Author/s:
Ou-Young, J;Royse, C;Clarke-Errey, S;El-Ansary, D;Riedel, B;Griffiths, J;Bowyer, A

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RESEARCH ARTICLE

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Recovery trajectories after major abdominal surgery: A retrospective pooled cohort study

Jared Ou-Young[1,2] | Colin Royse[1,2,3] | Sandy Clarke-Errey[4] | Doa El-Ansary[1,5] | Bernhard Riedel[6,7] | James Griffiths[8,9] | Andrea Bowyer[1,2,3]

[1]Department of Surgery, University of Melbourne, Melbourne, Victoria, Australia

[2]Department of Anaesthesia and Pain Management, The Royal Melbourne Hospital, Parkville, Victoria, Australia

[3]Outcomes Research Consortium, Cleveland Clinic, Cleveland, Ohio, USA

[4]Statistical Consulting Centre, University of Melbourne, Melbourne, Victoria, Australia

[5]School of Health and Biomedical Sciences, RMIT University, Melbourne, Victoria, Australia

[6]Department of Anaesthesia, Perioperative Medicine, and Pain Medicine, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia

[7]The Sir Peter MacCallum Department of Oncology, Department of Critical Care, University of Melbourne, Melbourne, Victoria, Australia

[8]Department of Anaesthesia, Royal Women's Hospital, Parkville, Victoria, Australia

[9]Department of Pharmacology, University of Melbourne, Melbourne, Victoria, Australia

Correspondence
Jared Ou-Young, Level 6, Centre for Medical Research, Department of Surgery, University of Melbourne, Royal Melbourne Hospital, Parkville 3050, VIC, Australia.
Email: jared.ou-young@heartweb.com

Abstract

Background: Recovery from major surgery can be difficult to predict given the many factors involved in treating disease and restoring preoperative function. Postoperative recovery metrics such as length of stay, complications, and mortality are typically described. However, large data quantities for patient-reported recovery are scarce. In this retrospective study, we aimed to describe the multidimensional recovery trajectory of patients undergoing major abdominal surgery 4–8 weeks after surgery and explore factors related to incomplete overall recovery.

Methods: We retrospectively analysed pooled cohort data of adults undergoing elective major abdominal surgery between 2018 and 2024 across three tertiary-level hospitals. Recovery was measured at postoperative days 1, 3, 7, 14, weeks 4–8, and 3 months using the Postoperative Quality of Recovery Scale (PostopQRS). Physiological, nociceptive, emotive, activities of daily living (ADL), and cognitive domains were assessed, with recovery defined as a return to, or improvement of, preoperative baseline levels. Overall recovery was defined as recovery in all domains. Length of stay was assessed for patients who recovered overall, or did not recover, at postoperative weeks 4–8.

Results: Six hundred and fifty-three patients were included, with mean (SD) age of 57.8 (14.4) years. Of these, 36% were aged ≥65 years and 58% were male. The incidence of overall recovery at postoperative week 4–8 was 42%. Domain-level recovery at postoperative weeks 4–8 was 63% for nociception, 81% for emotion, 82% for ADLs, and 83% for cognition. Patients failing to achieve overall recovery at weeks 4–8 had longer mean (SD) lengths of stay compared to those who recovered (11.3 (10.3) vs. 7.3 (7.1) days, $p < .001$).

Conclusions: The incidence of overall recovery at postoperative week 4–8 was 42%. Patients with incomplete overall recovery had longer lengths of stay. Multidimensional strategies to improve the recovery trajectory warrant further investigation.

Poster presentation at the 2024 Australian and New Zealand College of Anaesthetists conference.

Editorial Comment: Major surgical procedures are often followed by a lengthy and difficult recovery period. Traditional measures such as mortality and complications are usually analysed, but this 653-patient study investigated patient-reported recovery scores after major abdominal surgery. Novel findings include that only 42% of patients have recovered fully in all recovery domains at weeks 4–8, and these patients also had longer hospital stays. Preoperative risk factors were analysed for associations with recovery trajectories.

KEYWORDS
major abdominal surgery, multidimensional recovery, quality of recovery, risk factor, trajectory

1 | INTRODUCTION

Poor recovery outcomes following major surgery are associated with reduced quality of life, increased complications, increased length of stay, mortality, and patient and provider costs. Yet, an individual patient's recovery trajectory from major surgery can be difficult to predict given the many factors and recovery domains involved in the restitution of preoperative function following the treatment of disease. The high burden of morbidity associated with postoperative complications has driven efforts to predict the patients at risk of poor outcomes.[1,2] Reported risk factors for increased postoperative morbidity and increased length of stay (LOS) include older age,[3–5] higher BMI,[3,6,7] higher ASA Score,[5,7] comorbid disease,[3,8] cognitive impairment,[9–11] anaesthetic strategy,[12] longer surgical duration,[9] and route of surgical access (open vs. laparoscopic).[13] Poor preoperative status and frailty associate with incomplete postoperative functional and emotional recovery.[14–16] However, established data for *patient-reported* multidimensional recovery after major surgery are less known, with a paucity of evidence for risk factors of multidimensional recovery.[17]

Routine multidimensional recovery assessments after major surgery are not regularly a standard component of clinical care pathways, with repeated assessments after the first postoperative day even rarer.[18–20] We established a Postoperative Quality of Recovery Registry in Melbourne, Australia, to gather patient-reported recovery outcomes at multiple timepoints after surgery (Australian Register of Clinical Registries, ACSQHC-ARCR-879). The Postoperative Quality of Recovery Scale (PostopQRS™, PostopQRS Ltd., London, United Kingdom) is a validated multidimensional recovery tool for assessing patient-reported recovery in a range of domains including physiological, nociception, emotion, activities of daily living, cognition, and overall recovery in all domains.[21] Importantly, it is a questionnaire tool that measures multidimensional recovery after surgery from the acute postoperative period to the longer-term (post-discharge) weeks and months after surgery. Compared to other recovery tools, the PostopQRS defines recovery as an individualised return to, or improvement of, preoperative status which is inherently important to the patient.[22,23] Hence, recovery is measured over time and individually assessed according to the patient's own preoperative baseline. The PostopQRS has, therefore, been used as a research outcome tool within the global literature across multiple surgical specialties and patient populations.[24–26]

This study's hypothesis was 'incomplete overall recovery after major abdominal surgery is common and is affected by multiple recovery domains in the first 4-8 postoperative weeks'. We, therefore, aimed to describe the multidimensional recovery trajectories of patients receiving major abdominal surgery at the overall, domain, and subdomain level within the first 4–8 postoperative weeks, as well as the impact of incomplete recovery at this timepoint on length of stay. We also conducted exploratory analyses on the association between preoperative health variables and risk of incomplete overall recovery at postoperative weeks 4–8, as well as a subanalysis of recovery outcomes for patients receiving open versus laparoscopic surgery. This study utilised recovery data from the PostopQRS Registry and supplementary data from prior PostopQRS research studies[25] (Supplementary Table S1).

