Royal Australasian College of Surgeons

ANZCA FPM

Australian and New Zealand Emergency Laparotomy Audit – Quality Improvement (ANZELA-QI)

Second ANZELA-QI program summary report
1 January 2020 – 31 December 2021

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NZAGS New Zealand Association of General Surgeons

ASA Australian Society of Anaesthetists

New Zealand Society of Anaesthetists

Australasian College for Emergency Medicine

Geriatric Medicine

Collaborating organisations

This program is co-led by the Royal Australasian College of Surgeons and the Australian and New Zealand College of Anaesthetists.

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Australian and New Zealand College of Anaesthetists (ANZCA)

General Surgeons Australia (GSA)

New Zealand Association of General Surgeons (NZAGS)

Australian Society of Anaesthetists (ASA)

New Zealand Society of Anaesthetists (NZSA)

Additional collaborating partners:

Australasian College for Emergency Medicine (ACEM)

College of Intensive Care Medicine (CICM)

Australian and New Zealand Society for Geriatric Medicine (ANZSGM)

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ANZELA-QI Governance Committee

Dr Richard Perry, Dr Vanessa Beavis, Mr John Biviano, Mr John Ilott, Dr James Aitken, Associate Professor Wendy Babidge

ANZELA-QI Working Party

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Chair's report

On behalf of the Australian and New Zealand Emergency Laparotomy Audit – Quality Improvement (ANZELA-QI) Working Party, I am pleased to present the second annual report from the pilot program. It reports Australian data and covers the years 2020 and 2021.

The aim of the ANZELA-QI pilot was (i) to determine the standard of emergency laparotomy care in Australia; (ii) the need for an Australian emergency laparotomy clinical quality registry (CQR); and (iii) the feasibility of this being a national continuous improvement clinical quality registry (CICQR).

The ANZELA-QI pilot was inspired by the National Emergency Laparotomy Audit (NELA) in England and Wales. NELA was commissioned in 2011 following evidence of high mortality and wide variation in the provision of care and mortality. While international comparisons need to be undertaken with caution, NELA does provide an acceptable comparator for ANZELA-QI.

ANZELA-QI has shown there is a wide inter-hospital variation in care and outcome. This suggests that there is considerable scope to improve the care of Australian patients undergoing an emergency laparotomy.[1,2] Table 2 shows the 'transformative' impact of NELA, such that the standard of care in England and Wales is now higher than in Australia. [3-5]

Some will take comfort that the 6.2% postoperative mortality in ANZELA-QI was less than contemporary overseas studies. The section reporting mortality includes a discussion outlining why such comparisons may be misplaced. [6-11]

The average postoperative length of hospital stay (LOS), the primary driver of cost [12] is similar to that now reported by NELA.[5] Since it commenced, NELA has reported a 4-day reduction in LOS.

The CQR's of the future will offer near real-time continuous quality improvement and will replace the era of the traditional annual retrospective quality assurance 'data dump'. The current view is that it is better to return contemporaneous, albeit imperfect data, than delay and to later report more accurate data.[13] ANZELA-QI has clearly demonstrated this is feasible using near-real-time continuous prospective statistical process control (SPC). In this, ANZELA-QI has undoubtedly anticipated the future.

Over the last 10 years, the problems related to the delivery of emergency laparotomy care have been much better defined. The in-hospital knowns and unknowns have now been identified, even if best care is not always delivered. However, our knowledge stops when the patient is discharged. It is now apparent that following an emergency laparotomy, post-discharge quality of life for many patients is poor.[14-16]

A third of Australian emergency laparotomy patients are transferred. The greater distance between surgeon (perioperative team) and patient and more limited services in remote and rural areas will likely adversely impact on post-discharge care. This is a particularly strong reason for Australia to obtain its own emergency laparotomy data.

If Australia is going to enjoy the improved care obtained by overseas CQRs, the local barriers that are currently hindering participation will need to be addressed.[17] There is limited scope for individual clinicians to change care and further improvements in treatment and outcome will require wider system and organisation changes. This will require clear political and professional leadership and should include a robust national governance process with secure medium- to long-term funding.

In particular, Governments, jurisdictions, hospitals, the Colleges and individual clinicians must all recognise that the first step in any successful CQR is high case ascertainment and data completion. Data quality is always a key issue, and we all have a responsibility to achieve this.[17,18-21]

As CQRs develop, variation will be identified. It will be difficult for the profession to contribute to outlier discussions if it is not deeply involved in ensuring collection of the highest quality data. As in the United Kingdom (UK), Australia needs a uniform outlier policy that is agreed and respected by all health providers.[22]

