The Effect of Advanced Recovery Room Care on Postoperative Outcomes in Medium Risk Surgical Patients

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Abstract

Background

Postoperative complications are common, and may be under-recognised. This problem is predicted to increase substantially due to our ageing, comorbid population, with impacts on patient outcomes and healthcare costs.

Objective

This thesis aims to investigate current models of care delivery in the Post Anaesthesia Care Unit (PACU) and their impact on patient outcomes with a systematic review. A model of Advanced Recovery Room Care is proposed, with the primary hypothesis of feasibility, and exploratory secondary outcomes including a positive impact on a broad range of adverse post-operative events and outcomes.

Design

The three papers in this thesis are a systematic review, a correspondence letter and a prospective, multi-centre feasibility study. The systematic review utilised NCBI PubMed, EMBASE and Cumulative Index to Nursing and Allied Health Literature as data sources, and selected all studies published since 1990 investigating health system interventions undertaken in PACU. A total of 3288 unique studies were identified, with 14 selected for full-text review, and 8 included in the review. Narrative synthesis of data was the primary outcome measure, due to the heterogeneity of study designs and primary outcome measures.

The Advanced Recovery Room trial was a multicentre, prospective, before-and-after feasibility trial of moderate-risk patients undergoing non-cardiac surgery. Moderate-risk patients (predicted 30-day mortality of 1-4%) were managed in an Advanced Recovery Room Care setting immediately post-operatively, utilising PACU capacity, but extending care until the morning of post-operative day 1, and adding defined assessment checklists and goals of care. For this thesis, the large dataset from the Royal Adelaide Hospital (RAH) was analysed for (i) early post-operative adverse events (published

separately as a correspondence letter), and (ii) detailed analysis on outcomes.

Results

The systematic review identified four studies that investigated the use of the post-anaesthesia care unit as a non-ICU pathway for postoperative patients, two that investigated the implementation of physiotherapy in PACU, one evaluating the use of a new nursing scoring tool for detecting patient deterioration, and one evaluating a two-track clinical pathway in PACU.

The Advanced Recovery Room Care trial was feasible, as defined by recruitment and per protocol management of >120 patients. Data on post-operative adverse events from RAH suggest that there is an undetected and unmanaged high incidence of serious adverse events in moderate-risk surgical patients receiving standard post-operative ward care. Frequent observation in the recovery room setting allowed early detection of these events, rapid implementation of care, and suggested improved outcomes.

Conclusion

The systematic review concluded that managing selected postoperative patients in PACU, instead of ICU, does not appear to be associated with worse patient outcomes, however, the strength of evidence is moderate at best. Four of eight studies also examined hospital length of stay, with two finding the intervention was associated with decreased length of stay, and two finding no association. A trial of Advanced Recovery Room Care at the RAH was found to be feasible, and given the indicative data on outcomes, we believe a larger scale trial is warranted.

Candidate Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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Publications

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Introduction

There is a high incidence of post-operative complications in Australia[1, 2], with a significant impact on patient morbidity, mortality and quality of life[3]. In 2012, the WHO estimated the global volume of surgery to be 312.9 million operations, an increase of 38.2% compared to 2004[4]. Within Australia, there are 2.7 million surgeries performed annually, increasing by 2.5% every year[5]. The increasing rates of surgical procedures, combined with our aging comorbid population, means that post-operative complications are now at pandemic levels[1]. In Australia, over 45% of operations are performed on patients over 65 years old[6], and this increase in age is associated with increased incidence of complications; leading to prolonged length of hospital stay, higher readmission rates, and increased mortality both in-hospital and after hospital discharge[7-9]. These complications result in a significant public health and economic burden.

Approximately 20% of patients over the age for 70 years old who are undergoing surgery will have a major in-hospital complication[2]. Significant, preventable complications that we are particularly concerned with include; hypotension, respiratory compromise, delirium, suboptimal fluid administration and pain management. Recent studies investigating intra-operative and post-operative hypotension, and the impact on patient outcomes, have found significant evidence of harm associated with post-operative systolic arterial pressure <90mmHg[10], with an increased risk of myocardial infarction and increased 30-day mortality with even brief periods of untreated hypotension[11]. Hypoxaemia is also common after surgery, and is often unrecognised. Patient records often underestimate the magnitude of this problem, and it is only apparent during continuous pulse oximetry monitoring[12]. Respiratory compromise often requires complex management, that cannot always be done on the general ward (for example, non-invasive ventilation). Appropriate fluid administration is also crucial to patients' recovery post-operatively[13], but large volume fluid resuscitation does not always lead to a corresponding improvement in blood pressure, and can lead to complications such as pulmonary or surgical site oedema. Temporary vasopressor infusions are indicated in

these circumstances, but cannot be done on the ward; they require a higher-skilled area such as the Post Anaesthesia Care Unit (PACU). Pain management is also a complex post-operative issue, with complications of opioid analgesia such as respiratory depression and bowel dysfunction being increasingly recognised[14, 15]. This has spurred further interest in non-opioid techniques such as epidural analgesia and ketamine infusions. However, epidurals are often associated with worsening hypotension, and ketamine can cause confusion in the elderly (and its efficacy for acute postoperative pain remains unproven), making these techniques difficult to manage on the general surgical ward.

Medium risk patients are highly represented in data from the Royal Adelaide Hospital, examining post-operative complications[16]. High risk patients are often admitted to ICU routinely post-operatively, but medium risk patients usually receive ward-level care post-operatively, and there are increasing concerns that this may be inadequate[17]. Medium risk patients in this project are defined as predicted 30-day mortality of 1-4%, based on the American College of Surgeons' National Safety and Quality Improvement Program (NSQIP). These are predominantly American Society of Anaesthesiologists (ASA) 3 patients who would usually receive ward-level care. NSQIP is a database of risk-adjusted outcomes after surgery, containing data from millions of patients from over 700 hospitals. It is used to calculate the risk of major post-operative adverse events, including serious complications, and specific adverse events (i.e. myocardial infarction, readmission and 30-day mortality). It is a well validated tool[18-20], encompassing common comorbidities including diabetes, chronic obstructive lung disease, obesity and chronic liver disease[21]; all of which are occurring with increasing frequency in our aging population.

Several models of care have previously been proposed as potential solutions to the problem of post-operative complications, but none have shown substantial efficacy for either patient outcomes or healthcare costs. Medical Emergency Response (MER) teams were proposed as a potential 'outreach' service to manage deteriorating patients, however the only randomised control study of the model failed to demonstrate an improvement in patient outcomes[22]. Further studies have also highlighted significant difficulties with MER team implementation, and failure to escalate, as major barriers for

success of the model[23, 24]. A recent systematic review of surgical high dependency units did not show a significant positive impact on patient outcomes[25], and while ICU may offer higher quality care, it is probably not financially viable for the large numbers of moderate risk patients, at a cost of 5-7 times that of ward care, especially in our cost constrained post-COVID era.

This thesis focussed on a re-design of healthcare resources to address early postoperative complications, with a focus on improved outcomes, and improved costs. This work commenced with a systematic review, to identify and appraise previous studies surrounding models of care delivery in Recovery Rooms and their impact on patient outcomes after surgery. The key purpose was to highlight what was already known, and identify areas that warrant further investigation.

This was followed by formal development and initial prospective examination of a new model of care for early recovery from surgery. Our proposed solution was the introduction of Advanced Recovery Room Care (ARRC), using existing infrastructure (the Recovery Room) and staff. Managing select patients in PACU (Post Anaesthetic Care Unit) instead of ICU is not associated with worse patient outcomes[26-29], and a high incidence of serious adverse events in Recovery Rooms and shortly after discharge to the ward[16, 30] suggests that timely intervention during this period of greatest risk, may have a sustained impact on patient outcomes. While Advanced Recovery Room Care uses pre-existing resources; care is enhanced by adding principles known to be associated with improved quality, such as minimising unnecessary variability in care through structured checklists, more intensive monitoring, and minimising handover to provide continuity of care from arrival in the Recovery Room until the morning of day 1 post-operatively.

The Advanced Recovery Room Care feasibility trial was then commenced at the Royal Adelaide Hospital (RAH), Peter McCallum Cancer Institute (P Mac), and Lismore Base Hospital (LBH). The RAH was the first site to complete the ‘before’ and ‘after’ period of the trial, and interim analysis revealed a much higher, and very disturbing, rate of post-operative adverse events when patients were closely monitored in the Recovery Room

in the 'after' period as part of Advanced Recovery Room Care, compared to when they received standard ward monitoring. This data indicated that the rates of early post-operative complications had previously been under-recognised. It was considered a safety issue by the authorship team and hospital, leading to early publication of a Correspondence Letter in the British Journal of Anaesthesia detailing the rates and time-course of early adverse events in this medium risk cohort.

The multi-centre feasibility study was published as a combined paper in *Anaesthesia*. The RAH and P Mac completed both the 'before' and 'after' periods, but LBH was unable to complete the training and 'after' periods. Our primary outcome was feasibility of recruitment and follow-up, but secondary outcome data from the RAH are were also included in the paper as it was a large, high quality dataset.

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Contribution to the Paper	CL developed the review protocol, completed all title and abstract screening, full text reviews and data analysis. She completed the risk of bias assessment with GL. CL also drafted and revised the manuscript.		
Overall percentage (%)	60		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature	[redacted]	Date	29/9/20

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Guy Ludbrook		
Contribution to the Paper	GL developed the initial review question, and assisted writing the review protocol. He also completed the full text reviews, reviewed all data of included studies and completed the risk of bias assessment with CL. He also critically appraised the draft manuscript.		
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Contribution to the Paper	DS assisted with developing the initial review question, and reviewed all included articles for consensus. He also critically appraised the draft manuscript, and assisted with revisions.		
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Please cut and paste additional co-author panels here as required.

Name of Co-Author	Guy Maddern		
Contribution to the Paper	GM reviewed all included articles for consensus, and critically appraised the manuscript. All authors have given final approval for publication.		
Signature		Date	12/10/20

BMJ Open

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ABSTRACT

Context Postoperative recovery rooms have existed since 1847, however, there is sparse literature investigating interventions undertaken in recovery, and their impact on patients after recovery room discharge.

Objective This review aimed to investigate the organisation of care delivery in postoperative recovery rooms; and its effect on patient outcomes; including mortality, morbidity, unplanned intensive care unit (ICU) admission and length of hospital stay.

Data sources NCBI PubMed, EMBASE and Cumulative Index to Nursing and Allied Health Literature.

Study selection Studies published since 1990, investigating health system initiatives undertaken in postoperative recovery rooms. One author screened titles and abstracts, with two authors completing full-text reviews to determine inclusion based on predetermined criteria. A total of 3288 unique studies were identified, with 14 selected for full-text reviews, and 8 included in the review.

Data extraction EndNote V.8 (Clarivate Analytics) was used to manage references. One author extracted data from each study using a data extraction form adapted from the Cochrane Data Extraction Template, with all data checked by a second author.

Data synthesis Narrative synthesis of data was the primary outcome measure, with all data of individual studies also presented in the summary results table.

Results Four studies investigated the use of the postanaesthesia care unit (PACU) as a non-ICU pathway for postoperative patients. Two investigated the implementation of physiotherapy in PACU, one evaluated the use of a new nursing scoring tool for detecting patient deterioration, and one evaluated the implementation of a two-track clinical pathway in PACU.

Conclusions Managing selected postoperative patients in a PACU, instead of ICU, does not appear to be associated with worse patient outcomes, however, due to the high risk of bias within studies, the strength of evidence is only moderate. Four of eight studies also examined hospital length of stay; two found the intervention was associated with decreased length of stay and two found no association.

PROSPERO registration number This protocol is registered on the International Prospective Register of Systematic Reviews (PROSPERO) database, registration number CRD42018106093.

Strengths and limitations of this study

- This is the first systematic review to provide a summary of the organisation of care delivery in recovery rooms and the impact on patient outcomes. It is a current area of interest for many hospitals/health networks, due to the frequency and cost of postoperative complications.
- The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement was strictly adhered to, with a broad search strategy in an attempt to capture all relevant publications.
- The variation in study designs and primary outcome measures meant that we were unable to combine data for aggregate analysis or meta-analysis.
- Narrative synthesis of key results may introduce bias; however, steps were taken to minimise this, including the review of all data by a second author.

INTRODUCTION

Rationale

The concept of a postoperative recovery room or postanaesthesia care unit (PACU) was first described in 1847,[1] and the progression of surgical and anaesthetic techniques has seen marked advances in their form and function. However, there is a striking paucity of literature investigating the interventions undertaken in recovery, and their impact on patients after recovery room discharge. An editorial by C. Aps in 2004, discussed the concept of overnight intensive recovery; where patients can be managed in the PACU for up to 24 hours,[2] to avoid unnecessary intensive care unit (ICU) admissions and decrease cancellations due to lack of bed availability. This concept was introduced in the 1990s at St Thomas' Hospital, London[2];

and despite its apparent success, has not spawned further research surrounding such a model of care. Swart *et al* retrospectively examined the impact of the loss of access to a high-dependency unit (HDU) for postoperative management of medium risk patients, and showed a significant increase in emergency laparotomies and unplanned critical care admissions.[3] However, the use of HDU for postoperative patients has also been associated with an increase in postoperative respiratory complications.[4] The concept of extended 6-hour recovery, followed by a monitored ward bed instead of an elective ICU admission postoperatively, has also shown to be safe, with no worsening in patient outcomes.[5] This review focuses on health services research, also known as health systems research; investigating models of care delivery, rather than single therapeutic interventions. Health systems research is a multidisciplinary field that examines access to, and the use, cost, quality, delivery, organisation, financing and outcomes of healthcare services. This is used to identify new knowledge about the structure, processes and effect of health systems for individuals and populations.[6] This is the first systematic review to provide a summary of the organisation of care delivery in recovery, and its impact on patient outcomes after recovery room discharge. In presenting these finding, we hope to highlight the need for further research to help improve the care of patients in the postoperative period.

Objectives

The objective of this systematic review was to investigate any health system initiatives undertaken in operating suite recovery rooms, in the postoperative period, that have been shown to improve outcomes after PACU discharge, for adult, non-cardiac surgical patients. Important outcomes included mortality, morbidity, return to theatre, unplanned ICU admission and length of hospital stay. Prospective and retrospective randomised control trials, cohort studies, case–control studies and comparison studies were included for analysis.

METHODS

Protocol and registration

A review protocol was developed in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement by the author team prior to commencing the systematic review. This protocol is registered on the International Prospective Register of Systematic Reviews (PROSPERO) database, registration number CRD42018106093.