2 | METHODS

2.1 | Study design

This was a secondary exploratory retrospective analysis of pooled data from the PostopQRS Registry and three existing datasets between 2018 and 2024. In all underlying studies, informed consent was obtained from participants. These data were pooled to ensure that there was the highest possible external validity of measuring recovery incidences utilising appropriately robust available study data for the studied population. A major abdominal surgery population was chosen to ensure that there was sufficient generalisability of the results. Whilst there was diversity in the type of abdominal surgery included, all included surgeries shared a common surgical inflammatory response which is a major determinant of postoperative recovery. This multi-centre study was conducted at the Royal Melbourne Hospital (RMH), Royal Women's Hospital, and the Peter MacCallum Cancer Centre, and received ethical approval (RMH Human Research Ethics Committee QA2022080, QA2023148). The study was reported according to the STROBE Statement for Strengthening the Reporting of Observational Studies in Epidemiology.[27]

2.2 | Setting and participant eligibility criteria

Participants from the underlying studies were included if they were adults who underwent major abdominal surgery at one of three tertiary hospitals. Major abdominal surgery types included colorectal, upper gastrointestinal, hepatopancreatobiliary, urological, or gynaecological procedures lasting ≥2 hours, consistent with a grade of ≥2 on the modified Johns Hopkins score[28] (moderate to highly invasive procedures with estimated blood loss ≥500 mL, moderate to critical risk to the patient independent of anaesthesia, and/or patients who may have a usual postoperative ICU stay with invasive monitoring). Participants were excluded if they did not speak English, were unable to complete the PostopQRS baseline assessment, or had severe intellectual disability. Patients from the underlying studies were included only if they received equivalence to standard of care (observational studies, randomised controlled trial control groups, or randomised controlled trial intervention groups where the intervention did not show a difference in recovery outcomes).

2.3 | Timepoints and assessment

Patients in the included studies completed the PostopQRS survey on admission to the hospital preoperatively (baseline), and then at several postoperative timepoints depending on specific study protocol. These timepoints included postoperative days 1, 3, 7, and 14, between weeks 4–8, and at 3 months. All included studies assessed recovery on postoperative days 1, 3, and weeks 4–8. Two studies did not assess recovery at 3 months, one study did not assess day 7 and another study did not assess day 14 (Supplementary Table S1). Assessments were completed face to face whilst in hospital, and via telephone once the patient was discharged.

2.3.1 | Definitions of recovery

The PostopQRS tool assesses recovery in five domains (and their subdomains): physiological (blood pressure, heart rate, respiratory rate, temperature, and oxygen saturation), nociceptive (pain and nausea), emotive (depression and anxiety), activities of daily living (ADL; ability to walk, stand, dress, and eat and drink), and cognition.[21] The PostopQRS assesses the subdomains of pain, nausea, depression, and anxiety on a five-point Likert scale, and the ability to walk, stand, dress, eat, and drink on a three-point Likert scale. Recovery in any of these subdomains was defined as a return to preoperative baseline scores, or better. For domain recovery to be achieved, all corresponding subdomains for that domain must have been scored as recovered. The cognitive domain comprises of five verbal cognitive tests (orientation, number recall forward, number recall backwards, word recall, and word generation). Cognitive recovery is achieved when scores on all five tests return to within a tolerance factor of the preoperative baseline score. Patients who initially scored below the tolerance level for any of these tests preoperatively were defined as having a *low cognitive baseline*. These patients are scored according to a modified criterion whereby they must recover in *at least* the same number of tests that were not below the tolerance level.[10] Patients with a low cognitive baseline preoperatively are cognitively assessed at the domain level, and normal cognitive baseline patients are cognitively assessed at both the domain and subdomain level.[10] For a patient to be deemed as recovered '*overall*' each domain must have been scored as recovered. The physiological domain was only measured on day 1 postoperative. The PostopQRS recovery assessments are principally designed to mimic the changing focus of recovery from acute physiologic parameters in the first postoperative days, to home-readiness, cognitive recovery, and return to previous or expected level of functioning.[21] In PostopQRS validation studies, >95% of patients had recovered in the physiological domain after 24 h, making its discriminant utility after 24 h poor. The PostopQRS standard reporting therefore includes physiological assessments up to 24 h postoperative but can include multiple immediate timepoints within this period. Once the physiological domain is no longer tested, it is removed from the scoring of overall recovery. Therefore, for our study, overall recovery assessments did not include the physiological domain after day 1. The PostopQRS baseline assessment is included in Supplementary Figure S1.

2.4 | Outcomes

The primary outcome of this study was to report recovery trajectories at the overall, domain- and subdomain-level at 4–8 weeks postoperative, as well as the proportion of recovered patients at several other timepoints. Secondary outcomes included evaluating group differences for total length of stay (LOS; including hospital and hospital-in-the-home admissions) for patients who recovered overall at 4–8 weeks after surgery versus those who did not. Further exploratory outcomes included identifying risk factors for incomplete overall recovery at 4–8 weeks postoperative, and group differences in recovery for patients receiving open versus laparoscopic surgery.

2.5 | Statistical analysis and data collection

The data from the underlying studies were cleaned, filtered according to the inclusion criteria, and aggregated. All data were analysed using R (R version 4.3.2, R Core Team 2023). In the case of missing data for incidence of recovery at a given timepoint, only complete cases were used for that timepoint.

2.6 | Sample size calculations

The sample size calculation was performed prior to data collection and focused on the total sample size across all studies. Given that multidimensional PostopQRS recovery incidences for this population are unknown, the sample size was based on an expected proportion of 0.5 of overall recovery at 4–8 weeks postoperative. The accuracy of an estimated proportion depends on the value of the proportion itself, with a proportion of 0.5 resulting in the largest standard deviation, therefore making it the most conservative choice when the proportion is unknown.[29] The *samplingbook* package on R was used to calculate a minimum sample size of $n = 385$ based on a 95% confidence interval with precision ± 0.05 without finite population correction, and the most conservative possible expected proportion of 0.5.