James Aitken

Abbreviations

ACSQHC	Australian Commission on Safety and Quality in Health Care
ACTA	Australian Clinical Trials Alliance
ANZASM	Australian and New Zealand Audit of Surgical Mortality
ANZCA	Australian and New Zealand College of Anaesthetists
ANZELA-QI	Australian and New Zealand Emergency Laparotomy Audit – Quality Improvement
ASA	Australian Society of Anaesthetists
CADENZAA	Care Delivery in New Zealand for the Acute Abdomen
CCU	critical care unit
CICQR	continuous improvement clinical quality registry
CT	computed tomography
CTANZ	Clinical Trials Network Australia New Zealand
CQR	clinical quality registry
DTO	decision to operate
ED	emergency department
ELFUS	Emergency Laparotomy Follow-Up Study
ERAS	emergency laparotomy recovery after surgery
FFS	fee for service
GIRFT	Getting It Right First Time
GSA	General Surgeons Australia
HREC	Human Research Ethics Committee
IHI	Institute for Healthcare Improvement
KPI	key performance indicator
LOS	length of hospital stay
NCEPOD	National Confidential Enquiry into Patient Outcome and Death
NELA	National Emergency Laparotomy Audit
NZAGS	New Zealand Association of General Surgeons
NZSA	New Zealand Society of Anaesthetists
PELA	Perth Emergency Laparotomy Audit

RACS	Royal Australasian College of Surgeons
RAG	Red, Amber, Green
REDCap	Research Electronic Data Capture tool
RCS	Royal College of Surgeons of England
SD	standard deviations
SPC	statistical process control
SSA	site-specific assessment

Key messages

- Many Australian patients undergoing an emergency laparotomy do not receive best evidence-based care.
- There is wide inter-hospital variation in both care and outcomes.
- It is feasible to conduct a prospective emergency laparotomy clinical quality improvement registry in Australia.
- There is little scope for individual clinicians to improve processes, and further improvement will require system and organisation changes.
- There is an urgent need for a nationally agreed policy to coordinate governance and funding of national clinical quality registries. This will require robust political support.

Executive summary

This ANZELA-QI report relates to data collected on 3,178 patients at 25 participating hospitals between 1 January 2020 and 31 December 2021.

It focuses on 2 analyses. The first relates to 10 standards of care or ANZELA-QI key performance indicators (KPIs). These are summarised in 2 tables at the end of this executive summary (Tables 1 and 2). The second analysis covers 5 other outcomes: mortality, LOS, return to theatre after initial emergency laparotomy, Clavien-Dindo complication grade (Appendix A) and discharge destination.

The majority of patients (94.6%) were admitted as an emergency. Some 52.5% of patients were age ≥65 years. The largest category of surgical urgency was between 2 and 6 hours from diagnosis (43.5%). The 2 most common preoperative indications were small bowel obstruction (34.9%) and perforation (23.1%).

For the ANZELA-QI KPIs:

- There was very wide inter-hospital variation in all KPIs.
- An abdominal computed tomography (CT) scan was performed prior to surgery in 92.5% of patients. A report from a consultant radiologist was only available 61.6% of the time.
- Preoperative risk assessment was documented in 52.0% of patients.
- The surgical urgency was <18 hours in 76.1% of patients. Overall, 51.2% of these patients arrived in theatre within the appropriate timeframe.
- Only 24.3% of those needing the most urgent surgery (<2 hours) achieved this standard.
- Both consultant surgeon and anaesthetist were present in theatre for 75.4% of those who had a preoperative risk assessment. No consultant was present in 5.1% of patients. For patients with the highest risk (≥10%), both consultants were present in theatre for 77.2%, and no consultant was present for 4.3%. Consultants were less likely to be present out of hours.
- Nearly two-thirds (64.6%) of those with a NELA preoperative risk assessment score of ≥10% were admitted to critical care following surgery.
- For patients age ≥65 years, 17.4% received a postoperative assessment by a specialist in gerontology or a gerontology team.

For outcomes:

- The overall in-hospital mortality was 6.2%. After excluding hospitals with no mortality, the inter-hospital variation was between 1.6% and 13.3% – an 8.3-fold variation.
- The average LOS was 13.3 days for patients who were in hospital for ≤60 days. It was 111.8 days for patients who were in hospital for >60 days.
- Overall, 15.7% of patients had a planned or unplanned return to theatre after their original emergency laparotomy.
- Patients with an unknown NELA preoperative risk assessment had higher Clavien-Dindo grade V complication rates.
- Following discharge, 72.7% of patients returned to their prehospital residence.

Recommendations

- Continue data collection in pilot hospitals and other interested hospitals on a nominal fee basis and send reports to participating hospitals monthly.
- Refine the database using experience of the ANZELA-QI pilot; that is, based on findings in this report.
- Continue to engage with federal, state and territory governments, highlighting its importance and need for support.
- Commit, if funded, to:
    - develop a bespoke database that permits true real-time data feedback
    - expand the standard of care KPIs it monitors and returns to hospitals
    - explore how more data can be recovered from routine administrative data
    - extend follow-up to determine long-term outcomes.
- RACS to work with ANZCA to advocate the urgent need for federal, state and territory governments, as well as the Australian Commission on Safety and Quality in Health Care to address the existing governance framework that has hindered the establishment of ANZELA-QI. Without the necessary changes it will remain difficult, time consuming and expensive to establish high-quality clinical quality registries.