Patient and public involvement

As this is a systematic review of pre-existing literature, patients and the public were not involved in study design. However, this systematic review forms part of a broader research topic on postoperative care, and how to face the challenge of increasing postoperative complication rates. In 2012, the WHO estimated the global volume of surgery to be 312.9 million operations, an increase of 38.2% compared with 2004, resulting in a mean global surgical rate of 4469 operations per 100 000 people per year.[7] With an ageing population and increasing prevalence of comorbidities, postoperative complications are now at pandemic levels.[8] Investigating alternative healthcare systems and care delivery models is paramount to combatting this issue. It should be a priority for both patients and service providers, as it has the potential to provide great benefit to the broader population.

Eligibility criteria

Included studies investigated health system initiatives in the PACU, in the postoperative period, up to 48 hours postoperatively. Adult patient groups were the primary focus, however, studies that included a small cohort of children were not automatically excluded. Studies that explored the relationship between interventions in recovery and mortality, morbidity, hospital length of stay, unplanned ICU admission and return to theatre were included. Varying study designs were eligible for inclusion; such as randomised control trials, cohort studies, case–control studies and before and after studies. Cross-sectional studies and case reports were excluded. Only studies published from 1990 onwards were included, to focus on up to date clinical practice and minimise the inclusion of irrelevant data. Studies published in a language other than English, grey literature and studies focusing solely on ambulatory surgery were excluded.

Information sources and search strategy

Medical Subject Heading terms were generated from the NCBI (National Center for Biotechnology Information) PubMed advanced search area with the assistance of the University of Adelaide Health Sciences librarian. Logic grids were used as a tool, to replicate the search throughout the three databases; NCBI PubMed, EMBASE and Cumulative Index to Nursing and Allied Health Literature. The full electronic search strategy for the PubMed database is presented in online supplementary appendix 1. This search strategy was used across the three databases from 23 March 2018 to 8 April 2018 to yield the articles screened for inclusion in the review.

Study selection

Search results from each data base were recorded, and imported into EndNote V.8 (Clarivate Analytics, Boston, USA). Key word searching was also performed to identify new studies that had not yet been assigned indexing terms for the databases. Reference lists from key articles were also reviewed to identify further papers that may have been relevant to the review. Titles and abstracts were screened by one reviewer (CL), who was not blinded to journal titles or to the study authors or institutions. Articles selected for full-text review were reviewed by two reviewers (CL and GL), and any discrepancies arising regarding the relevance of a study were resolved by

consulting a third party. The list of references for inclusion was sent to all authors to ensure consensus.

Data collection process

The Cochrane Data Extraction Template for Included Studies from their consumers and communication page was used as a base for our data extraction form. This form was piloted on two initial studies for usability, with no further modifications required. One reviewer extracted the initial data from each study (CL), and these data were confirmed by a second reviewer (GL) before inclusion in the review. One study only included data in pictorial form, and an attempt was made to contact the authors to obtain the raw data. Unfortunately, this was unsuccessful.

Data items

Data items extracted from each study included patient population and characteristics, intervention aims and methods, comparison groups and outcome measures. These data items are presented in the Characteristics of Included Studies Tables.

Risk of bias in individual studies

Risk of bias in individual studies was assessed by two reviewers (CL and GL) using Gate-Lite and Robins-I (previously known as A Cochrane Risk of Bias Assessment Tool: for Non-Randomized Studies of Interventions). Narrative synthesis of data placed more weight on higher quality studies; however, all studies and their results are presented, with caveats to highlight the individual biases that will affect interpretations of results.

Summary measures and planned methods of analysis

Narrative synthesis of data was the principle summary measure. This was due to the differing study designs and variable outcome measures in each study. Meta-analysis was not appropriate for the data in this systematic review. All data are presented individually, in relation to each study, with further narrative synthesis to summarise results. Results from studies were unable to be combined due to the variation in primary and secondary outcome measures, and differences in study design. No additional analysis or subgroup analysis was performed during this systematic review.

Risk of bias across studies

Risk of bias across studies was assessed by two reviewers (CL and GL), using the Cochrane Risk of Bias Tool, and discussing any evident publication bias or selective reporting.

RESULTS

Study selection

Database results and numbers of studies screened are presented in the flow diagram (figure 1). All references were imported into EndNote V.8 for title and abstract screening. One reviewer (CL) screened all titles and abstracts, with ambiguous studies included for full text review. Fourteen studies were selected for full-text review. Full-text reviews were completed by two reviewers (CL and GL), and eight studies were selected for inclusion in the review. A summary of included and excluded studies was sent to the third and fourth authors for consensus.

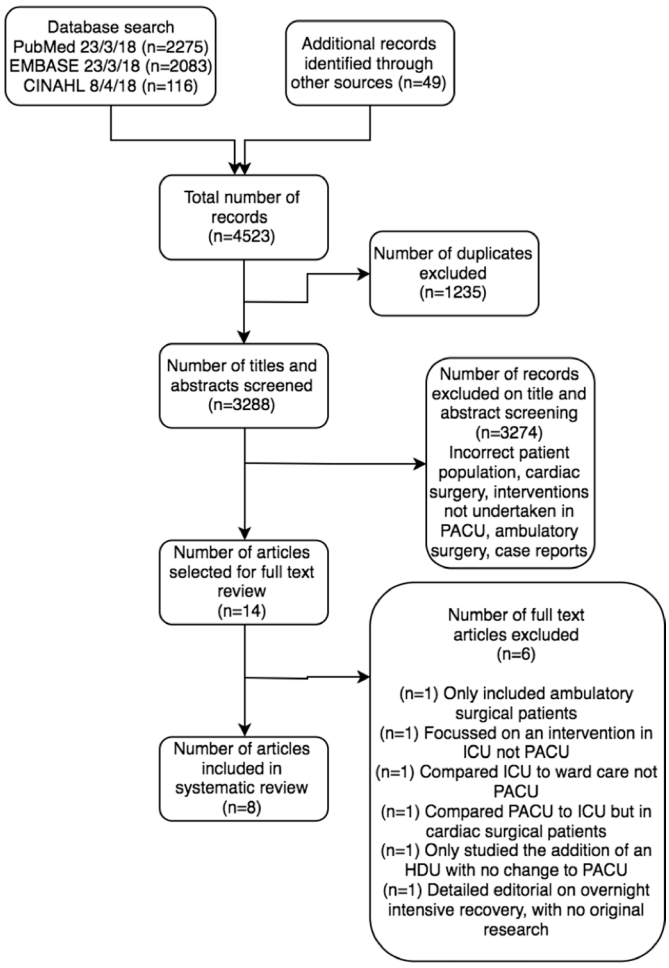

Figure 1 Flow diagram for selection of studies included in review. ICU, intensive care unit; PACU, post anaesthesia care unit.

Study characteristics

Of the eight studies included, four of the included studies were retrospective cohort studies,[9–12] two were observational cohort studies,[13 14] one was a prospective non-randomised pre–post intervention study[15] and one was a prospective randomised cohort study.[16] Study characteristics for each of the included studies are outlined in the Characteristics of Included Studies Summary Table (table 1). Four studies investigated the use of PACU as a non-ICU pathway for postoperative patients.[9 11 13 14] Two investigated the implementation of physiotherapy in PACU, and the impact on patient outcomes.[12 16] One evaluated the use of a new nursing scoring tool, and its impact on recognition of patient deterioration in PACU,[15] and one evaluated the implementation of a two-track clinical pathway in PACU and the effect on patient outcomes.[10] All studies focused primarily on adults, but one included a small cohort of children.[11] Common outcome measures

Table 1 Characteristics of included studies summary table

Source	Aim	Study design	Number of arms/ groups	Population	Intervention	Comparison group	Outcome measures
Callaghan *et al*[9] (n=178)	To determine the safety of introducing non-ICU pathways for selected patients. And evaluate the effect on cost, ICU beds availability and cancellation rates of elective surgery.	Retrospective cohort study.	Intervention group: patients selected for OIR. Comparison group: patients booked for an elective ICU admission.	All patients undergoing elective open aortic surgery between 1 January 1998 and 31 December 2002.	(n=152) Introduction of OIR	(n=26) Elective postoperative ICU bed	In-hospital mortality In-hospital morbidity Postoperative length of stay ICU length of stay
Eichenberger *et al*[10] (n=6375)	To assess the impact of a clinical pathway implemented in a postanaesthesia care unit on postoperative outcomes.	Retrospective cohort study based on electronic patient records.	Fast track: nurse driven, ASA 1–2. Slow track: physician driven, ASA 3–5 who have undergone minor or major surgery, or developed postoperative complications. Comparison group: Pre-existing PACU conditions without the clinical pathway.	All elective and non-elective inpatients, who underwent a surgical or endoscopic procedure under anaesthesia during the study period.	(n=3345) Introduction of a two-track clinical pathway that clearly defined and coordinated medical and nursing interventions.	(n=3030) Pre-existing PACU conditions without the clinical pathway.	PACU length of stay In-hospital mortality Unplanned ICU admissions after PACU stay.
Fraser and Nair[13] (n=119)	To assess if elective surgical patients were stable enough to return to the general ward after a stay in Extended Recovery instead of being routinely admitted to ICU.	Observational cohort study.	One arm. No control group	Elective surgical patients who would have previously been booked for level two care postoperatively.	(n=119) Opening of an extended recovery unit.	Nil	Discharge destination after extended recovery unit admission
Kastrup *et al*[11] (n=51 090)	To evaluate the effect of around-the-clock intensivist PACU coverage on the structure of ICU, and to demonstrate the economic effect on the hospital.	Retrospective cohort study.	Intervention group: after the introduction of 24 hours intensivist coverage. Comparison group: prior to introduction of 24 hours intensivist coverage.	All patients undergoing a surgical procedure (adults and children) between 1 January 2008 and 30 April 2011.	(n=26 118) Introduction of 24 hours intensivist coverage in PACU	(n=24 972) Pre-existing PACU with no intensivist coverage	PACU LOS ICU LOS Preoperative days Hospital LOS Casemix index Cost

Continued

Table 1 Continued

Source	Aim	Study design	Number of arms/ groups	Population	Intervention	Comparison group	Outcome measures
Schweizer *et al*[14] (n=933)	To assess the impact of a new PACU on ICU utilisation, hospital length of stay and complications following major non-cardiac surgery.	Observational cohort study.	Intervention group: after opening of a new PACU. Control group: before opening of the new PACU	Adult patients undergoing abdominal aortic reconstruction or resection of lung cancer during the study periods.	(n=485) Opening of a new PACU (PACT)	(n=448) Pre-existing PACU	Mortality Reoperation Secondary admission to ICU Postoperative complications Hospital LOS
Street *et al*[15] (n=1417)	To evaluate whether use of a discharge criteria tool for nursing assessment of patients in PACU would enhance nurses' recognition and response to patients at-risk of deterioration and improve patient outcomes.	Prospective non-randomised pre–post intervention study.	Intervention group: after the implementation of the Postanaesthetic Care Tool (PACT) Comparison group: prior to the implementation of PACT.	All adult patients undergoing elective surgery on days of data collection.	(n=694) Implementation of a PACT	(n=723) Standard PACU care without PACT	Nursing management of symptoms Rates of adverse events Mortality PACU LOS Hospital LOS Health service usage and healthcare costs
Tayrose *et al*[12] (n=900)	To address the impact of rapid rehabilitation beginning in the recovery room on length-of-stay after primary hip and knee arthroplasty.	Retrospective cohort study.	Intervention group: rapid rehabilitation group. Comparison group: standard rehabilitation protocol	900 consecutive hip and knee arthroplasty patients.	(n=331) Rapid rehabilitation pilot programme where the first two cases of the day were mobilised in the recovery room.	(n=569) Remainder of cases received standard rehabilitation protocol starting on the morning of postoperative day one.	Overall hospital LOS Hip arthroplasty subgroup LOS Knee arthroplasty subgroup LOS
Zoremba *et al*[16] (n=60)	To evaluate the impact of short-term respiratory physiotherapy during the PACU stay, on postoperative lung function tests and pulse oximetry values in obese adults after minor surgery.	Prospective randomised cohort study	Intervention group: physical therapy treatment group that performed incentive spirometry in the PACU Control group: patients who did not undergo physical therapy	60 obese adult patients (BMI 30–40) ASA 2–3, scheduled for minor peripheral surgery.	(n=30) Patients performed incentive spirometry in the PACU.	(n=30) Not instructed to do any breathing exercises or spirometry.	Pulse oximetry and spirometry at 1, 2, 6 and 24 hours postoperatively

ASA, American Society of Anaesthesiologists physical status classification; BMI, body mass index; ICU, intensive care unit; LOS, Length of stay; OIR, overnight intensive recovery; PACU, postanaesthesia care unit.

included in-hospital mortality, PACU length of stay and hospital length of stay. Further details regarding patient population characteristics, study methodology and outcome measures are also outlined in the supplementary tables published online (online supplementary file).

Risk of bias within studies

The overall risk of bias within studies was serious. Critical risk of bias was identified in two studies,[12 13] serious risk of bias in three studies,[9 14 15] moderate risk of bias in one study[11] and low risk of bias in two studies.[10 16] Significant patient selection and allocation bias was the most common identified cause[9 11 12 14 15]; as patients in these studies were not randomly allocated to their postoperative level of care. The most clinically unwell patients were sent to ICU automatically, and only the lower risk patients, as deemed by the treating teams, were allowed a trial of care in the PACU. The relatively small numbers of participants in each study, with the exception of Kastrup *et al*, also introduced a significant risk of bias; as these studies were not adequately powered to assess critical outcomes such as mortality and other serious postoperative complications. Articles, which were considered as being of serious and critical risk of bias, were still included in the review, due to the sparse literature available. The risk of bias summary table (table 2) provides further analysis, and comment regarding the risk of bias within individual studies.