2.7 | Primary outcome

Overall, domain and subdomain recovery were classified as binary outcomes (recovered vs. not recovered) and were reported as proportion (%) recovered.

2.8 | Secondary outcomes

2.8.1 | LOS for patients with incomplete overall recovery at 4–8 weeks

Exploratory analyses exploring the relationship between LOS between patients who did not recover overall at 4–8 weeks, compared to those who did, were censored at 8 weeks postoperative. LOS was tested for skewness using the Shapiro–Wilk test. Non-normally distributed data were log-transformed and group differences assessed using the independent sample Student *t*-test. Differences in secondary demographic data were not compared to avoid type I errors.

2.9 | Exploratory outcomes

2.9.1 | Risk factors of incomplete overall recovery at 4–8 weeks

Potential risk factors were analysed using a multivariate logistic regression model to assess the association between all variables and incomplete overall recovery at postoperative weeks 4–8. Each variable was adjusted for all other variables. All outcome estimates were reported as odds ratios [95% confidence intervals].

Variable selection was based on current risk factors reported in the literature and available data. Nineteen variables were included: age ≥ 65 years, sex, ASA score ≥3, cancer diagnosis, anaesthetic duration ≥4 h, open surgery, not working due to ill health, current/ex-smoker, BMI ≥30 kg/m^2, completed secondary education, alcohol consumption ≥10 units/week, low cognitive baseline measured preoperatively, preoperative pain classified as moderate or worse, preoperative nausea classified as moderate or worse, preoperative anxiety or nervousness classified as moderate or worse, preoperative depression or sadness classified as moderate or worse, preoperative difficulty walking, standing or dressing. The measurements of preoperative cognitive baseline, pain, nausea, anxiety, sadness, and difficulty walking, standing, or dressing were assessed using the PostopQRS.

2.9.2 | Recovery outcomes associated with open versus laparoscopic surgery

A second exploratory subanalysis was conducted post hoc due to the high prediction value observed for open surgery on incomplete overall recovery at 4–8 weeks postoperative. Correlational analyses with the data from patients in the open surgery group and each domain and subdomain were conducted to investigate the constituents of incomplete recovery. Significant findings in domains and subdomains in group comparisons were further explored and reported. Descriptive statistics for recovery incidence and odds ratios with 95% confidence intervals were reported. To reduce potential type I error, the criterion for significance for this second exploratory analysis was defined as $p < .001$. The raw patient-reported scores for affected subdomains at postoperative weeks 4–8 were also reported.

3 | RESULTS

3.1 | Patients

Of 875 patients assessed for eligibility in the primary studies conducted between 2018 and 2024, 222 were excluded due to not having major abdominal surgery. Hence, 653 patients were included for analysis of the primary outcome (Figure 1). The characteristics of the included studies are described in Supplementary Table S1. Demographic and clinical characteristics of the entire cohort are described in Table 1. The mean (SD) age was 57.8 (14.4) years with 58% male and 48% of the cohort receiving surgery for a cancer-related diagnosis. 66% of the procedures were colorectal, hepatobiliary, or upper gastrointestinal, and 39% of the surgeries were open procedures. The mean (SD) anaesthetic duration was 313.6 (171.2) minutes.

3.2 | Primary outcome

3.2.1 | Recovery trajectories after major abdominal surgery

The follow-up rate for each postoperative timepoint was as follows: day 1; 635 out of 653 (97%); day 3; 582 out of 653 (89%); day 7, 510 out of 572 (89%); day 14; 298 out of 354 (84%); 4–8 weeks, 566 out of 653 (87%); 3 months, 227 out of 273 (83%).

The incidence of overall recovery for the entire cohort was 6%, 12%, 20%, 37%, 42%, and 60% for postoperative days 1, 3, 7, 14, weeks 4–8, and month 3, respectively (Figure 2A). The incidence of recovery for each domain at 4–8 weeks postoperative was 63% for nociception, 81% for emotion, 82% for ADLs, and 83% for cognition (Figure 2C–F).

