest mediator of days alive at home in existing evaluations.[32] The reasons for this divergence may be several fold and explained in part by our secondary and sensitivity analyses. First, we found consistent effect modification of the consultation days at home association by well-established risk factors known to increase the risk of postoperative morbidity, mortality, and resource use, such as vascular surgery, higher ASA scores, greater cardiac risk, and the presence of frailty.[22] This suggests that the benefit from anaesthesia consultations may be limited to individuals with greater perioperative risk, consistent with the expected causal pathway from consultation to improved outcomes. For individuals without substantive preoperative risk, consultation could lead to over-medicalisation and related possible harms.[33] Second, at 90 days after surgery, we did identify a statistically significant increase in the number of days alive at home across the adjusted populations. Therefore, it is possible that for higher-risk patients, who make up a relatively smaller proportion of the population and often have more complex discharge recovery trajectories (e.g. require longer hospitalisation and post-acute rehabilitative or nursing home care), a longer time window may be required for the strength of association to emerge in a manner detectable at a population level. At the individual level, this effect is likely not clinically meaningful, as estimated differences were all less than the 3 days currently understood to represent a minimally important difference.[24]

Our study revealed a significant adjusted reduction in 30-day risk of mortality that persisted up to 1 yr after surgery. These findings align with two single-centred studies,[12,34] although a previous population-based study in Ontario found no association between consultations and mortality.[9] This association with lower mortality also contrasts with findings in observational studies of preoperative internal medicine consultations, which report increased mortality among patients seen by medical specialists before surgery.[35] Although our finding, a secondary outcome in an observational study, must be cautiously appraised, possible explanations should be considered as the finding is contrary to what would be expected as a result of unmeasured confounding. Specifically, we would expect attenuation of the association between consultation and mortality to the null as higher-risk patients having higher-risk surgeries were more common in the anaesthesia consultation group. First, the observed association could be causal, resulting from assessment and optimisation initiated during the preoperative consultation and application of evidence-based care. Interestingly, although patients assessed by both anaesthetists and internists were provided more diagnostic evaluations, only in medical patients were invasive interventions (e.g. angiography), which carry greater risk of harm, more commonly initiated. Compared with internists, anaesthetists are also involved in perioperative care of all surgical patients, therefore, the continuity in care plans between preoperative consultation and in-hospital care may be more direct. Future research, including qualitative approaches, will be needed to identify the clinical processes that could mediate the associations identified in this study. Alternatively, one cannot rule out the presence of unmeasured health behaviours among patients who received a consultation that may lead to lower mortality, although our findings of limited correlation between receiving an anaesthesia consultation and cancer screening behaviours may make this explanation less likely.

Finally, further associations with small reductions in healthcare resource use should also be considered. Although anaesthesia consultations cost approximately $100 CAD in physician service payments, total perioperative health system costs were lower (adjusted mean reduction of $159) among those who received a consultation; these patients also underwent more preoperative testing. Although these per-patient savings are small relative to the cost of an episode of surgical care ($17,000/episode), the fact that patients who received a greater number of tests and assessments did not consume greater resource overall does suggest potential value from preoperative anaesthesia consultation. Based on approximately 40 000 surgeries conducted annually, potential savings to the healthcare system could amount to 6 million dollars per year. The decrease in cost may have resulted from a reduction in length of index admission, as observed in our study, or day-of-surgery cancellations, as reported in previous studies.[36,37]

Ultimately, ours and related studies all suffer from limitations inherent in observational research. Therefore, to determine the causal impact of preoperative anaesthesia consultations on patient and health system outcomes, data from randomised trials will be required. Based on our findings, future trials should likely evaluate the effectiveness of anaesthesia consultation among an enriched trial population comprising patients with well-established risk factors for adverse postoperative events (e.g. high-risk patients are those living with frailty, cardiovascular disease, or multimorbidity) preparing for higher-risk surgeries. Such trials will require innovative design considerations to support pragmatic and efficient estimation of a clinically meaningful effect estimate. For example, a trial designed to detect the mortality effect estimated in our study (OR=0.85) in a population with a control group mortality rate of 2% would require randomisation of more than 60 000 patients. Design considerations should include approaches to enrol participants most likely to derive benefit, such as adaptive designs that allow recruitment to focus on subgroups demonstrating the greatest benefit as the trial proceeds[38]; use of repeated measures capturing information-rich, patient-relevant ordinal recovery scales[39]; and registry linkage to support efficient collection of jurisdiction-wide, validated outcome measures.[40] Partnership with patients and health system leaders would also support meaningful knowledge translation from these required trials.

Conclusions

In this population-based comparative effectiveness study, preoperative anaesthesia consultation prior to intermediate-to high-risk elective, inpatient, noncardiac surgery was not associated with a greater number of days alive at home in the 30 days following surgery. However, specific high-risk subgroups, including individuals who were living with frailty, IHD, high ASA scores, or who underwent vascular surgery, experienced more number of days alive at home within 30 days after surgery. Additionally, preoperative consultation was associated with several benefits within the full study population, including an adjusted decreased hospital stay, risk of 30-day and 1-yr mortality, health system costs, and increased number of days alive at home in the 90 days after surgery. In the absence of randomised trials, these results support the potential use of preoperative anaesthesia consultation before intermediate-to high-risk elective surgery, particularly among high-risk patients. To further optimise patient outcomes and preoperative anaesthesia consultation use, future trials examining causal impacts by incorporating innovative designs to maximise efficiency and impacts will be required.

Authors' contributions

Conception: DIM
Study design: JSE, WB, DNW, SA, JL, SG, GLB, MML, AW, DIM
Data acquisition: WB, DIM
Data analysis: JSE, WB, DIM
Data interpretation: all authors

Drafting and revision of the manuscript: all authors
Approval of the final manuscript version: all authors

Declaration of interest

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Appendix A. Supplementary data

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