Results of individual studies

The results of each individual study are presented in the results of included studies table (table 3). Four studies[9 11 13 14] investigated non-ICU pathways for care of postoperative patients, and these pathways were not associated with increased mortality rates in three of the included studies.[9 11 14] However, it must be noted that due to sample size, only one study[11] was adequately powered to show a reliable difference in mortality rates, and one study[13] did not investigate mortality as an outcome measure. Admission criteria for PACU care instead of ICU care postoperatively were only stated in two of the included studies.[9 11] Callaghan *et al* outlined contraindications to use of overnight intensive recovery; including significantly impaired renal function, technically difficult or prolonged surgery expected, poor exercise tolerance or likelihood of requiring postoperative ventilation. However, the selection of patients was ultimately at the discretion of the attending anaesthetist and vascular surgeon. Kastrup *et al* only listed planned length of stay <24 hours as their admission criteria to PACU instead of ICU or the intermediate care unit. Fraser *et al* did not mention their admission criteria for extended recovery care,[13] and Schweizer *et al* admitted patients to PACU instead of ICU purely at the discretion of the attending anaesthetist.[14] Four of eight studies also examined hospital length of stay,[9 11 12 14] and two found the intervention was associated with decreased length of stay and two found no association (table 3). Kastrup *et al* demonstrated a significant decrease in length of stay for all surgical patients after their introduction of 24 hours intensivist coverage to the PACU.[11] Tayrose *et al* also demonstrated a decreased length of stay for patients who received early mobilisation in PACU.[12] However, Callaghan *et al* and Schweizer *et al* did not demonstrate any statistically significant decrease in length of stay.[9 14] PACU length of stay was another common outcome measure in three of the included studies.[10 11 15] Eichenberger *et al* demonstrated a decreased PACU length of stay for ASA (American Society of Anaesthesiologists physical status classification) 1–2 patients, but no difference for ASA3-5, while Kastrup *et al* and Street *et al* both demonstrated an increase in PACU length of stay following their interventions.[11 15] Due to the variations in study designs, we were unable to combine the data for further aggregate analysis.

Synthesis of results

The overall quality of studies was poor, with significant selection and allocation bias; however, managing postoperative patients outside of the ICU is not associated with worse patient outcomes, especially in an extended recovery setting. There was no increase in mortality rates identified in three of the studies investigating non-ICU pathways for postoperative patients,[9 11 14] and the fourth did not investigate mortality as an outcome measure.[13] Use of extended recovery also meant that ward discharge was usual, bypassing the ICU.[9 13] Kastrup *et al* showed that the addition of intensivist coverage to PACU was associated with decreased length of hospital stay, and Tayrose *et al* demonstrated that early mobilisation in PACU was associated with decreased length of hospital stay, but significant preselection bias for early mobilisation of arthroplasty patients confounds results.[12] Other changes to the PACU environment, including the opening of a new PACU[14] and introduction of overnight intensive recovery,[9] did not appear to have any effect on hospital length of stay. The use of a two-track pathway for nurse-driven and physician-driven PACU management and discharge, appears to be beneficial in reducing PACU length of stay, and improving outcomes after discharge from PACU, including a significant decrease in postoperative mortality.[10] However, introduction of a Post Anaesthetic Care Tool, and introduction of 24 hour intensivist coverage in PACU was associated with increased length of stay in PACU.[11 15] While incentive spirometry in PACU did improve pulse oximetry values and lung function for the first 24 hours postoperatively, there were no long-term positive effects investigated or identified.[16] It must be noted that the risk of bias of the included studies modifies results. Critical risk of bias was identified in two studies,[12 13] serious risk of bias in three studies,[9 14 15] moderate risk of bias in one study[11] and low risk of bias in two studies.[10 16] Only one of the included studies was adequately powered,[11] and reliable conclusions cannot be drawn from single studies with such small datasets.

Table 2 Risk of bias summary table

Source	Bias due to confounding	Bias in selection and allocation of participants	Bias in measurement of interventions	Bias due to departures from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of reported Results	Overall risk of bias judgement	Comments
Callaghan *et al*[9]	Low	Serious	Low	sModerate	Low	Moderate	Low	Serious	Significant selection bias of lower risk patients who were sent to OIR. Used predictive values for mortality (based on POSSUM variables) as a comparison measure.
Eichenberger *et al*[10]	Low	Low	Low	Low	Low	Low	Low	Low	High-quality study. No specific concerns from review authors.
Fraser and Nair[13]	Low	Moderate	Moderate	Moderate	Critical	Serious	Moderate	Critical	Over 25% of data missing. No clear objective stated, no explanation of methodology. Poorly defined selection criteria.
Kastrup *et al*[11]	Low	Serious	Low	Moderate	Low	Low	Low	Moderate	Significant selection bias of patients allocated to PACU, intermediate care unit or ICU by intensive care physician. This study also included a population of children (numbers not given).
Schweizer *et al*[14]	Critical	Serious	Low	Low	Low	Low	Low	Serious	Introduction of preoperative risk assessment guidelines (AHA/ACC) with increased antiadrenergic administration preoperatively confounds results. Significant selection bias, no admission criteria stated for PACU or ICU. Patient allocation was determined by treating clinician.
Street *et al*[15]	Low	Serious	Low	Moderate	Low	Serious	Critical	Serious	Power analysis included all patients (including day surgery) when investigating postoperative outcomes after PACU discharge, giving inaccurate results. Poor objective (with different objectives stated in the abstract and the article).
Tayrose *et al*[12]	Low	Critical	Serious	Moderate	Low	Serious	Low	Critical	Patients who were deemed too unwell to be mobilised in recovery, were included in analysis for the standard recovery group. Operative order bias, by including the first two cases of the day. No methods reported for data collection.
Zoremba *et al*[16]	Low	Low	Low	Low	Low	Low	Low	Low	Good-quality study. However, does not address the longer-term outcomes of interest.

ACC, American College of Cardiology; AHA, American Heart Association; ICU, intensive care unit; PACU, postanaesthesia care unit; POSSUM, Physiological and operative severity score for the enumeration of mortality and morbidity.

Table 3 Results of included studies

Source	Intervention	Mortality	Other key results
Callaghan *et al*[9]	Introduction of overnight intensive recovery	No significant difference between groups. Overall in hospital mortality was 2%. fewer than predicted patients died (observed mortality 3 vs predicted 95% CI 8 to 21).	Morbidity: No significant difference between groups. Overall, fever than predicted patients experienced one or more complications (observed 101 vs predicted morbidity 103%–125% 95% CI) Hospital length of stay: No significant difference between groups
Eichenberger *et al*[10]	Introduction of a two-track clinical pathway that clearly defined and coordinated medical and nursing interventions.	Overall in-hospital mortality decreased significantly from 68 patients (1.5%) to 39 patients (0.8%) (p<0.001). In ASA 3–5 patients, mortality was nearly halved (adjusted OR 0.40) (p<0.001).	Unplanned ICU admission: Total number of unplanned ICU admissions after stay in PACU decreased from 113 (2.5%) to 90 (1.9%) (adjusted OR 0.70) (p=0.70) PACU length of stay: After adjustment for differenced in patients and procedures. Statistically significant decrease in PACU length of stay for ASA 1–2 patients (adjusted p<0.001). There was no difference for ASA 3–5 patients (adjusted p=0.768)
Fraser and Nair[13]	Opening of an extended recovery unit.	Not investigated	Discharge destination after extended recovery unit admission: Data from the first 119 patients admitted to the extended recovery unit were collected. 76 patients (63.9%) who would have otherwise gone to critical care were able to go back to the ward.
Kastrup *et al*[11]	Introduction of 24 hours intensivist coverage in PACU	No difference between groups	Hospital length of stay: Overall length of stay decreased significantly for all surgical patients. From 8.3 (±11.8) days to 7.71 (±10.99) days. PACU length of stay: More patients were treated in the PACU for a longer period of time. Mean LOS increased from 0.27 (±0.2) days to 0.45 (±0.41) days Cases treated in ICU: Mean number of cases treated in the ICU per month decreased significantly from 164.7 (±14.37) to 133.8 (±19.42) (p=<0.001) ICU treatment days: Mean number of treatment days per month did not change. Relative number of patients with longer LOS (>7 days) increased after introduction of PACU, whereas average number of patients staying <24 hours in the ICU decreased by ~50%.
Schweizer *et al*[14]	Opening of a new PACU	No difference between study periods	Morbidity: Vascular patients had decreased rates of myocardial infarction (6.4% vs 1.3% p=0.009) and decreased rates of pulmonary oedema (5.1% vs 1.7% p=0.08) Reoperation: No difference between study periods Hospital length of stay: Total hospital length of stay did not change over time
Street *et al*[15]	Implementation of a Postanaesthesia Care Tool (PACT)	No significant difference between groups.	Patient management in PACU: More requests for medical review 19% vs 30% (p=<0.001), more patients with MET criteria modified by an anaesthetist 6.5% vs 13.8% (p<0.001), higher rates of analgesia administration37.3% vs 54.2% (p=0.001). Adverse events in PACU: More adverse events recorded in PACU in phase 2, 29.4% vs 21.2% (p<0.001). May represent a greater recognition of adverse events in PACU after implementation of PACT. Adverse events after PACU: Significant decrease in rates of clinical deterioration and significant decrease in cardiovascular events after PACU discharge. PACU length of stay: Increase in median PACU length of stay from 45 min in phase 1 to 53 min in phase 2 (p<0.001)
Tayrose *et al*[12]	Rapid rehabilitation pilot programme where the first two cases of the day were mobilised in the recovery room.	Not investigated	Overall hospital length of stay: Rapid rehabilitation had significantly decreased length of stay that patient who began therapy on postoperative day 1 (p<0.001). Hip arthroplasty subgroup length of stay: Decreased length of stay for rapid rehab patients in the hip arthroplasty subgroup (p<0.001). Knee arthroplasty subgroup length of stay: Decreased LOS for rapid rehab patients in the knee arthroplasty subgroup (p=0.16).
Zoremba *et al*[16]	Patients performed incentive spirometry in the PACU.	Not investigated	Pulse oximetry: Significantly improved pulse oximetry values at 1 and 2 hours in PACU, and at 6 hours postmobilisations (p<0.0001), and significant improvement in pulse oximetry values at 24 hours postoperative (p<0.0001). Spirometry results: Incentive spirometry group recovered lung function faster in during the PACU stay (p<0.0001). Lung function had almost reached baseline at 6 hours in the incentive spirometry group, however, the control group were up to 25% below baseline (p<0.0001). Overall difference in lung function between groups had decreased 24 hours after surgery, but significant differences still remained (p=0.0040).

ASA, American Society of Anaesthesiologists physical status classification; ICU, intensive care unit; LOS, Length of stay; MET, Medical emergency team; PACU, postanaesthesia care unit.

Risk of bias across studies and additional analyses

Risk of bias across studies for the key common outcome measures of mortality, hospital length of stay and PACU length of stay was high due to the study designs, with no level I or II evidence available. There was no additional analysis required for this review.

DISCUSSION

Summary of evidence

Of the eight studies included in this systematic review, only one was a prospective randomised cohort study,[16] and one was a prospective non-randomised pre–post intervention study.[15] The rest were observational and retrospective cohort studies.[9–14] There was no level I or level II evidence available for inclusion in this review. Common outcome measures identified, included mortality, hospital length of stay and PACU length of stay. Despite the poor quality of evidence, we found that managing selected higher risk postoperative patients in the PACU instead of ICU was not associated with worse outcomes,[9 11 13 14] and may be associated with decreased unnecessary ICU admissions, with potential large cost savings. However, due to study types, small participant numbers, and the significant selection and allocation bias of patients within these studies, the overall strength of evidence is only moderate. Unfortunately, only two of the included studies stated the admission criteria for PACU care instead of ICU care postoperatively,[9 11] making the use of this finding to guide care difficult, with further research into risk stratification of patients needed. The addition of intensivist coverage to PACU was associated with deceased hospital length of stay in one study,[11] as was the rapid mobilisation of arthroplasty patients.[12] However, the introduction of overnight intensive recovery and the opening of a new PACU had no effect on hospital length of stay.[9 14] The introduction of a two-track clinical pathway appeared to be associated with a decreased PACU length of stay,[10] however, the introduction of a Post Anaesthesia Care Tool and introduction of intensivist coverage was associated with increased PACU length of stay.[11 15] Only one of the included studies was adequately powered,[11] and we are unable to draw accurate conclusions from single studies with such small participant numbers. This has significant implications for future research and health resource allocation. Further studies that prospectively randomly allocate patients to a treatment arm would be of great value, however, we acknowledge that due to the risk profile and care requirements of surgical patients, this may not be possible until further safety is proven.

Limitations

The protocol development and search strategy for this review were developed in accordance with the PRISMA statement. With help from experienced health science research librarians, we attempted to ensure that all references were captured; however, it is possible that studies were missed. Due to the variation in study design and primary outcome measures, we were unable to combine data for aggregate analysis or meta-analysis. The narrative synthesis of key results may introduce bias; however, steps were taken to minimise this, including the review of all data by a second author. The most significant limitation of this systematic review was the high risk of bias within the individual studies included in the review. Selection and allocation bias, missing data, inclusion of inappropriate patient groups such as day surgery, and lack of fidelity assessment were some of the key flaws within each study. However, the thorough risk of bias assessment and its implications on reported results allows readers to interpret the data appropriately.

CONCLUSIONS

Managing selected postoperative patients in PACU instead of ICU does not appear to be associated with worse patient outcomes, however, due to study design, and the high risk of bias within studies, the strength of evidence is moderate at best. The addition of intensivist coverage to PACU and early mobilisation were associated with decreased hospital length of stay. While the use of a two-track clinical pathway decreased PACU length of stay, however, there is no evidence of this improving patients' overall outcomes. This is the first systematic review to investigate the health system initiatives undertaken in recovery rooms and their impact on patient outcomes after PACU discharge. There is a striking paucity of literature on this topic, with very few high-quality studies; and further research is required to evaluate and improve the care of postoperative patients in the recovery room setting.

Contributors CL developed the review protocol, completed all title and abstract screening, full-text reviews and data analysis. She completed the risk of bias assessment with GL. CL also drafted and revised the manuscript. GL developed the initial review question, and assisted writing the review protocol. He also completed the full-text reviews, reviewed all data of included studies and completed the risk of bias assessment with CL. He also critically appraised the draft manuscript. DS assisted with developing the initial review question, and reviewed all included articles for consensus. He also critically appraised the draft manuscript and assisted with revisions. GM reviewed all included articles for consensus, and critically appraised the manuscript. All authors have given final approval for publication. There were no other contributors.

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Appendix 1.