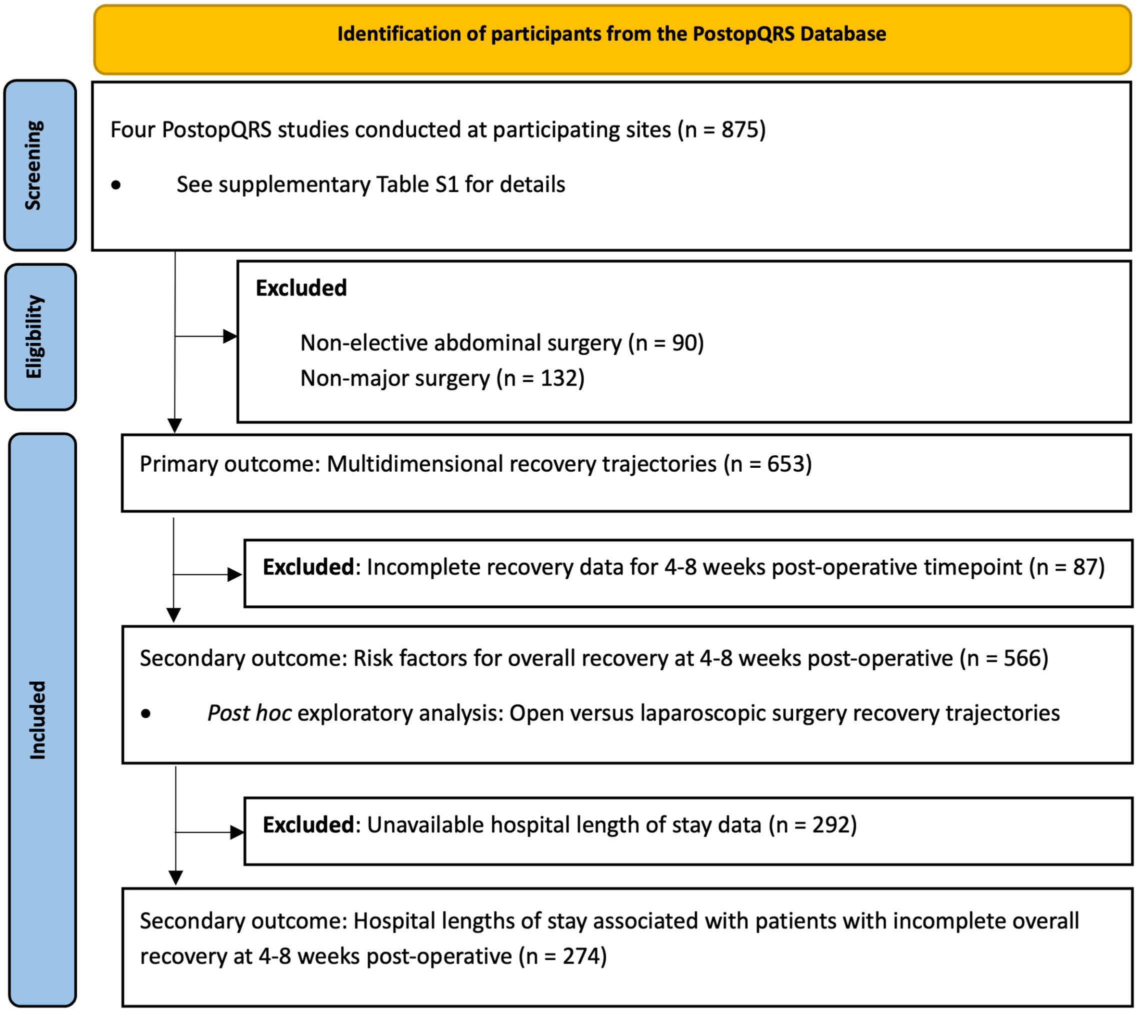

FIGURE 1 STROBE participant flow diagram for included patients that received major abdominal surgery. PostopQRS, Postoperative Quality of Recovery Scale; STROBE, strengthening the reporting of observational studies in epidemiology.

Recovery trajectories for each of the subdomains are illustrated in Figure 3. Regarding the nociceptive subdomains, the proportion of patients who recovered from pain was lower at alltime points compared to nausea recovery. At 4–8 weeks postoperative, 70% of patients recovered from pain, and 89% recovered from nausea.

Regarding the emotive subdomains, the proportion of patients who recovered from sadness and depression was slightly lower at all-time points compared to recovery from anxiety and nervousness and followed a similar recovery trajectory. At 4–8 weeks postoperative, 84% of patients recovered from sadness and depression, and 91% recovered from anxiety and nervousness.

Regarding the ADL subdomains, the ability to independently eat and drink recovered fastest, and the ability to independently dress recovered slowest, compared to other ADLs in the first two postoperative weeks. At 4–8 weeks postoperative, 92% of patients recovered the ability to independently stand, 90% recovered in their ability to independently walk, 95% recovered the ability to eat and drink, and 90% recovered in their ability to dress independently.

Regarding the cognitive subdomains for normal baseline patients, number recall backwards, word recall, and word generation were the slowest subdomains to recover over time, compared to orientation and number recall forwards which were recovered by over 95% of patients by day 3 postoperative. At 4–8 weeks postoperative, 99% of patients recovered in orientation, 98% recovered in number recall forwards, 92% recovered in number recall backwards, 95% recovered in word recall, and 91% recovered in word generation.

3.3 | Secondary outcomes

3.3.1 | Relationship between failed overall recovery and LOS

LOS data were available for 274 patients treated at all three sites within the PostopQRS Registry. Patients that failed to recover overall at postoperative weeks 4–8 had longer mean (SD) lengths of stay

TABLE 1 Characteristics and preoperative data of patients receiving elective major abdominal surgery.

Characteristic	Patients ($n = 653$)
Demographics	
Age; mean (SD), years	57.8 (14.4)
≥65, No. (%)	253 (36)
BMI; mean (SD), kg/m^2	28.3 (6.1)
≥30, No. (%)	184 (33)
Sex; No. (%), male	380 (58)
ASA score ≥3, No. (%)	275 (42)
Cancer, No. (%)	315 (48)
Education; mean (SD), years	13.0 (4.0)
Completed secondary education, No. (%)	420 (64)
Alcohol consumption; mean (SD), units/per week	4.0 (8.3)
Current or ex-smoker, No. (%)	328 (50)
Currently employed, No. (%)	302 (46)
Not employed due to ill-health, No. (%)	67 (10)
Operative data	
Surgical access	
Open, No. (%)	256 (39)
Laparoscopic, No. (%)	232 (36)
Robotic assisted, No. (%)	165 (25)
Surgical specialty	
Colorectal, hepatobiliary, or upper gastrointestinal, No. (%)	431 (66)
Gynaecological, No. (%)	61 (9)
Urological, No. (%)	161 (25)
Anaesthetic technique	
General anaesthesia only, No. (%)	447 (68)
General anaesthesia and spinal anaesthesia, No. (%)	153 (23)
General anaesthesia and epidural anaesthesia, No. (%)	42 (6)
General anaesthesia and regional block, No. (%)	11 (2)
Duration of anaesthesia; mean (SD), minutes	313.6 (171.9)
≥4 h, No. (%)	367 (56)
Baseline (preoperative) PostopQRS scores	
Nociception	
Pain score ≥3/5 (moderate pain or worse), No. (%)	56 (9)
Nausea score ≥3/5 (moderate nausea or worse), No. (%)	20 (3)
Emotion	
Sadness/depression score ≥3/5 (moderate sadness or worse), No. (%)	72 (11)
Anxiety/nervousness score ≥3/5 (moderate anxiety or worse), No. (%)	192 (29)
Activities of daily living	
Difficulty standing, No. (%)	37 (6)
Difficulty walking, No. (%)	50 (8)
Difficulty eating and drinking, No. (%)	25 (4)
Difficulty dressing, No. (%)	33 (5)
Cognition	
Low cognitive baseline score, No. (%)	82 (13)

Note: Values are mean (SD) or number (proportion).
Abbreviations: ASA, American Society of Anesthesiologists physical status score; BMI, body mass index; No., number; PostopQRS, Postoperative Quality of Recovery Scale; SD, standard deviation.

compared to those that did recover (11.3 (10.3) vs. 7.3 (7.1) days, $p < .001$) (Figure 4).

3.4 | Exploratory outcomes

3.4.1 | Risk factors for incomplete overall recovery

Three hundred and twenty-eight patients out of 566 had incomplete overall recovery at 4–8 weeks postoperative (58%). Patient characteristics between overall recovered and non-recovered groups are shown in Supplementary Table S2. A forest plot of risk factors associated with incomplete overall recovery at this timepoint is shown in Figure 5. Open surgery (OR 1.99 [1.33, 2.98], $p = .001$) was the most significant predictor of failed recovery at 4–8 weeks postoperative.