PubMed Electronic Search Strategy

Postoperative period	Adults	Recovery room	Patient outcomes
“Postoperative Period”[mh] OR Anesthesia[mh] OR "surgical procedures, operative"[mh] OR "perioperative period"[mh] OR “Postoperative period”[tiab] OR “post anaesthes*”[tiab] OR “post anesthes*”[tiab] OR postoperative[tiab] OR “post operative”[tiab] OR "Anesthesia recovery period"[tiab] OR "Anaesthesia recovery period"[tiab] OR anesthesia[tiab] OR anaesthesia[tiab] OR "surgical procedures"[tiab] OR surger*[tiab] OR operation*[tiab] OR operative[tiab] OR "perioperative period"[tiab]	“adult”[mh] OR adult*[tiab] OR elderly[tiab] OR “young adult*”[tiab] OR “young people”[tiab] OR “aged person”[tiab] OR “aged people”[tiab] OR senior*[tiab] OR frail[tiab]	“recovery room”[mh] OR PACU[tiab] OR “recovery room”[tiab] OR “advanced recovery room”[tiab] OR “extended recovery room”[tiab] OR “post anaesthesia care unit*”[tiab] OR “post anesthesia care unit*”[tiab] OR “postanaesthesia care unit*”[tiab] OR “postanesthesia care unit*”[tiab] OR “post operative recovery unit*”[tiab]	"Patient outcome assessment"[mh] OR "treatment outcome"[mh] OR mortality[mh] OR "length of stay"[mh] OR "postoperative complications"[mh] OR reoperation*[mh] OR "Patient outcome assessment"[tiab] OR "patient outcome*"[tiab] or outcome*[tiab] OR "treatment outcome"[tiab] OR mortality[tiab] OR "fatal outcome*"[tiab] OR morbidity[tiab] OR "length of stay"[tiab] OR "postoperative complications"[tiab] OR "return to theatre"[tiab] OR complication*[tiab] OR "intensive care"[tiab] OR "intensive care admission"[tiab] OR "health outcome"[tiab] OR "adverse event*"[tiab]

Lloyd C, *et al*. *BMJ Open* 2020; 10:e027262. doi: 10.1136/bmjopen-2018-027262

Characteristics of Included Studies Additional Tables

Participants additional table:

Source	*Location and Setting*	*Inclusion Criteria*	*Exclusion Criteria*	*Ages involved*	*Gender*	*Exclusion of important groups*	*Numbers involved*
Callaghan, Lynch et al. 2005	Addenbrooke's Hospital. Cambridge, United Kingdom. Cambridge vascular unit, OIR (based in PACU) and ICU, within a major teaching hospital and research centre.	All patients undergoing elective open aortic surgery between 1/01/98 and 31/12/02.	Patients with missing case notes.	Median age for all patients was 72 (66-77)	Intervention group: 88% males Comparison group: 85% males	No group appears to be excluded from the study. However, some multi-morbid patients were not offered surgery.	Intervention group n=152 Comparison group n=26
Eichenberger, Haller et al. 2011	Geneva hospital Switzerland. Post Anaesthesia Care Unit (PACU), within a tertiary teaching hospital.	All elective and non-elective inpatients, who underwent a surgical or endoscopic procedure under anaesthesia (including major surgery and high risk surgical patients required temporary NIV, haemodynamic support and continuous monitoring).	Exclusion: multi-trauma, persistent intraoperative shock, transplants, cardiac surgery and intra-operative respiratory failure.	Before period: <49yo 34.25%, 49-67yo 32.6%, >67yo 33.3% After period: <49yo 34.7%, 49-67yo 32.5%, >67yo 32.8%	Intervention group: male 56.3%, female 43.7% Comparison group: male 55.9%, female 44.1%	No groups excluded apart from those patients already specified in the exclusion criteria.	Intervention group n=3345 Comparison group n=3030
Fraser and Nair 2016	Northern General Hospital Sheffield, England. Extended recovery unit within a tertiary teaching hospital, major trauma centre.	Elective surgical patients who would have previously been booked for level 2 care post-operatively. Including patients with significant comorbidities, endovascular AAA repair, carotid endarterectomy and revision arthroplasty.	Not stated	Not stated	Not stated	No apparent exclusion of specific population groups. Not specifically addressed.	Intervention group n=119
Kastrup, Seeling et al. 2012	The Charite-University Hospital Campus Mitte Berlin, Germany. PACU within a large tertiary teaching hospital.	All patients undergoing a surgical procedure (adults and children) between 1/01/08 – 30/04/11	Ambulatory surgical patients, patients who were readmitted to hospital for the same reason as the initial admission (due to issues with accuracy of the administrative database)	Not given	Not stated	No apparent exclusion of specific population groups. Not specifically addressed.	Intervention group n=26118 Comparison group n=24972
Schweizer, Khatchatourian et al. 2002	The University Hospital of Geneva, Switzerland. PACU within a tertiary teaching hospital.	Adult patients undergoing abdominal aortic reconstruction or resection of lung cancer.	Exclusion criteria not stated	Not stated	Not stated	No apparent exclusion of specific population groups. Not specifically addressed.	Intervention group n= 485 Comparison group n= 448

Street, Phillips et al. 2017	Three hospitals within one Australian metropolitan healthcare organisation. PACUs within the three hospitals.	All adult patients undergoing elective surgery on days of data collection before and after the implementation of PACT (before period July-Oct 2012) (after period July-Sept 2014). (Half the patients were day surgery cases.)	Emergency surgery, minor procedure only requiring sedation, post-operative planned admission to ICU.	Intervention group: mean= 50.87 (SD 17.4) Comparison group: mean= 52.14 (SD 18.6)	Intervention group: male= 38.8%, female= 61.2% Comparison group: male=41.6%, female= 58.4%	No specific groups appear to have been excluded from the study.	Intervention group n=694 Comparison group n=723
Tayrose, Newman et al. 2013	NYU hospital for Joint Diseases, New York. Recovery room and general orthopaedic ward.	900 consecutive hip and knee arthroplasty patients.	Not stated	Intervention group: mean= 63.7 Comparison group: mean= 64.3	Intervention group: male=125, female=206 Comparison group: male= 216, female=353	Unable to assess, and exclusion criteria are not stated.	Intervention group n=331 Comparison group n=569
Zoremba, Dette et al. 2009	University of Marburg, Germany. PACU within a tertiary teaching hospital.	60 obese adult patients (BMI 30-40) ASA 2-3, scheduled for minor peripheral surgery. Minimum surgery duration=40min, maximum surgery duration= 120 min.	Abdominal surgery, surgery requiring head-down tilt, history of GORD, hiatus hernia, likely difficult intubation, pregnancy, emergency operation, severe renal dysfunction, asthma requiring therapy, cardiac disease associated with dyspnoea (NYHA >2), severe psychiatric disorders or difficulties in cooperating during measurements.	Intervention group: mean 52 years Control group: mean 53 years	Not stated	Multimorbid patients with ASA >3 have been excluded (this is stated specifically in the exclusion criteria). All major surgery (including abdominal surgery) has also been intentionally excluded.	Intervention group n=30 Control group n=30

Interventions additional table:

Source	*Intervention name*	*Aims and rationale*	*Methods*	*Intervention delivery (staff and location)*	*Timing of intervention*	*Tailoring of intervention*	*Modifications made*	*Assessment of fidelity*
Callaghan, Lynch et al. 2005	Introduction of OIR (Overnight Intensive Recovery)	The majority of vascular surgical patients were routinely admitted to ICU post-operatively. However, several studies have demonstrated that extubation in theatre after AAA repair is safe[1] and that routine admission to ICU after infra-renal aortic surgery is unnecessary [2, 3].	Surgical patients assessed preoperatively by vascular surgeon and anaesthetist (ECG and full bloods). Patient referred to specialist if further pre-operative assessment is required. OIR located in theatre recovery. Maximum stay 24 hours. No facilities for mechanical ventilation or renal replacement therapy. Patients reviewed in the morning by surgical teams, and discharged to the ward if stable. If ongoing instability, patients transferred to ICU Face to face delivery of intervention No co-interventions apparent	Nurse to patient ratio 1:1 Day time medical coverage provided by PACU anaesthetist and vascular surgical teams. Overnight medical care provided by the on-call anaesthetist and general surgical teams. No specific training or upskilling period detailed. Pre-existing medical and nursing skills required	Intervention provided post-operatively for a maximum of 24 hours.	Post-operative medical care tailored to each patient. However, the OIR environment was not changed during the study.	OIR does not appear to have been modified or adapted during the study	No specific mention of steps taken to ensure fidelity in the OIR pathway. Anaesthetic techniques do appear to have been standardised, as well as post-operative analgesia.
Eichenberger, Haller et al. 2011	Introduction of a two-track clinical pathway that clearly defined & coordinated medical and nursing interventions.	Post-operative complications have a major impact on survival, especially in the older population [4, 5]. A clinical review of current practices prior to implementation of the pathway showed that poorly defined	Fast track pathway: nurse driven, ASA 1-2. At 15min intervals nursing staff evaluate patients' vitals using Aldrete score, and pain is assessed using verbal numeric rating scale. Slow track pathway: physician driven, ASA 3-	Fast-track programme: initial post-operative care prescribed by the anaesthetist and provided by the PACU nursing staff. Ongoing care is delivered by the PACU nursing staff only (unless	Fast-track programme: care provided immediately post-operatively. Discharge performed without further communication with the PACU anaesthetist if	Initial post-op treatment plan prescribed by the treating anaesthetist was tailored to the patient and their specific medical needs.	No adaptations appear to have been made to either pathway during the study period. However, this is not specifically discussed	Fast track pathway: methods of ensuring adherence to the pathway not discussed. Slow track pathway: adherence to the clinical pathway was ensured during daily rounds by the

		management and discharge criteria resulted in insecurity of the PACU physicians, nursing staff stress and delayed admission of patients from theatre. Evidence suggests that significant post-operative complications can be detected and successfully treated in well-organised PACUs, resulting in increased survival [6-9].	5 who have undergone minor or major surgery, or developed post-op complications. Formal handover to PACU anaesthetist. Standardised investigations and treatment guidelines for early post-operative complications. Intervention delivered face-to-face in PACU No co-interventions identified	there is evidence of a complication). Slow-track programme: care provided by the PACU anaesthetist with the help of nursing staff Pre-existing skills required: PACU specialist nursing staff (overnight nurse also ICU qualified). No specific training for either nursing staff or medical staff is detailed in the study.	Aldrete score is ≥ 8 and the verbal numeric rating scale is ≤ 3 Slow-track programme: care provided immediately pos-operatively. Discharge based on Aldrete score ≥8 and normal blood gas analysis. PACU physician in charge decides on discharge			medical head of the PACU, and during weekly quality control, feedback and information meetings.
Fraser and Nair 2016	Opening of an extended recovery unit	Was felt that some patients admitted to critical care post-operatively only required short term monitoring and optimisation [10]. Unnecessary admissions of patients to critical care increases bed occupancy in the unit, and was contributing to significant numbers of OT cancellations.	Extended Recovery Unit was opened in Oct 2014. Patients booked into the unit in advance. 4-6 hour stay. Standard form was completed by nursing staff for every patient: recording time and place of discharge, complications encountered and medical assistance required. (Recorded how many patients were assessed as safe to return to ward, and how many still required level 2 care) Nil co-interventions evident	Anaesthetists provided post-op medical care/ plans in the extended recovery unit. Recovery nursing staff provided care and completed the standard service evaluation form.	Patients stayed in the extended recovery unit for 4-6 hours post-op.	Not tailored	No	No mention of steps taken to ensure standardisation of treatment. Standard form provided to nursing staff, but no mention if forms were audited to ensure correct data collection.
Kastrup, Seeling et al. 2012	Introduction of intensivist coverage in PACU	Increasing demand for critical care, which can lead to capacity limitations in the ICU. This causes	PACU physician is in charge of allocation of patients to the PACU, ICU and IMCU (intermediate care unit)	Staffing of the PACU was changed so that both the nursing and physician staffing are covered by the ICU	Intervention provided immediately post-operatively.	Immediate post-operative care tailored to each patient by the treating	No apparent modification to the intervention were made	There is no mention of fidelity assessment. As intervention was a change in staffing

		delay in admissions of patients from ED, cancellation of surgery[11, 12], early discharge from ICU [11, 13-15], initiation of treatment in ED or on a standard ward and inter-hospital transfers [12, 16].	in collaboration with the surgeons. If no intensive care bed available, patients can be treated in the PACU for up to 24 hours (independent of the degree of organ failure) There are 6 beds with complete intensive care monitoring and respiratory care possibilities available. Face to face delivery of intervention No co intervention evident or discussed	team. The physician staffing was changed to a 24hr in-house critical care physician and nurse presence for the PACU. 1:3 nurse, patient ratio. 1 physician for all PACU patients.	Patients can be immediately admitted to the PACU around the clock (without any delays).	anaesthetist and surgeon.	during the study period.	model, this would have been monitored by the anaesthetist/ ICU physician in charge.
Schweizer, Khatchatourian et al. 2002	Opening of a new PACU (post-anaesthesia care unit)	Utilisation of the ICU for routine post-op care is commonplace, however ICUs account for an increasing proportion of a hospitals budget [17-19].	PACU moved to an area closer to theatres and the ICU, and was expended with additional beds to provide overnight care following major, non-cardiac surgery. Standardised rounding (morning and evening), with review of patient's clinical status, laboratory results and chest radiographs. Co-interventions: Preoperative risk assessment guidelines of the American Heart association and the American College of Cardiology (AHA/ACC) were introduced, and antiadrenergic medications (beta-blockers and alpha-2-agonists) were	New PACU staffed with anaesthesia-trained nurses (1:3 ratio), post-operative care coordinated by cardiothoracic surgical and anaesthesia teams, 24-hour medical coverage provided by one PACU resident (supervised by an attending).	New PACU provided 24-hour medical coverage. Patients were admitted immediately post-operatively. (Time limit on PACU admission not specified)	Post-operative care standardised as much as possible, but ongoing care tailored to each patient based on pre-existing medical comorbidities, intra-operative events and post-op complications	Intervention does not appear to have been altered during the study period	Variations in medical practice were minimised using standard protocols for blood test analysis, CXR orders, antibiotic prophylaxis, pain control, fluid administration, respiratory therapy, nutrition and mobilisation. All surgical procedures and approach standardised as much as possible. General anaesthesia standardised. Post-operative analgesia regimen also standardised.

			increasingly administered peri operatively					
Street, Phillips et al. 2017	Implementation of a Post Anaesthesia Care Tool (PACT)	Current post-operative death rate of 0.4-4%, and major complication rate of 3-17%. 40% of in-hospital complications are associated with surgery [20, 21]. Hospital costs for surgical patients experiencing a complication are significantly higher than for patients without complications [22-24]. Intensive observation of patients in PACU by nurses can help with the early detection of complications [25].	Implementation of the tool was supported by peri-operative nursing educators. Materials included posters summarising how to complete the PACT, and feedback sessions between the nurses using the tool and the perioperative team. PACT was included in the revised 'Post-anaesthetics care record' Working party was established to develop the tool. Extensive review of the current processes at each of the hospitals was done. Researchers conducted a systematic review and an expert consensus statement to evaluate the current evidence. PACT tool developed in line with the National Consensus Statement on the essential elements for recognising and responding to clinical deterioration. Face to face delivery of the intervention. No co-interventions apparent.	Perioperative nurse educators trained recovery nurses in the use of the tool. Feedback sessions during the training period were attended by the perioperative team including, educators, nurse unit managers and the quality unit of the organisation. Recovery nursing staff used the PACT in recovery. Medical staff responded to concerns that were triggered by the PACT	PACT used immediately post-operatively, until patient was safe for discharge to the ward (of home for day surgery patients). Patient readiness for discharge from PACU was recorded by a checklist of criteria: last 2 sets of observations were not within the MET criteria, no active vomiting, pain management ordered and all surgical concerns had been met.	Intervention does not appear to be tailored.	No modifications appear to have been made once the study period commenced.	Feedback sessions during the training period were attended by the perioperative team including, educators, nurse unit managers and the quality unit of the organisation. However, there is no mention of fidelity assessment or auditing once the tool was in use.
Tayrose, Newman et al. 2013	Rapid rehab patients started as part of a pilot	Previous studies have shown that early mobilisation after	Therapy program was the same for each group: therapist would	Physiotherapists delivered the intervention	Therapy commenced in the	Intervention was tailored to the speed of recovery	No adaptations or modifications appear to have	No assessment of fidelity reported. Unclear how the

	program where the first 2 cases of the day were mobilised in the recovery room.	total joint replacement enhances post-op recovery and promotes faster rehabilitation [26, 27]. Previous studies have also demonstrated early mobilisation leads to a decreased LOS, improve patient outcomes, and demonstrate cost savings [28-30]. However, it's unclear if early mobilisation that starts in the recovery room will lead to a reduction in LOS while maintaining patient outcomes.	start with having patients hang their legs over the side of the bed. Therapy would then progress with transferring to a chair, ambulation, and climbing stairs. The expectation for a patient was to ambulate 100 feet or greater, and climb 6 stairs, prior to discharge. Face to face delivery of intervention by physiotherapists No co-interventions described	Standard rehabilitation program implemented. Reliance of physiotherapists pre-existing skills and training.	recovery room on the day of surgery	of each patient. If a patient was unfit to mobilise on the day of surgery in PACU (as per the anaesthetist, surgeon or ICU doctor), they were not mobilised despite being one of the first 2 cases for the day.	occurred during the study.	standardisation of the rehabilitation program was ensured.
Zoremba, Dette et al. 2009	Patients performed incentive spirometry in the PACU	Even several days after surgery, obese patients exhibit a measurable amount of atelectasis, predisposing them to post-op pulmonary complications [31-35].	Physiotherapist supervised the respiratory physiotherapy treatment at all times. Exercises were started approximately 15 minutes after extubation, and the patients were encouraged to perform 15 deep breaths (incentive spirometry) every 10-15 minutes within the first 2 hours after surgery. If needed, patients were asked to cough during the pause to mobilise secretions. All therapy was performed in the sitting position if possible.	Physiotherapists supervised the respiratory physiotherapy treatment at all times Pre-existing skills required to deliver the intervention. No mention of specific training provided to the physiotherapists apart from the study protocol.	Intervention was delivered commencing 15 minutes post-operatively, continuing until 2 hours after surgery.	Intervention does not appear to have been tailored	No change to intervention during the study	Spirometry was standardised as much as possible. At each assessment time, spirometry was performed at least 3 times, and the best measurement was recorded (in line with the criteria of the European Respiratory Society). Factors that interfered with breathing (eg pain, shivering) were eliminated, or minimised to produce reliable measurements)

			No co-interventions described					

Outcomes and comparison groups additional table:

Source	*Primary outcomes*	*Method of assessing primary outcome measure*	*Timing of primary outcome assessment*	*Adverse events*	*Secondary outcomes*	*Method of assessing secondary outcome measure*	*Timing of secondary outcome measure*
Callaghan, Lynch et al. 2005	In hospital mortality In hospital morbidity Mean postoperative stay, days Mean ICU stay, days Median POSSUM operative severity score	Patients who had surgery were identified using a combination of computerized theatre records, surgeon's logbooks, and theatre booking diaries. Case notes analysed retrospectively. POSSUM variables collected prospectively (during the pre-operative assessment)	Retrospective analysis No follow-up required	OIR group: Admission to ICU within 48 hours of surgery	Operative characteristics. Common post-operative complications.	Case notes analysed retrospectively. Only complications occurring on more than four occasions during the study period are included.	Retrospective analysis of notes. No follow-up required.
Eichenberger, Haller et al. 2011	PACU length of stay	Anaesthetic Information system (computerize patient information system. PACU data entered by PACU nurses and PACU secretary)	Data entered in real time in PACU. Data reviewed retrospectively by investigators.	Nil reported	Nil reported	NA	NA
	In-hospital mortality	The hospital administrative database (administrative information used for financial purposes). Cause of death extracted from patient discharge reports, and entered into the administrative database by professional coders.	Data entered throughout the post-operative period until discharge. Data reviewed retrospectively by investigators				
	Unplanned ICU admissions after PACU stay	The hospital administrative database. Reason for unplanned ICU admission extracted from patient discharge report and entered into database by professional coders.	Data entered throughout the post-operative period. Reason for ICU admission entered after patient discharge.				
Fraser and Nair 2016	Discharge destination after extended recovery unit admission	Standard form completed by nursing staff in extended recovery, documenting time and place of discharge, complications encountered and medical assistance required.	Assessment made at time of extended recovery discharge. No follow-up done.	Nil reported	Nil reported	NA	NA

Kastrup, Seeling et al. 2012	LOS in PACU (days) LOS in ICU (all types of ICU's)(days) Pre operative days (all patients) Pre operative day (PACU-patients) Pre operative day (ICU-patients) Days on normal ward LOS hospital (days) CMI (case mix index) normal ward CM ICU CW (cost weight) per hospital stay (overall)	Data collected from the hospital administration system. All clinically relevant data are documented in a patient data management system (PDMS) and can be extracted for evaluations. Every patient admitted to the ICU in included in the system (COPRA-System® GmbH, Sasbachwalden, Germany). 24-hours after patient discharge, the record is changed to a read-only version so that no modifications can be made.	Retrospective analysis of data. Data continuously collected until patient discharge. No follow-up post-discharge.	Nil reported	General descriptive variables for the ICU, before and after the introduction of the PACU (ICU patients only).	Data extracted from patient data management system (PDMS). DRG system allows for coding of the intensive care as DRG procedure, making the severity of disease relevant for reimbursement. The "Complex intensive care treatment" is based on several scores, which are collected within the PDMS system.	Retrospective analysis of data. Data continuously collected until patient discharge. No follow-up post-discharge.
Schweizer, Khatchatourian et al. 2002	Mortality	Data prospectively collected on standardized worksheets describing the pre-operative, intraoperative and postoperative periods. One investigator also reviewed all nursing charts, medical records and hospital discharge letters.	Outcome assessments done during inpatient stay, and on review of the hospital data base. No follow-up required after hospital discharge	Nil reported	Identification of independent risk factors for mortality and major complications following thoracic surgery	Data abstracted from two institutional databases	Patient risk factors reported pre-operatively and intraoperatively (prospective data collection). Analysed at a later date
	Re-operation	Data abstracted from two institutional databases					
	Secondary admission to ICU (either from PACU or from the ward)	Data obtained from the hospital computer			Identification of independent risk factors for mortality and major complications following major vascular surgery		
	Cardiac complications • Myocardial infarct • Arrhythmias • Pulmonary oedema	Data were prospectively collected on standardized worksheets describing the pre-operative, intraoperative and postoperative periods. One investigator also reviewed all nursing charts, medical records and hospital discharge letters.					
	Respiratory complications • Atelectasis • Bronchopneumonia	As above			Evaluation of perioperative antiadrenergic treatment administration		
	Mechanical ventilation >6 hours	As above					
	Renal dysfunction	As above					

	Hospital length of stay	Data obtained from the hospital computer					
Street, Phillips et al. 2017	Nursing management of patient symptoms Rates of adverse events Mortality Length of stay in PACU Length of hospital admission Discharge destination	Data collected by research nurses from the medical record following patient discharge. Severity of each adverse event was graded using the Common Terminology Criteria for Adverse Events (V.4.03) and grouped into mild (no or minimal effect to the patient and resolved spontaneously), moderate (event with resolved after intervention, with no lasting effect for the patient) and severe (required intervention and caused harm to the patient, including death).	Data reviewed from case notes on patient discharge. No longer term follow-up required.	Nil reported	Health service usage and healthcare costs	Economic evaluation done from organization data that were routinely submitted to the regional health department for benchmarking. Healthcare costs for each patient admitted to hospital are calculated on a cost-weight analysis using the Australian Refined Diagnostic-Related Groups (AR-DRGs). The AR-DRG was used to calculate the costs for all initial admissions and unplanned readmission, using the nations efficient price determination.	Data reviewed from case notes on patient discharge. No long term follow-up required.
Tayrose, Newman et al. 2013	Overall hospital length of stay Hip arthroplasty subgroup length of stay Knee arthroplasty subgroup length of stay	Retrospective review of cases, however it is not stated how this was done (case note reviews versus use of the hospital's database)	At time of discharge	Nil reported	Percentage completion of the rapid rehabilitation program	Progression of rehab was followed, however methods for assessing this were not stated.	Followed as an inpatient until the time of discharge.
Zoremba, Dette et al. 2009	Pulse oximetry at 1hr, 2hr, 6hr and 24hr post-operatively Spirometry at 1hr, 2hr, 6hr and 24hr post-operatively	Assessed face to face by an investigator. The investigators were blinded.	At 1hr, 2hr, 6hr and 24hr respectively	Nil reported	Nil reported	NA	NA

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Overall percentage (%)	50		
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Incidence of early major adverse events after surgery in moderate-risk patients: early postoperative adverse events

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Editor—A high incidence of postoperative complications is recognised, especially in 'high-risk' groups,[1,2] although recent data suggest this is also an issue for lower- or 'moderate'-risk patients.[3] As populations become older and sicker, it is expected that this problem will increase substantially for all groups.[4] For moderate-risk patients (predicted 30-day mortality of 1–4%), there are retrospective data to suggest that brief higher-acuity care may have lingering effects on postoperative complications and efficiency measures, such as length of stay.[3] An advanced recovery room care (ARRC) model has been proposed for these patients, with the key principles being moderate-risk identification, continuity of care, using existing recovery resources, minimising handovers, structured care and checklists, and Day 1 triage to ongoing care. A multicentre feasibility before-and-after trial, including patient follow-up to 90 days, is ongoing in three hospitals. This will be reported in full on completion, which is anticipated by early 2020. However, because of evidence of a previously unrecognised very high incidence of early postoperative complications from one site revealed by the ARRC, initial data on adverse events are reported here.

Because of concerns about postoperative complications, a feasibility trial of an ARRC model for 'moderate-risk' patients is being conducted. This is a prospective randomised multicentre before-and-after feasibility trial, with ethics approval (HREC/17/TQEH/104) and prospective registration (ANZCTRN 1261700117338). Eligibility was primarily based on the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) score, a well-validated tool that accounts for patient co-morbidities and the nature of surgery to predict the risk of postoperative adverse events and 30-day mortality.[5] Patients studied were those with an NSQIP-predicted 30-day mortality of 1–4% and scheduled for postoperative management on normal postoperative surgical wards. In the 'before' period (5 weeks), up to 16 patients were identified weekly and treated with usual recovery and ward care. After 4 weeks of training, the 'after' period with the ARRC ran for 5 weeks, with eligible patients treated until the morning of Day 1. The primary endpoint was 80% recruitment and follow-up. Two sites completed the 'before' and 'after' arms, with one site yet to complete the after arm. The secondary endpoints included quality of recovery; serious adverse events,

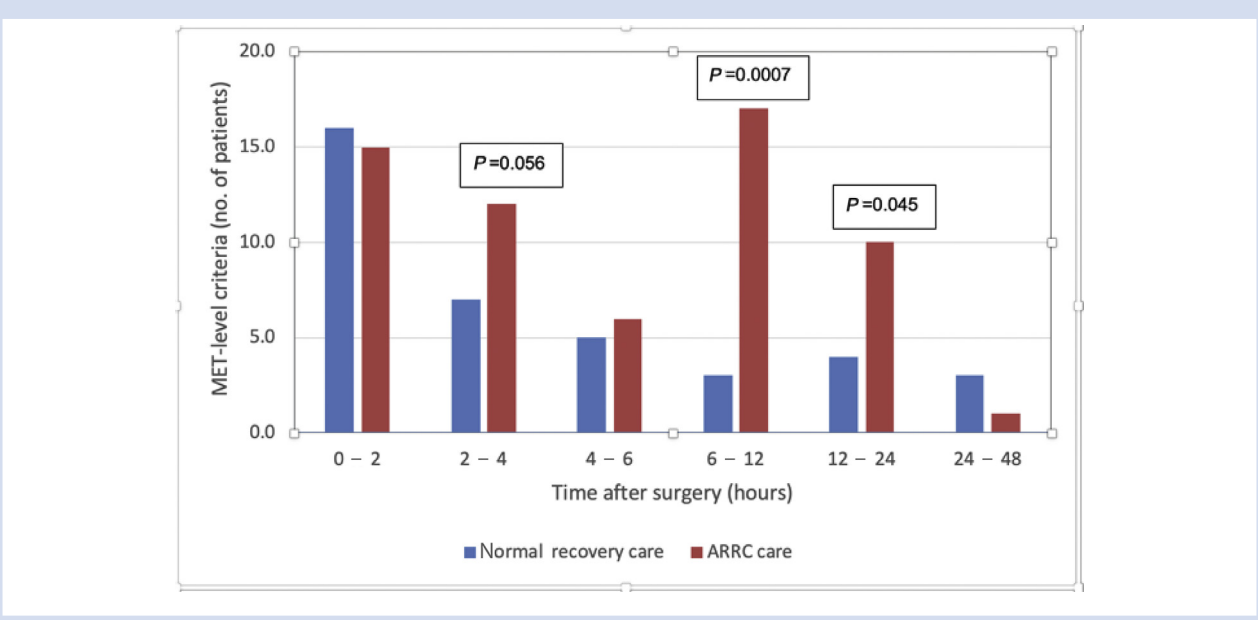

Fig 1. Percentage of patients in whom medical emergency team (MET)-level events were detected over time after surgery when managed in the ward or when closely observed in advanced recovery room care (ARRC) until the morning of Day 1.

which would usually precipitate calling of a medical emergency, or rapid response, team (MET-level events)[6]; ICU admissions; length of stay; 90-day readmissions; mortality; and quality of life. Case notes and study case report forms were manually examined for events that would meet the hospital's criteria for a medical emergency response (MET call). At the Royal Adelaide Hospital site, the site with the largest data set, MET-level events were collected from the time of arrival in the recovery room, with data analysed using a binary logistic generalised-estimating-equation modelling—events *vs* interaction of time and period, adjusting for repeated measurements over time (SAS 9.4; SAS Institute Inc., Cary, NC, USA).