3.4.2 | Recovery outcomes at 4–8 weeks postoperative associated with open versus laparoscopic surgery

When further investigating the constituents of incomplete overall recovery at 4–8 weeks postoperative in the open surgery group, significant group differences were observed in the nociceptive domain (open surgery 51% recovered vs. laparoscopic 72% recovered, OR 0.31 [0.20, 0.49], p <.001) and ADL domain (open surgery 69% recovered vs. laparoscopic 90% recovered, OR 0.15 [0.08, 0.28], p <.001). No significant differences were seen in the emotive and cognitive domains (Supplementary Figure S2).

When drilling down to the subdomains for nociception, pain was the most significant factor (OR 0.40 [0.25, 0.64], p <.001) of incomplete nociceptive recovery at postoperative week 4–8 as compared to nausea (OR 0.39 [0.22, 0.71], $p = .002$) (Supplementary Figure S3). At this timepoint, 20% of patients receiving open surgery had moderate pain or worse, and 8% had moderate or worse nausea (Supplementary Figure S4).

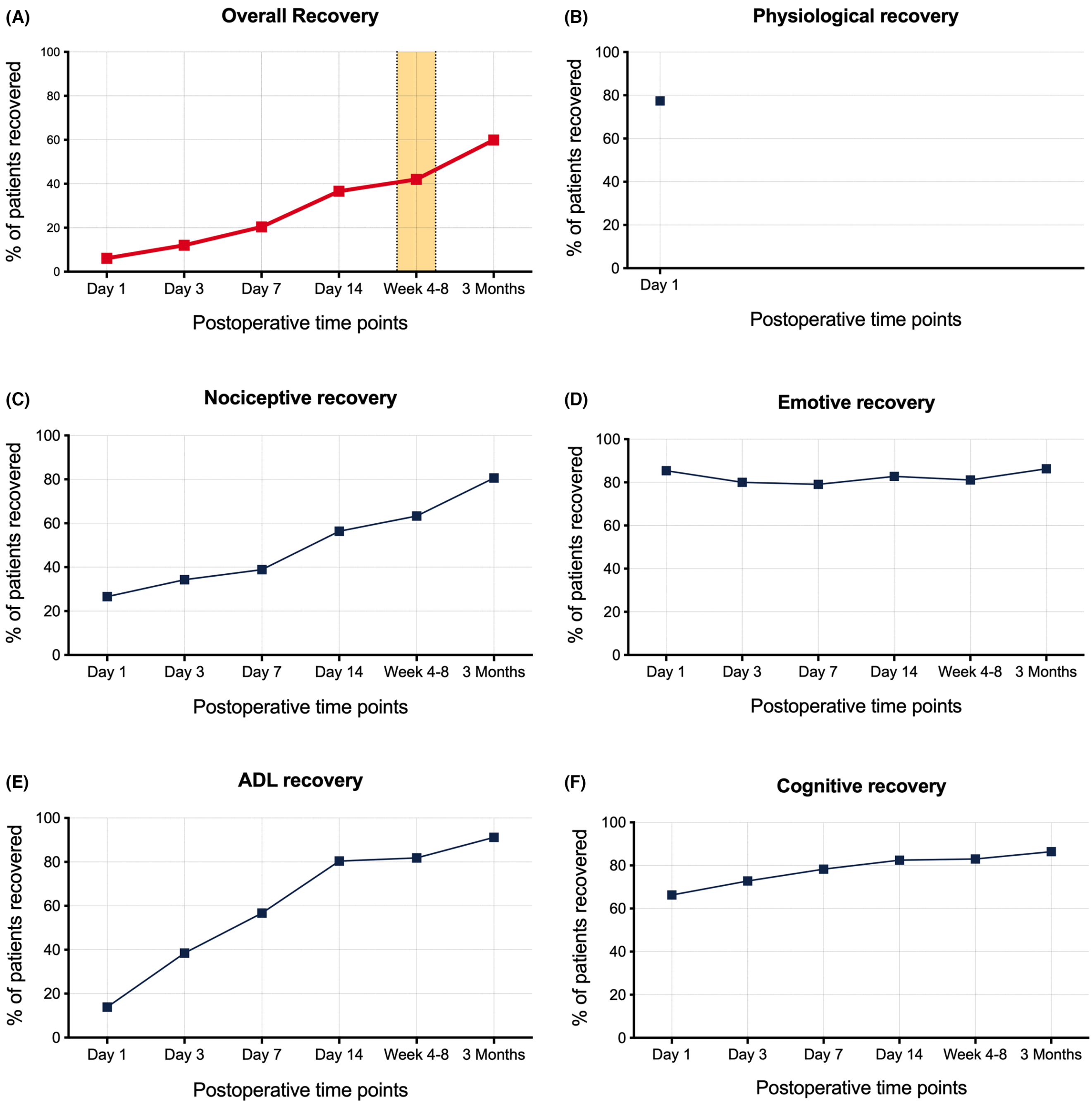

FIGURE 2 Incidences of overall and domain-level recovery in patients receiving elective major abdominal surgery ($n = 653$). Recovery was assessed using the Postoperative Quality of Recovery Scale (PostopQRS). (A) recovery in *all* domains, (B) recovery in the physiological domain at day 1 (vital signs and physical observations), (C) recovery in the nociceptive domain (pain and nausea), (D) recovery in the emotive domain (sadness/depression and anxiety/ nervousness), (E) recovery in the activities of daily living (ADL) domain, (F) recovery in the cognitive domain.

When drilling down to the subdomains for ADLs, the ability to stand (OR 0.25 [0.11, 0.57], p <.001), walk (OR 0.21 [0.10, 0.43], p <.001), and dress (OR 0.20 [0.09, 0.41], p <.001), were all significant contributing factors of incomplete ADL recovery at postoperative week 4–8 (Supplementary Figure S5). At this timepoint, 17% of opensurgery patients had difficulty standing, 23% had difficulty walking, and 20% had difficulty dressing themselves (Supplementary Figure S6).