Observations at one site revealed a high, sustained incidence of adverse events, usually undetected in hospital wards. In total, 126 patients were recruited at the Royal Adelaide Hospital (n=71 'before'; n=55 'after') between April and July 2018. Recruitment targets of 71 (89%) and 55 (92%), and follow-up targets of 68 (85%) and 53 (88%) were achieved for the 'before' and 'after' groups, respectively. The groups were well matched, with age (mean; standard deviation) of 72 (12) and 73 (11) yr (P=0.432), and NSQIP-predicted 30-day mortality (median; inter-quartile range) of 1.5% (1.2; 2.5) and 2.0% (1.4; 2.7) (P=0.0832) for the 'before' and 'after' groups, respectively. The profiles of the ASA physical status differed between groups: (['before' ASA 1: 0%, ASA 2: 7%, ASA 3: 93%, and ASA 4: 1%; 'after' ASA 1: 0%, ASA 2: 20%, ASA 3: 80%, and ASA 4: 0%]; [P=0.0303]). The incidences of MET-level events in both groups are displayed in Figure 1. In both groups, these events were frequently detected during periods of close observation in the recovery room in the initial hours after surgery. In the 'before' group managed on surgical wards, the MET-level events were relatively uncommon and declined rapidly over time. In the 'after' group, who stayed in recovery with frequent observations and regular care by anaesthetists, the MET-level events were detected very frequently. Of note, these events were very common in the period when patients would usually be managed in surgical wards and commonly after-hours. In the period 24–48 h after surgery, when all patients had been discharged from recovery or ARRC, the frequency of MET-level events was 4.6% (three patients) in the 'before' group and 1.9% (one patient) in the 'after' group (P=0.421).

These MET-level data from one hospital, and the close matching of the 'before' and 'after' groups, suggest that there is an undetected and unmanaged high incidence of serious adverse events in moderate-risk surgical patients receiving standard postoperative ward care. Frequent observations in a recovery room setting allowed early detection of these events and rapid implementation of care by anaesthetists and surgeons if needed. Data on the association between adverse events, such as hypotension, and poor outcomes are now described,[7–10] suggesting some of these undetected adverse events may have consequences for patient recovery and outcomes. Data from the UK revealing that loss of higher acuity care was associated with higher complication rates and longer lengths of stay suggest that there are also cost consequences for institutions.[3] The impact of ARRC on short- and long-term patient outcomes and costs will be available on completion of this multicentre trial, although, based on these data, quality improvement activities to address this issue at the Royal Adelaide Hospital have already commenced. The ARRC trial is a feasibility trial and not powered for outcomes, although the data from this single site suggest that adverse events are much more common than anticipated, and it is possible there is reversal in the incidence of MET-level events after discharge from the ARRC based on the 24–48 h data presented here. Alternate approaches to postoperative ward care may be indicated.

Declaration of interest

The authors declare that they have no conflicts of interest.

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Original Article

The effect of advanced recovery room care on postoperative outcomes in moderate-risk surgical patients: a multicentre feasibility study

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Summary

Postoperative complications are common and may be under-recognised. It has been suggested that enhanced postoperative care in the recovery room may reduce in-hospital complications in moderate- and high-risk surgical patients. We investigated the feasibility of providing advanced recovery room care for 12–18 h postoperatively in the post-anaesthesia care unit. The primary hypothesis was that a clinical trial of advanced recovery room care was feasible. The secondary hypothesis was that this model may have a sustained impact on postoperative in-hospital and post-discharge events. This was a multicentre, prospective, feasibility before-and-after trial of moderate-risk patients (predicted 30-day mortality of 1–4%) undergoing non-cardiac surgery and who were scheduled for postoperative ward care. Patients were managed using defined assessment checklists and goals of care in an advanced recovery room care setting in the immediate postoperative period. This utilised existing post-anaesthesia care unit infrastructure and staffing, but extended care until the morning of the first postoperative day. The advanced recovery room care trial was deemed feasible, as defined by the recruitment and per protocol management of > 120 patients. However, in a specialised cancer centre, recruitment was slow due to low rates of eligibility according to narrow inclusion criteria. At a rural site, advanced recovery room care could not be commenced due to logistical issues in establishing a new model of care. A definitive randomised controlled trial of advanced recovery room care appears feasible and, based on the indicative data on outcomes, we believe this is warranted.

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Introduction

Postoperative complications are common and result in increased healthcare costs [1, 2]. Recent data suggest the magnitude of this problem is under-recognised, especially very early after surgery [3]. The rising global volume of surgery [4], ageing populations and increasing frequency of

comorbidities, all suggest that postoperative complications will increase substantially in the future [5]; this will have a negative impact on patient-centred outcomes (including quality of life [6]) and will result in increased healthcare expenditure. There is evidence that patients who have adverse events (e.g. hypotension) in the recovery room (also known as the post-anaesthesia care unit (PACU)) are more likely to require interventions on the postoperative ward [7]. In fact, postoperative hypotension is associated with an increased incidence of acute kidney injury, myocardial infarction and mortality [8]. Studies have shown that enhanced interventions in the PACU may have positive effects on the incidence of in-hospital complications in moderate- and high-risk patients [9], and on intensive care admission [10, 11]. This suggests that a model of extended PACU care warrants further exploration. A recent single-centre retrospective analysis of early brief high dependency care in moderate-risk patients (predicted 30-day mortality of 1–4%) was associated with a reduction in postoperative complications [12]. Furthermore, recent discussions in the UK have highlighted the potential need for mid-level postoperative care, sitting between ward and intensive care unit (ICU) levels of care [13]. Therefore, we proposed a model of advanced recovery room care (ARRC) using existing PACU infrastructure, including personnel and the range of care usually involved in the PACU, but extended until the first postoperative day. The name ARRC was deliberately chosen to emphasise its links to recovery room staff and capacity, with 'advanced' chosen to highlight the emphasis on consistent processes. We conducted a multicentre pilot before-and-after feasibility study to test this model of care. The aim of the intervention was to improve the recognition and treatment of complications, which might subsequently reduce postoperative morbidity and healthcare costs. The primary hypothesis was that a clinical trial of ARRC was feasible, and thus would potentially allow a subsequent larger trial to be conducted [14]. An exploratory secondary hypothesis was that this model may have a sustained impact on postoperative in-hospital and post-discharge events.

Methods

Ethics committee approval was obtained, with approval for opt-out consent and the trial was registered prospectively. This study was a multicentre, prospective, feasibility trial with before-and-after study cohorts consisting of moderate-risk patients who were listed for non-neurosurgical and non-cardiac surgery and were scheduled to receive postoperative ward-level care. Moderate risk was defined as a 30-day mortality of 1–4% predicted by the American College of Surgeons National Surgery Quality Improvement Program (NSQIP) risk stratification tool; this incorporates patient and surgical factors to determine the probability of postoperative events [15]. Other inclusion criteria were: age ≥ 18 years; predicted duration of hospital stay ≥ 2 days (to allow in-hospital assessment of quality of recovery); good English comprehension; and likely availability for follow-up at 90 days.

Recruitment of patients occurred based on surgery conducted from Monday to Thursday for each period, in order to avoid weekend staffing. To test feasibility, we anticipated two phases of about 5 weeks each, in order to test data collection during usual care, and then to test both clinical implementation and data collection in the intervention phase. We anticipated that we would test feasibility based on a pragmatic, convenient sample size that reflected each of the participating hospitals' workload and capacity. We estimated at least 120 patients would be adequate to test feasibility. Three different types of hospitals participated in this study: the Royal Adelaide Hospital (RAH), a large metropolitan tertiary centre which treats a wide range of adult patients requiring emergency and elective surgery, aimed to recruit three to four patients per day, 4 days a week; the Peter MacCallum Cancer Centre (PMAC), a tertiary hospital largely treating cancer patients requiring elective surgery, with emergency and ICU patients largely cared for in an adjacent large public hospital, aimed to recruit one to two patients per day, 4 days a week; and Lismore Base Hospital (LBH), a regional base hospital with an ICU, aimed to recruit two to three patients per day, 4 days a week. At RAH and LBH, an experienced trials nurse screened theatre lists for potentially suitable patients. At PMAC, all patients attending the pre-anaesthetic clinic and those on the weekly theatre lists were screened by an anaesthetist and two experienced research nurses.

There were three defined time periods within this feasibility trial: a 5–8-week before-period; then a training period to establish ARRC procedures; and then a 5–8-week after-period. Patients were initially treated in the PACU and then transferred to the ARRC area, an existing space within, or adjacent to, the PACU. Advanced recovery room care utilised the same range of staff and care usually involved in the PACU. Care during the day was primarily from the pool of anaesthetists in the theatre complex, with evening care until 22:00 provided by a rostered anaesthetist or senior registrar. Overnight care was provided by registrars already available for emergency cases, supported by a specialist anaesthetist on remote call. Nursing ratios were 2:3 (RAH) and 1:1 (PMAC) for the purposes of the trial and data collection, but were envisaged to be in the order of 1:2 to

1:3 going forward. The range of care available included continuous invasive cardiovascular monitoring and administration of vasopressors, but excluded invasive or non-invasive ventilation (with the exception of pre-existing continuous positive airway pressure (CPAP) therapy). The level of monitoring was left to the discretion of the attending medical staff, as was the choice of treatment of any identified postoperative complication or medical issue (e.g. hypotension, desaturation, uncontrolled postoperative pain, bleeding etc.).

In addition to standard PACU care, there were some specific additions to ARRC, aligning with the quality principle of consistency in care. Patients were reviewed regularly by an anaesthetist (hourly for the first 3 h, then 3-hourly until 22:00), and thereafter as requested by nursing staff. A 19-point checklist (see online Supporting Information, Figure S1) was used at each review, which assessed key parameters such as cardiorespiratory vital signs, urine output, pain scores and blood glucose, with specific focus on the criteria for ward-care escalation (such as calling the medical emergency response team (MERT)) [16]. Care escalation to the MERT is part of defined standards for Australian healthcare, and criteria for escalation are consistent across hospitals (see online Supporting Information, Figure S2). However, MERT escalation was not utilised as part of ARRC, as specialised staff were available to manage these situations. The checklist was used to identify abnormal parameters, and required clinicians to record the treatment instituted for each. This ensured identified problems were not left unnoticed, and assisted other clinicians who may subsequently takeover care. Other medical staff from surgery or internal medicine were available for issues within their specific area of expertise. The goal was to have all parameters within the normal physiologic range for ward-level care by the morning of the first postoperative day. In the morning, patients were reviewed by an anaesthetist, the checklist was completed again, and then patients were handed over to ward medical and nursing staff. If a patient was determined to be unsuitable for ward-level care, additional treatment was instituted. The patient was then either planned for review later that morning, or a referral was made to ICU for ongoing management; this was because ARRC was limited to managing patients within the first 24 h of their surgery.

Patients were followed-up daily as in-patients, with written consent occurring at postoperative day 2 or the most suitable later opportunity. This was then followed by assessment of the quality of recovery score (QoR-15) [17]. Other trial endpoints were recorded from case notes and by telephone follow-up conducted at postoperative day 90.

The primary outcome measure was the feasibility of recruitment and postoperative follow-up of a total of 120 patients. Exploratory in-hospital outcome measures also assessed included: the number of patients meeting MERT escalation criteria; incidence of unplanned ICU admissions; quality of recovery scores; duration of hospital stay; and 90-day mortality. Exploratory post-discharge outcome measures were also investigated and included: quality of life at postoperative day 90 (EQ-5D-5L, summed scores from all domains) [18]; days alive and out of hospital; and hospital readmissions. As this was an exploratory study with the primary endpoint being feasibility, no formal sample size calculation was performed. In line with guidelines for feasibility trials [19], data for secondary endpoints are reported descriptively, without formal statistical testing.

Results

A total of 200 patients were recruited. The proportion of patients who met exclusion criteria for the study varied between sites, and was dependent on the hospital case-mix and recruitment method used (Figs. 1–3). At RAH, experienced trials nurses had rates of exclusion of 74/146 (51%) and 43/98 (44%) for the before- and after-periods, respectively. The most common exclusion criteria were: NSQIP scores being out of range (often too low); and patient unwillingness to participate. At PMAC, all patients who attended the pre-anaesthetic clinic and/or were on a theatre list were screened, reflecting the high numbers screened but not included. Once again, the most common exclusion criterion at PMAC was NSQIP scores being out of range.