4 | DISCUSSION

Our study found that the incidence of overall recovery was 42% at 4–8 weeks postoperative for patients receiving major abdominal surgery; a timepoint where typically a final surgical review is scheduled, after which a patient's postoperative journey is often considered. However, our findings indicate that *over half of this patient cohort* did not recover back to their overall baseline function by this time, with

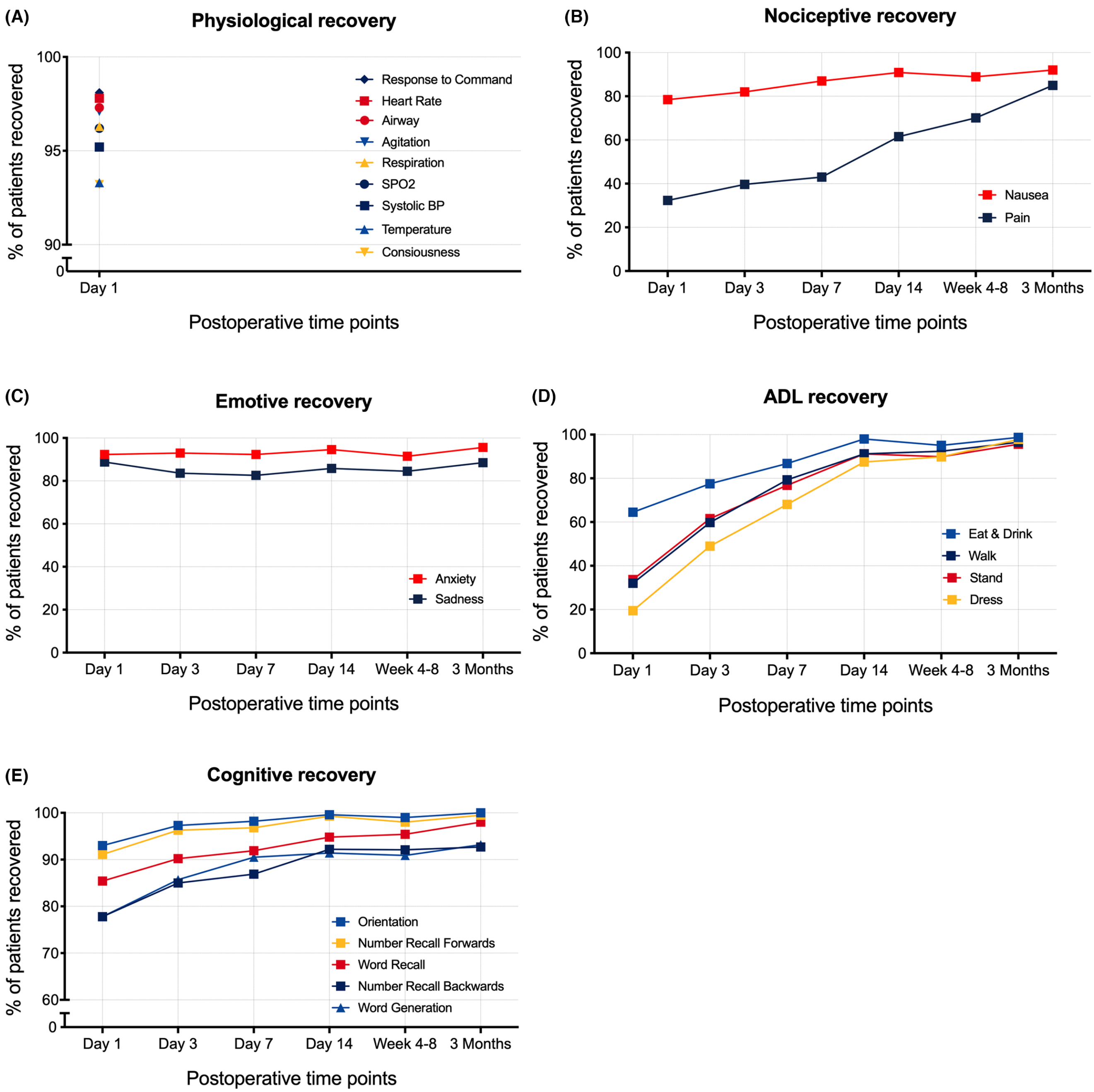

FIGURE 3 Incidences of subdomain-level recovery in patients receiving elective major abdominal surgery ($n = 653$). Recovery was assessed using the Postoperative Quality of Recovery Scale (PostopQRS). (A) recovery in the physiological subdomains on day 1 only (vital signs and physical observations), (B) recovery the nociceptive subdomains (pain and nausea), (C) recovery in the emotive subdomains (sadness/depression and anxiety/ nervousness), (D) recovery in the activities of daily living (ADL) subdomains, (E) recovery in the cognitive subdomains (normal cognitive baseline patients only).

those not recovered having experienced a longer length of hospital stay. It is therefore essential that multidimensional recovery is periodically assessed leading up to this time and drilling down into the domain and subdomain level may give clinicians a perspective into which areas the patient is failing to recover at certain timepoints, and therefore institute measures to optimise their recovery.

In our exploratory analysis, we identified potential perioperative risk factors associated with future incomplete overall recovery. Open surgery was the strongest variable associated with incomplete overall recovery at 4–8 weeks postoperative and incomplete recovery after open surgery was primarily driven by nociceptive and ADL domains. Investigating these risk factors in larger datasets with adequate statistical power is important, as these are factors that can be identified *prior* to patient discharge, and hence can identify patients at risk of poor recovery *before* they leave hospital allowing for early postdischarge intervention to be directed.

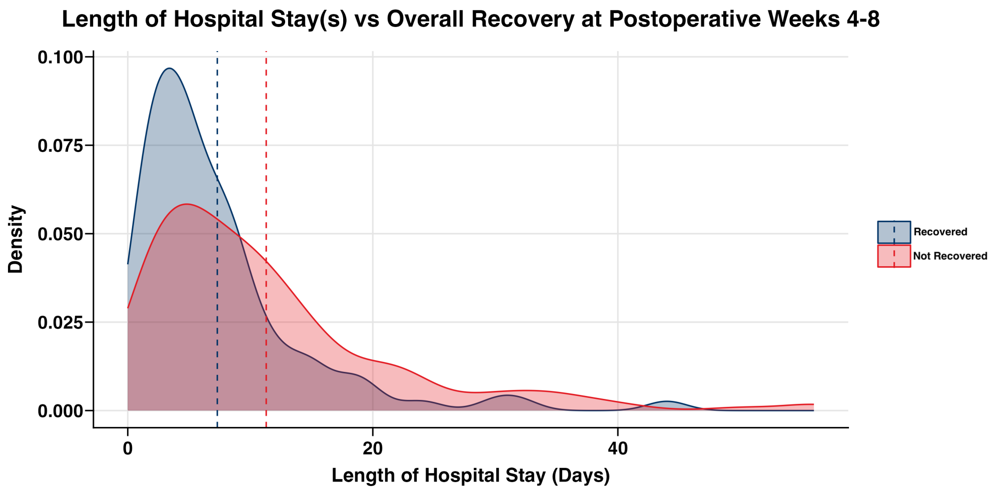

FIGURE 4 Density plot representing proportions of length of stay for patients that recovered overall in all domains (shaded in blue; $n = 94$) versus those that did not recover (shaded in red; $n = 180$) at postoperative weeks 4–8. The mean value for each group (by overall recovery) is represented by the dotted vertical lines. Patients that failed to recover overall at postoperative weeks 4–8 had a longer mean [SD] length of stay compared to those that did recover (11.3 [10.3] vs. 7.3 [7.1] days, $p < .001$).