Of those patients recruited, 126 were recruited at the RAH (April 2018 to July 2018: 71 patients in the 5-week before-period, and 55 patients in the 5-week after-period) and 40 patients were recruited at PMAC (August 2018 to January 2019; 24 patients in the 8-week before-period and 16 patients in the 8-week after-period). Before- and after-periods were separated by a 4-week training period at both hospitals. Although LBH recruited 34 patients in the 8-week before-period (October 2018 to December 2018) it was not possible to commence the training and after-period within the timeframes set for the trial; the data from this site were, therefore, excluded from analysis. Patient characteristics are shown in Table 1. Overall, patients were at the lower end of the moderate-risk range and were predominantly ASA physical status 3. There was reasonable matching in the before- and after-periods at both sites. There was reasonable within-site variation in types of surgery, but substantial between-site variation, reflecting the individual

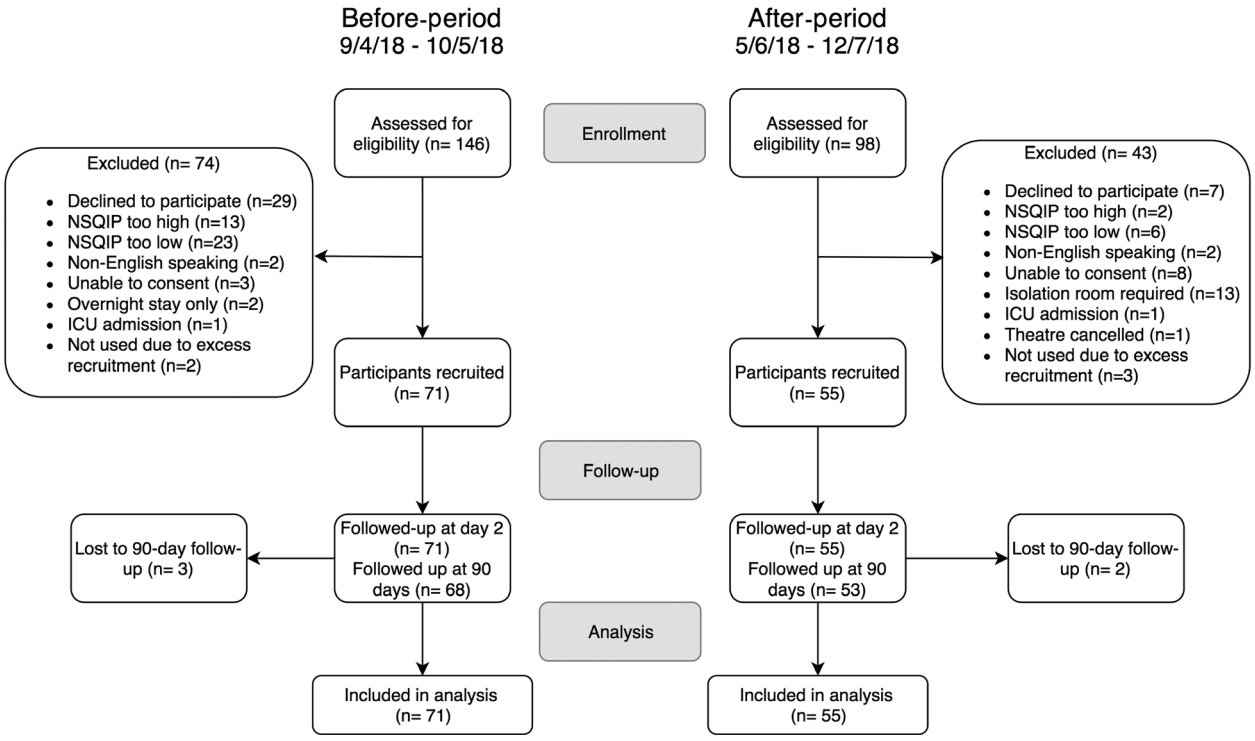

Figure 1 Study flow diagram of patient recruitment at the Royal Adelaide Hospital for the before- and after-periods. NSQIP, American College of Surgeons National Surgical Quality Improvement Program; ICU, intensive care unit.

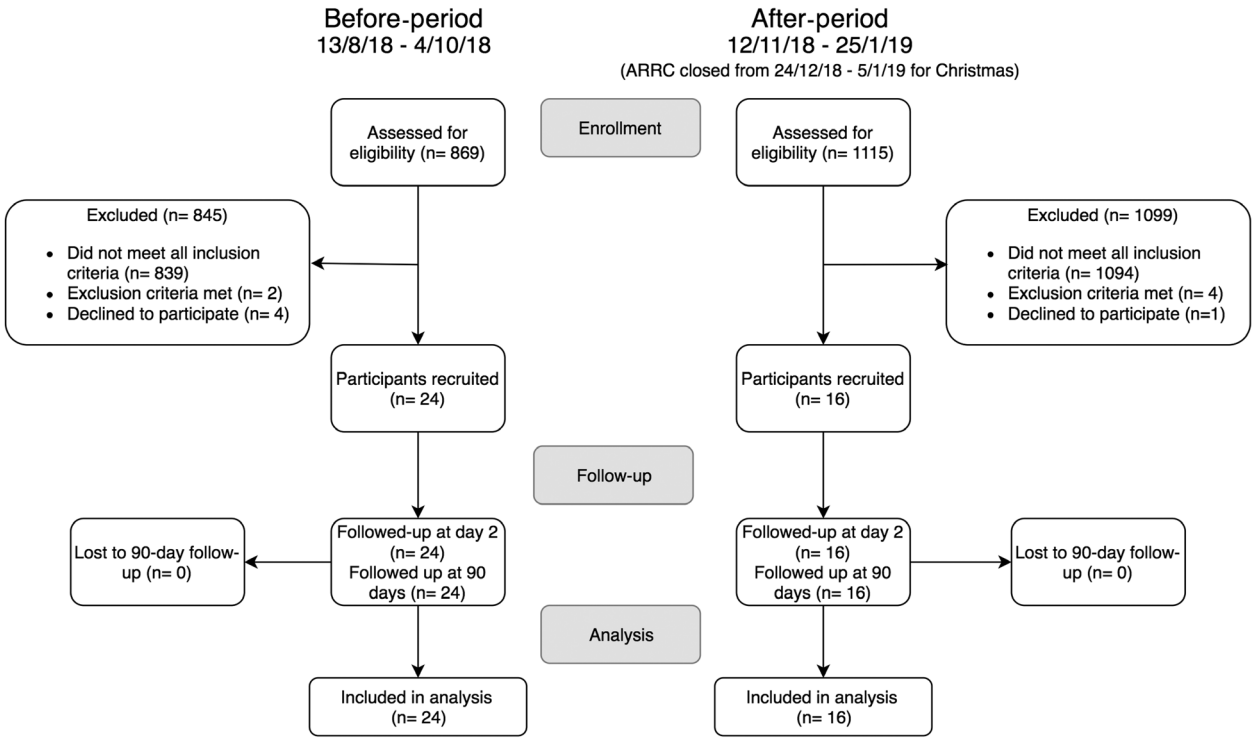

Figure 2 Study flow diagram of patient recruitment at the Peter MacCallum Cancer Centre for the before- and after-periods.

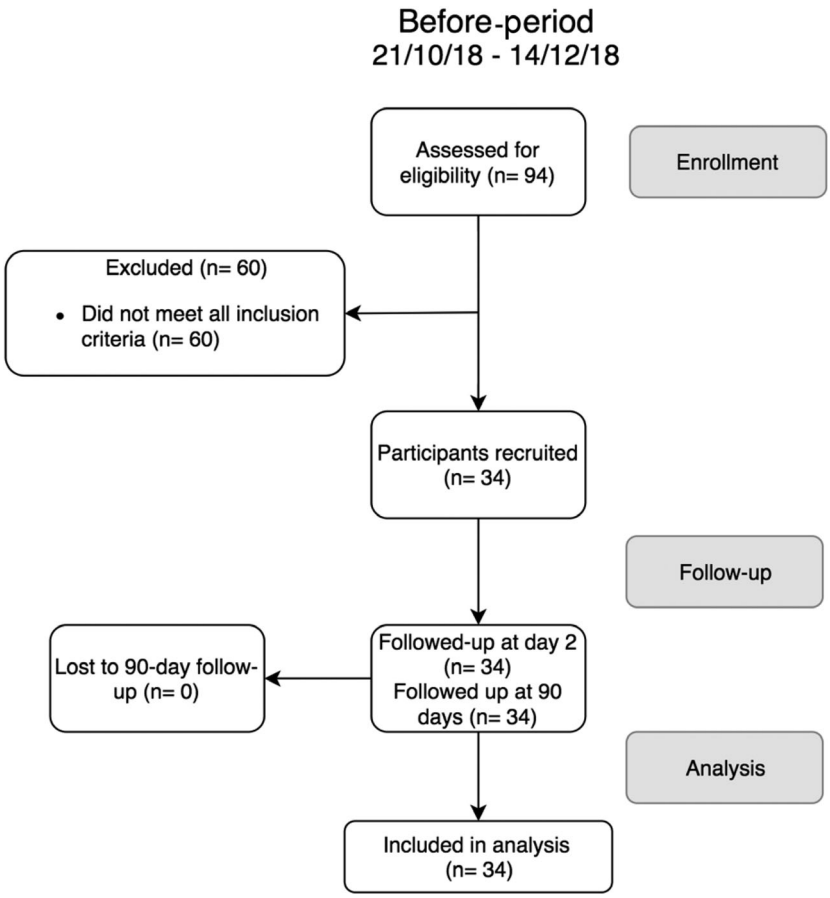

Figure 3 Study flow diagram of patient recruitment at Lismore Base Hospital for the before-period only (this site did not complete the after-period).

hospitals' roles, with the absence of emergency, vascular and orthopaedic surgery at PMAC being the most noticeable difference.

Follow-up rates at 90 days for the before- and after-periods were 68/71 (94%) and 53/55 (96%) for RAH and 24/24 (100%) and 16/16 (100%) for PMAC, respectively. These follow-up rates suggest that the ARRC trial was feasible, with > 120 patients recruited and followed-up at 90 days. However, recruitment was slow at PMAC with many patients being ineligible for exclusion for the reasons discussed earlier.

Patient review and completion of the checklist per protocol occurred in 220 of 246 (88%) and 84 of 123 (68%) of scheduled reviews at RAH and PMAC, respectively. The most common time for a missed review at RAH was in the late afternoon or early evening, around the time of elective list completion and transition to after-hours staffing. The compliance with checklist completion at PMAC was much lower in the final two weeks of data collection in January 2019 which occurred after a break in recruitment due to operating suite closure for the December holiday period. This highlights the importance of lead-in training periods and continuity in research protocols.

A number of postoperative events were measured in this study, reflecting its exploratory nature (Table 2). Serious in-hospital adverse events, as defined by patients meeting the criteria for care escalation to a MERT call, were very common. The predominant groups of adverse events within the RAH cohort were as follows: haemodynamic (blood pressure and fluid-related): 27/55 patients (49%); respiratory-related 4/55 patients (7%); and pain-related 3 patients (5%).

Discussion

We have shown that a trial of ARRC is feasible in a tertiary hospital, such as RAH, that has a broad case-mix and relatively large patient numbers. Although recruitment of patients at PMAC (a smaller specialist cancer centre) was possible, many patients were not suitable, because of the calculated patient risk was either too low or too high. The

Table 1 Characteristics of patients receiving standard ward-level care (in the before-period) and advanced recovery room care (in the after-period) at each site. Values are median (IQR [range]) or number.

	Royal Adelaide Hospital		The Peter MacCallum Cancer Centre	
	Before n = 71	**After n = 55**	**Before n = 24**	**After n = 16**
Age; years	73 (65–80 [38–93])	74 (68–80 [36–97])	68 (53–79 [36–96])	69 (60–75 [40–80])
Sex; male	42	29	13	12
Elective surgery	48	31	24	16
ASA physical status 1–2	5	11	6	2
ASA physical status 3–4	66	44	18	14
Predicted 30-day mortality (%)	1.5 (1.3–2.4 [1.0–4.0])	2 (1.4–2.7 [1.0–3.8])	2.1 (1.3–2.6 [1.0–3.4])	2.0 (1.5–2.5 [1.0–3.4])
Duration of surgery; min	136 (63–218 [1–540])	174 (127–248 [37–386])	178 (118–237 [40–608])	240 (180–284 [127–533])
Surgery types				
General	10	4	8	5
Orthopaedics	19	17	–	–
Vascular	14	14	–	–
Colorectal	7	12	3	2
Urology	11	1	5	5
Gynaecology	3	4	1	1
Plastics	3	3	4	3
Other	4	–	3	–

case-mix of PMAC is not typical of many hospitals and the baseline data on outcomes may have been affected by off-site management of potentially eligible patients in the HDU/ICU situated in a co-located institution.

It was not feasible to introduce ARRC at LBH, a regional hospital, for logistical reasons primarily related to a small pool of anaesthetic and nursing staff available to be redeployed to night duty. In addition, there were concerns expressed at this and other sites explored for inclusion in the trial about commitment of resources to a trial in the absence of clear evidence of unmet need and benefit of the proposed model. However, discussions with clinicians in

Table 2 Postoperative events in the before and after-periods. Values are number or mean (SD).

	Royal Adelaide Hospital		The Peter MacCallum Cancer Centre	
	Before n = 71	**After n = 55**	**Before n = 24**	**After n = 16**
Patients meeting MERT criteria during ARRC	n/a	30	n/a	1
Patients meeting MERT criteria in the ward	23	4	2	5
Unplanned ICU admission from the ward	7	1	–	–
ICU transfer from ARRC	n/a	6	n/a	–
Quality of recovery score; QoR-15	105 (23)	111 (23)	100 (24)	116 (40)
Quality of life score at 90 days; EQ-5D-5L	8.6 (3.9)	7.9 (3.9)	8.5 (3.8)	7.9 (3.2)
Duration of stay; days	9.2 (8.2)	9.2 (9.6)	7.6 (5.1)	10.9 (7)
Patients re-admitted within 90 days	25	12	6	5
Re-admission duration of stay; days	10.3 (7.5)	5.5 (5.8)	11.2 (11.3)	9.0 (8.4)
Mortality at 90 days	3	6*	–	–
Re-operation within 90 days	7	1	1	1

MERT, medical emergency response team; AARC, advanced recovery room care; ICU, intensive care unit; QoR-15, 15-item quality of recovery score; EQ-5D-5L, five-level version of the EQ-5D.
*Three patients in the after group were treated with palliative care after surgical findings revealed inoperable disease, compared with zero in the before group.

other hospitals suggest these issues can be overcome. This study also suggests that the clinical application of the ARRC model is feasible: PMAC has introduced a version of this model into routine clinical practice and RAH is introducing a larger unit for ARRC (up to 10 beds). This suggests that the AARC model is cost-effective and has wide clinical support. Discussions with other hospitals have revealed enthusiasm for this approach, and suggest that staffing and infrastructure challenges can be overcome.

The proportion of patients screened but not included was dependent on the methodology used and case-mix of the recruiting site. At RAH, skilled trials staff reviewed theatre lists shortly before scheduled surgery with subsequent formal screening of likely candidates. This led to fairly low rates of exclusion, in part because of access to contemporary detailed data on the proposed surgery, expected duration of stay, patient comorbidities and English comprehension. At PMAC, all patients who attended the pre-anaesthetic clinic and/or were scheduled on weekly theatre lists were screened, with only a small proportion proving suitable for inclusion. It was notable that the pre-operative calculation of NSQIP scores was not routine practice in either hospital. Trials staff reported that there may have been a learning component at judging likely NSQIP scores. In future trials, there would be merit in all patients being formally risk scored early in the assessment period for potential surgery; this is something which is considered a high priority in improving peri-operative health systems outcomes in Australia [20].

It was acknowledged by the hospitals involved in this study that the PACU infrastructure necessary for ARRC was already in place, but tended to be underutilised out of hours and could, therefore, accommodate the patients receiving ARRC. Modest adaptions for patient care, such as lighting control, bathroom facilities and visitor access were considered important by patients and their families, nursing and medical staff.

There was reasonable within-site group matching of factors potentially associated with complications and outcome, such as predicted mortality, comorbidities, duration of surgery and emergency surgery. However, at RAH, in the after-period, there was a trend towards a greater risk of mortality (related to three cases having conservative surgical management and palliative care due to disease state). This may have been due to RAH having a greater proportion of emergency surgical cases and a longer mean duration of surgery, both of which are factors known to adversely affect outcome [21, 22]. Regardless, this suggests that group matching is unlikely to be a major confounding factor in a before-and-after design.

The patients recruited to the study were largely in the lower half of the moderate risk range. Despite this, the number of MERT-level events and 90-day re-admission rates at RAH were high. It was noted that for some surgical procedures such as arthroplasty, hysterectomy and colorectal resection, patients often did not reach the threshold of 1% NSQIP-determined mortality, and hence were not included in the trial. However, clinical opinion was that many of these cases would have had an early risk of mortality that was similar to those in the 1–4% range. Broadening the definition for moderate risk to an NSQIP-determined mortality risk of 0.7%–5.0% would capture this case-mix and may better reflect the views of clinicians involved in the trial as to which patients might benefit from extended high acuity postoperative care. Recent Australian data have confirmed that the NSQIP risk calculator can be adapted to suit the Australian population, and its use is expanding with at least seven Australian hospitals currently enrolled in the programme [23].

This was a small exploratory trial and as such, the outcome data on adverse events and outcomes must be interpreted with caution. The most striking of the secondary outcomes was the very high incidence of early serious complications, as defined by triggering a call for the MERT. The adverse event data from RAH have been reported previously [3], and suggested that these events predominantly occurred early after discharge from the PACU, often after-hours, and were usually not detected or treated, with standard ward observation regimens. A number of studies have shown that postoperative adverse events are common in hospital [2, 24] especially in older patients (who made up the majority of patients in this study). However, there is increasing recognition of the significance of problems such as even brief periods of hypotension [25], which was the most common adverse event at RAH. The limited treatment options for hypotension available on wards (largely fluid administration), concerns about excess fluid administration postoperatively [26] and the capacity to evaluate and treat hypotension with approaches such as vasopressors, all suggest that a higher acuity postoperative unit is well-suited to these patients. This aligns with the retrospective data of Swart et al. [12] and the prospective data from Eichenberger et al. [9] (albeit with a mix of higher and moderate-risk patients) which suggested a prolonged positive benefit from early high-acuity care. In contrast, a recent systematic review [27] and large international cohort study [28] did not show evidence of survival benefit from a three-tier model of care that included ward-level care, surgical special care units and ICUs. However, this is likely to represent a higher-risk patient cohort, rather than the

moderate-risk patients often cared for in the general ward. Furthermore, outcomes such as adverse events and re-admissions may be more sensitive indicators of the benefits of early enhanced care than mortality.

There is some indication this intervention may have clinical benefit. It was noted that a number of adverse events plausibly related to better early postoperative care (e.g. re-admission rates, MERT calls on the ward, re-operation) may have been less common in the after-period at RAH; however, the small numbers preclude definitive conclusions and these findings should be only seen as hypothesis-generating. Quantitatively, the largest difference was days in hospital due to re-admission, a factor known to be closely associated with in-hospital complications [29]. This highlights the importance of collecting longer-term postoperative outcome data. This is supported by a recent study examining the economics of prehabilitation that showed a much greater impact on re-admissions than costs in the primary admission [30]. In addition, a recent study by Bell et al. showed that days at home up to 30 days after surgery is a highly sensitive metric of changes in surgical risk and impact of complications, and has prognostic importance [31].

There are a number of limitations to this trial. First, there were differences in case-mix and circumstances between study sites which, while highlighting the importance of testing and adapting to different sites, limit the validity of pooling of data. Second, the numbers were small in this exploratory study, and with the primary aim being feasibility, recommendations do not support statistical analysis [19]. However, the fact that a number of secondary endpoints may have been less common in the after-group suggests a trial involving a larger number of patients is worthwhile.

This trial shows that an advanced recovery model of care is feasible at hospitals with sufficient numbers of relevant patients and an adequate pool of staff. A larger trial is indicated now that the profile of outcomes is better understood and the factors affecting feasibility better appreciated. The data in this trial also confirm that even moderate-risk patients may be at high risk of serious adverse events early after surgery, and that delayed events such as re-admission are common. The nature of the events, such as sustained hypotension, respiratory problems and pain management issues, suggests that standard ward-level care may not be adequate for detection and management of these issues. While this is a small trial, the data suggest that extended care into the first postoperative day in the recovery room setting may have clinical benefit and should be explored further to determine the impact of this intervention on the incidence on postoperative outcomes and establish whether it is cost effective.

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Supporting Information

Additional supporting information may be found online via the journal website.

Figure S1. Advanced recovery room checklist.

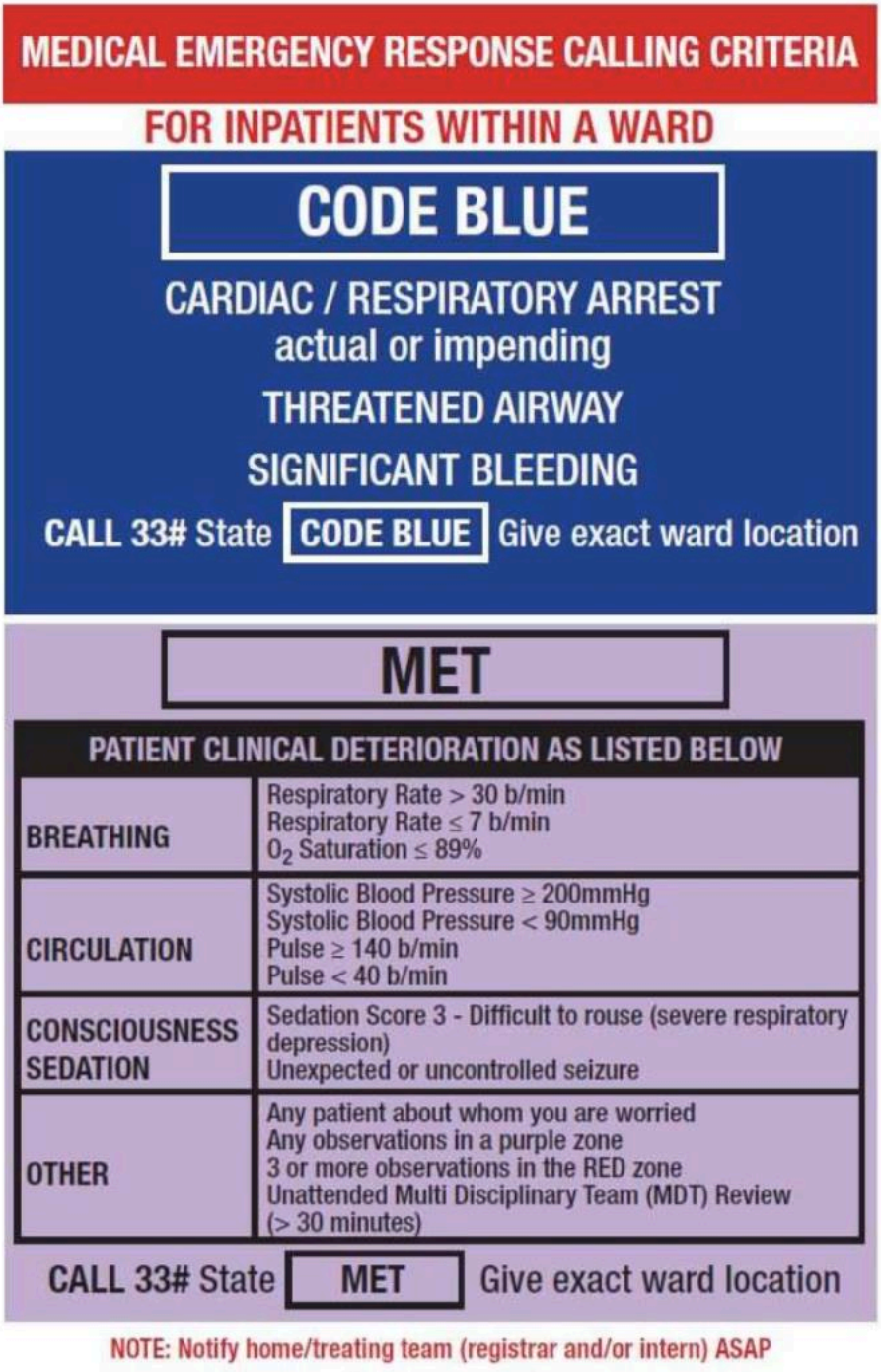
Figure S2. Current medical emergency response call criteria at the Royal Adelaide Hospital, Adelaide, Australia.

Figure S1. Advanced recovery room checklist

Unit Assessment and Management Checklist

	Unit rounds - Systems checklist	Goals achieved	Plan/actions to achieve goals	Suitable for ward discharge
	Time of round _ _ : _ _			
	Anaesth / Surgeon Dr _____			
CNS	Goal – Sedation score ≤ 1/3	☐ Y ☐ N		☐ Y ☐ N
	Goal – Orientated T, P, P	☐ Y ☐ N		☐ Y ☐ N
	Goal – Adequate limb function (block/surgery-dependant)	☐ Y ☐ N		☐ Y ☐ N
Airway	Goal – Continuously unobstructed	☐ Y ☐ N		☐ Y ☐ N
	Goal - Able to cough effectively	☐ Y ☐ N		☐ Y ☐ N
	Goal - Full airway reflexes	☐ Y ☐ N		☐ Y ☐ N
Breathing	Goal - Respiratory rate 11 -20	☐ Y ☐ N		☐ Y ☐ N
	Goal - Adequate tidal volume	☐ Y ☐ N		☐ Y ☐ N
	Goal – Saturation ≥ 95% on ≤ 4L 0_2 / min	☐ Y ☐ N		☐ Y ☐ N
Circulation	Goal – Stable cardiac rhythm	☐ Y ☐ N		☐ Y ☐ N
	Goal – Heart rate 60 – 100 bpm	☐ Y ☐ N		☐ Y ☐ N
	Goal - Blood pressure 100/ – 170/ mmHg	☐ Y ☐ N		☐ Y ☐ N
	Goal – Ongoing blood loss acceptable	☐ Y ☐ N		☐ Y ☐ N
	Goal – Adequate hydration & haemoglobin	☐ Y ☐ N		☐ Y ☐ N
	Goal – Urine output adequate	☐ Y ☐ N		☐ Y ☐ N
Other	Goal – Pain scores ≤ 4/10	☐ Y ☐ N		☐ Y ☐ N
	Goal – No PONV	☐ Y ☐ N		☐ Y ☐ N
	Goal – Temperature 35.6 – 38^{O}C	☐ Y ☐ N		☐ Y ☐ N
	Goal - Glucose 5 – 10 mmol/L	☐ Y ☐ N		☐ Y ☐ N
	Handover comments:			**Discharge destination** ☐ General Ward ☐ ARRC care ☐ ICU

Figure S2. Current medical emergency response call criteria at the Royal Adelaide Hospital, Adelaide, Australia. MET, medical emergency team.



Conclusion

This research aimed to investigate and improve post-operative care models for medium risk patients, to address the growing burden of post-operative complications on patients, and health care costs. Advanced Recovery Room Care (ARRC) may be a potential solution at well-resourced sites, with data suggesting that a larger scale prospective trial is feasible and indicated. The initial systematic review confirmed that managing selected post-operative patients in the post-anaesthesia care unit (PACU) instead of ICU is not associated with worse outcomes. However, it also revealed a striking paucity of literature on health system interventions in recovery rooms, or PACU), and reinforced the need for further research into how care is provided at such a critical point in the patient journey. Preliminary analysis of post-operative complication rates at the Royal Adelaide Hospital (RAH) during the ARRC trial revealed an alarming rate of patient deterioration when they were closely monitored in the ARRC setting. This suggests that many post-operative complications go undetected and unmanaged when patients receive standard surgical ward care, and again highlighted the unmet need for higher level care for medium risk patients. The Advanced Recovery Room Care feasibility trial showed that the ARRC model of care is feasible at hospitals with sufficient numbers of eligible patients and an adequate pool of anaesthetic and nursing staff. While it was a small study, ARRC may have clinical benefit, and should be investigated further.

During this project, there were a number of problems encountered, some directly related to the focus of this thesis (RAH data) and some more broadly in the healthcare sector. In relation to RAH, it was clear that an ARRC model needs to be well resourced and structured to achieve success, with a high demand to review and manage patients due to an unexpected high incidence of major adverse events early after surgery. However, there are means to achieve this, with appropriate planning. In relation to other sites, and the healthcare sector more broadly, the most significant was a recognition of the need for such an intervention. Lismore Base Hospital being unable to complete the *training* or *after* periods of the ARRC trial. Several contributing factors were identified, with the predominant issue being a lack of overnight staff. This provided

valuable insight into the staffing requirements, and types of institutions that will be able to participate in a larger scale prospective trial of ARRC.

Publication delays were also encountered when submitting the systematic review with, for example, periods of up to 6 months between responses to submissions and responses. This was overcome through ongoing communication with both journal editors and reviewers, and did not impact completion of the thesis. Working with a large author group for the multi-centre ARRC study highlighted the need for timely communication and following-up with busy clinical staff.

Improvement in post-operative care models appears to be a high-value proposition, and this thesis supports the need for further research into ARRC as a potential solution to the growing pandemic of post-operative complications. A powered prospective, single site case matching trial of ARRC is now planned to occur at the RAH, with cost-effectiveness as a primary endpoint. This approach is supported by findings from the 'Pandemic of Postoperative Complications Summit' held in Adelaide in March 2020[1]; with implementation science suggesting that new end-to-end care models such as ARRC may best start as single site studies, with multicentre trials commencing as the study gains people's confidence. This staged implementation allows the trial to initially occur within locally engaged teams, with established relationships, to monitor and measure the outcomes achieved and any modifications required[2]. A Clinical Rapid Implementation Project Scheme (CRIPS) grant has been received from the Central Adelaide Local Health Network for implementation and validation of ARRC[3].

Following the RAH single site trial, and further confidence in the model, we propose a large multicentre prospective case matched trial of early enhanced care after surgery. This will investigate whether a model of postoperative Advanced Recovery Room Care for moderate risk surgical patients reduces early complications, hospital length of stay, unplanned readmissions, and increases patient days at home after surgery and reduces overall costs of care.

Early post-operative complications are predicted to increase 5-fold over the next 30 years, with a significant associated increase in post-operative mortality and health care

costs. This ongoing research aims to both improve patient outcomes, and overall costs, significantly contributing to the sustainability of the healthcare system.

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