4.1 | Comparisons with the literature

4.1.1 | Incidence of overall recovery

Comparison of our study's findings with those in the literature is challenging due to the lack of a gold standard with which to define recovery, and the heterogeneity of tools used to assess it. Many studies assess postoperative recovery using quality-of-life instruments, and others use a range of unidimensional and multidimensional tools that are either clinician- or patient-reported. Thiels et al. reported that 64% of patients returned to their overall baseline at 1 month post major gastrointestinal surgery ($n = 340$) using the 10-point linear analog self-assessment questionnaire quality of life tool.[30] Heit et al. reported 20% and 25% of patients recovered fully at 6 weeks and 3 months, respectively after laparoscopic sacrocolpopexy ($n = 171$) using the post-discharge surgical recovery score (PSR13).[3] In patients undergoing colorectal cancer surgery ($n = 119$),[31] at 1-month post-discharge, Jakobsson et al. reported 2.8%– 5.4% as 'fully recovered', 9.5%–16.2% as 'almost fully recovered' and 44.5%–57.1% considered as 'partly recovered'. Generally, these recovery incidences differed with our observed incidence of overall recovery of 42%, given the PostopQRS defines 'recovery' as a return to preoperative baseline levels or better (as a dichotomous outcome) versus a scale of symptom-absence.

4.1.2 | Incidence of domain-level recovery

At the domain level and subdomain level, the incidences of recovery are easier to compare with the literature due to consistency in definitions and measurements. For example, pain is widely and consistently reported according to visual analogue scores. Whilst much of the literature focuses on pain recovery in the acute postoperative period, fewer studies report pain recovery in the weeks to months after surgery. A recent review highlighted the gap in longer-term quality of recovery research using specific analgesic techniques in the major abdominal surgery population.[32] Theunissen et al. reported 84% recovery from pain at 3 months post-hysterectomy ($n = 412$).[33] Evenson et al. reported that 76% of patients reported pain management to be 'very successful' at 6 weeks after gynaecologic surgery.[34] In patients undergoing renal cancer surgery ($n = 82$), the incidence of pain recovery at 4 and 12 weeks was 78% and 82%, respectively, for patients receiving radical nephrectomy, and 58% and 77% for those receiving partial nephrectomy.[35] These are comparable findings with this study's incidence of 70% pain recovery at postoperative weeks 4–8. Regarding ADLs, Sikder et al. reported 90% of patients recovered to preoperative values for ADLs and 76% for independent ADLs in patient's undergoing elective major abdominal surgery ($n = 144$). These incidences were comparable to our study's incidence of 82% recovery of ADLs at postoperative weeks 4–8. Sidker et al. also found differences in recovery proportions between patients who were classified as frail, pre-frail, or non-frail, highlighting a future area of focus for recovery outcomes in these frailty subgroups.[36] In the same study, the authors reported that 66% recovered emotively and 75% recovered cognitively at 6 months, which was slightly lower than the incidences we reported in our study for postoperative weeks 4–8. This may be due to a longitudinal effect at 6 months postoperative that we did not capture as part of our study. A similar observation of our study's 4–8 week cognitive recovery incidence was seen in another study after partial nephrectomy for renal cancer, with incidences of 81% and 82% cognitive recovery at 4 and 12 weeks post-operative, respectively.[35]

4.1.3 | Risk factors for failed overall recovery

Reduced physical function preoperatively has been identified as a potential factor to predict poor recovery after major abdominal

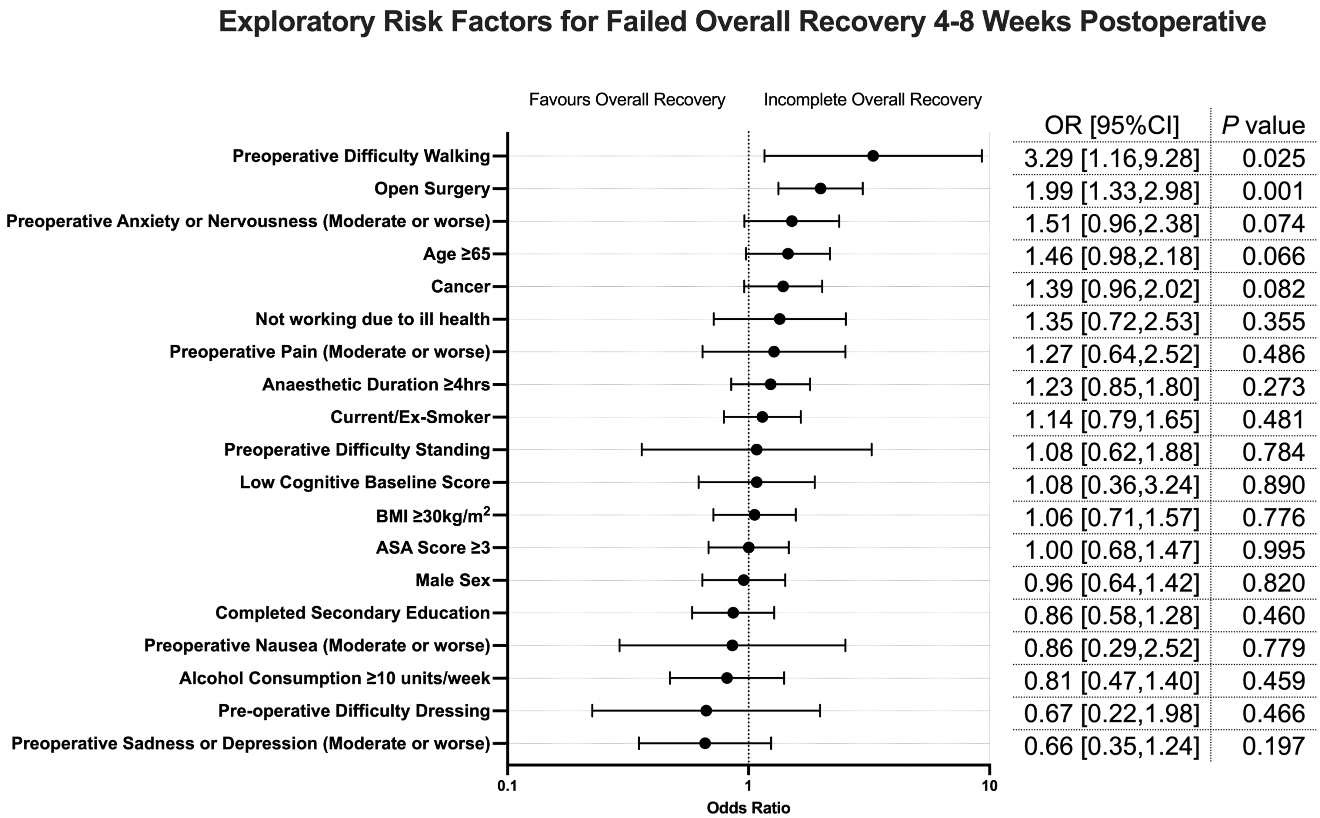

FIGURE 5 Multivariate logistic regression analysis exploring pre-operative risk factors for incomplete overall recovery at 4–8 weeks postoperative ($n = 566$). Data for each risk factor are presented as odds ratios (OR) with error bars showing 95% confidence intervals. Each variable has been adjusted for all other variables.

surgery. Onerup et al. observed that physically-able and active patients experienced fewer postoperative complications after colorectal cancer surgery,[37] whilst in a hysterectomy cohort, lower physical functioning scores predicted poorer recovery at 6 weeks postoperative.[16] Furthermore, reduced physical function may be indicative of pre-frail or frail patients, supporting previous studies that report frailty as a key predictor of poor postoperative recovery outcomes.[2,36,38] Poor functional recovery is a modifiable risk factor, with multimodal prehabilitation reported to reduce postoperative complications.[39] In our analyses, open surgery was a strong predictor of poor recovery outcomes, with nociceptive and ADL domains particularly affected, supporting the literature.[30] We also found strong trends for preoperative anxiety, age ≥ 65, and a cancer diagnosis as risk for poor overall recovery, again supporting the literature.[5,7,15,16,40–43] Although none of these factors were statistically significant in our cohort, larger sample sizes with adequate power may confirm these findings.

4.2 | Clinical implications

Our analysis found that incomplete overall recovery at 4–8 weeks after surgery was common and strongly associated with increased length of stay. Both have negative implications for the patient and the healthcare system. Our data highlighted that postoperative recovery is multidimensional and that many domains and subdomains contribute to the patient's overall recovery.

The clinical utility of our findings is threefold. Firstly, given the incidence of incomplete recovery *is over* 50% at 4–8 weeks postoperative, it is essential that there exists a tool with which healthcare providers can identify preoperatively those patients at high risk of incomplete recovery. A multidimensional tool, such as the PostopQRS, allows clinicians to identify incomplete recovery at multiple timepoints after surgery but further allows for a 'drill down' of the domains and subdomains to identify where the problem is, and to identify the severity (e.g., pain intensity). This would facilitate tailored perioperative care aimed at optimising health outcomes. For example, in cancer patients, close monitoring of real-time recovery outcomes and intervening to improve lagging postoperative recovery domains may help increase timely access to adjuvant therapies and, hence, cancer survival. In patients receiving open surgery, the recovery risks are known immediately in the perioperative phase. A closely monitored and tailored pain management and physiotherapy plan may then be prospectively instituted before discharge to ensure that the chance of recovery is optimised at postoperative weeks 4–8, and beyond. Conversely, patients deemed low risk of incomplete recovery can be fast-tracked for discharge, thus rationalising finite health services towards those patients who would benefit most. Secondly, access to established recovery data across multiple domains and subdomains informs clinicians. Given the expected recovery incidences at hand, an informed and shared decision-making discussion can occur with their patients regarding the expected recovery journey. Including the patient in these discussions, may engage the patient in their recovery journey and increase self-awareness and active participation in their recovery. Finally, by utilising repeated measurements to assess recovery, clinical teams can continuously track the patient's progress over time. Doing so enables identification of patients experiencing suboptimal recovery at the time it is occurring, in a particular domain or subdomain, facilitating timely targeted intervention aimed at the cause of incomplete recovery.

The PostopQRS represented an ideal tool for our study by measuring recovery over time and across multiple domains. Given that PostopQRS baseline variables aided in risk stratification and are required for recovery assessments, it represents an ideal digital tool to measure and tailor recovery throughout the entire postoperative journey; from preoperative assessment to recovery in the ward, and discharge into the community.

4.3 | Limitations

This was a retrospective secondary analysis of previously pooled data and caution must be taken when interpreting the results. Attempts were made to reduce potential bias in clinical and study heterogeneity, as well as potential selection bias by ensuring there were appropriately defined inclusion and exclusion criteria for our pooled data. A major abdominal surgery population was chosen as we had a clear definition of major surgery to follow, appropriate data quality from the underlying studies, and the target population was representative of a real-world cohort at three similar publicly funded tertiary hospitals where application of the results would be generalisable in the perioperative setting. We included patients from three randomised controlled trials across three different sites over a 7-year period (accounting for recency bias) to complement the Australian Postoperative Quality of Recovery Registry. This ensured that there was adequate heterogeneity in our population. Larger sample sizes, ideally in prospective studies, are required to validate these recovery data, investigate surgical subgroups, explore predictors of incomplete recovery, and further investigate the correlation between LOS with postoperative quality of recovery.

5 | CONCLUSIONS

The incidence of overall recovery was 42% at 4–8 weeks after major abdominal surgery. Patients with incomplete overall recovery at postoperative weeks 4–8 had longer lengths of stay. Strategies to improve the recovery trajectory warrant further investigation.

AUTHOR CONTRIBUTIONS

Jared Ou-Young was responsible for study conceptualisation, study design, ethics submission and approval, data collection and management, analyses, interpretation of the data, study administration, and drafting and revision of the paper. Colin Royse was involved in study conceptualisation, data interpretation, provision of oversight, and revision of the paper. Sandy Clarke-Errey was involved in statistical design of the study, provision of statistical oversight, and revision of the paper. Doa El-Ansary was involved in provision of oversight, interpretation of the data, and revision of the paper. Bernhard Riedel was involved in provision of oversight for one of the study sites, interpretation of the data, and revision of the paper. James Griffiths was involved in provision of oversight for one of the study sites, interpretation of the data, and revision of the paper. Andrea Bowyer was involved in study conceptualisation, study design, data interpretation, provision of oversight for one of the study sites and the overall study, and revision of the paper.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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