Summary tables

Table 1: Compliance with key care standards (Red, Amber, Green [RAG])

Key standards*	Key performance indicators (KPI)	Patients achieving standard (%)	Hospitals rated green (n = 24)	Patients achieving standard (%)	Hospitals rated green (n = 25)
		2018–2019		2020–2021	
Before surgery					
Hospitals that admit patients as emergencies must have access to CT scanning 24 hours per day	Proportion of all emergency laparotomy patients for whom a CT scan was performed and reported by a consultant radiologist before surgery (PRE 1)	68.1% n = 1,747	5	61.6% n = 1,809	11
In September 2021, availability of lactate level to the surgeon at time of referral for patients admitted via the emergency department was added as a regularly reported metric	Lactate level available to the surgeon at the time of surgical referral for patients admitted via the emergency department (PRE 2)	N/A	N/A	65.3% n = 1,835	6
An assessment of mortality risk should be made explicit to the patient and recorded clearly on the consent form and in the medical records	Proportion of patients for whom a risk assessment was performed and documented preoperatively (PRE 3)	45.0% n = 1,299	1	51.4% n = 1,635	0
Along with lactate levels, frailty assessment has recently been added to the monthly reporting, and it is an important consideration with which to guide patient management during and after surgery	Preoperative frailty assessment performed for patients age ≥65 years (PRE 4)	N/A	N/A	28.0% n = 468	2
Hospitals should ensure theatre access matches need and ensure prioritisation of access is given to emergency surgical patients ahead of elective patients whenever necessary	Proportion of patients arriving in theatre within an appropriate time frame where urgency of surgery is 24 hours or less (PRE 5)	59.7% n = 1,351	0	51.3% n = 1,631	0

During surgery					
Each high-risk case should have the active input of a consultant surgeon/anaesthetist	Proportion of patients with a calculated preoperative National Emergency Laparotomy Audit (NELA) risk of death ≥5% for whom a consultant surgeon and consultant anaesthetist were present in theatre (OP 1)	75.2% n = 445	7	75.4% n = 608	16
	Proportion of patients with a calculated preoperative NELA risk of death ≥5% for whom a consultant surgeon was present in theatre (OP 2)	84.1% n = 498	10	83.6% n = 674	20
	Proportion of patients with a calculated preoperative NELA risk of death ≥5% for whom a consultant anaesthetist was present in theatre (OP 3)	90.4% n = 535	14	84.6% n = 682	18
After surgery					
Highest-risk patients should be admitted to critical care	Proportion of patients with a preoperative NELA risk of death ≥10% who were directly admitted to critical care postoperatively (POST OP 1)	69.6% n = 296	8	64.2% n = 327	12
Each patient over the age of 65 should have multidisciplinary input that includes early involvement of geriatrician teams	Proportion of patients age ≥65 years who were assessed by a specialist in elderly medicine (POST OP 2)	17.7% n = 271	1	17.4% n = 280	0

Abbreviations:
OP = operative
POST OP = postoperative
PRE = preoperative

Notes
* Key standards used here have been based on NELA's standard of care.
N/A = not applicable**, n** = number of cases meeting the KPI, **Red** = <50% of patients meet the KPI, **Amber** = 50% to 79% of patients meet the KPI, **Green** = ≥80% of patients meet the KPI

Table 2: Overall compliance with key care standards by patient – comparison of ANZELA-QI and NELA

Care standard	NELA I 2012–2013	NELA VII 2020–2021	ANZELA-QI 2020–2021
Pre-op CT report by consultant radiologist	68.0%	65.9% in-house 19.1% outsourced	61.6%
Pre-op risk assessment	56.0%	85.0%	51.4%
Pre-op lactate (admit via ED)	N/A	75.0%*	65.3%
Theatre access by urgency			
<2 hours	77.0%	68.4%	24.3%
2 to 6 hours	86.0%	85.2%	51.3%
≤24 hours			51.3%
Both consultants in theatre			
RA ≥5%	70.0%	90.1%	75.4%
ICU admission			
RA ≥5%	81.0%	82.3%	55.7%
RA ≥10%	89.0%	87.6%	64.2%
Seen by Care of Elderly medicine team specialist/geriatrician			
Age ≥80 years	14.0%	28.7%	24.5%
Age ≥65 years		27.3%	17.4%
Frailty assessed when age ≥65	N/A	91.8%	28.0%

Abbreviations
ED = emergency department
ICU = intensive care unit
N/A = not applicable
NELA = National Emergency Laparotomy Audit
Pre-op = preoperative
RA = risk assessment

Notes
***** Lactate data taken from NELA data reported by the Emergency Laparotomy Collaborative. NELA I refers to the report produced by NELA 1 year after establishing the audit and collecting the data. NELA VII refers to the report produced on the 7th year of the audit.

1 Introduction

This introduction provides a brief outline to explain some of the important features of ANZELA-QI. Additional details are available on the ANZELA-QI website: https://www.surgeons.org/en/research-audit/morbidity-audits/morbidity-audits-managed-by-racs/anz-emergency-laparotomy-audit-quality-improvement.

In the first decade of this millennium, the only data reporting the outcome following emergency laparotomy were derived from retrospective analyses of administrative data, which have well-recognised limitations. The lack of reliable data prompted the prospective Emergency Laparotomy Network study (UK), which confirmed an overall postoperative mortality of 15%, and 25% for those age 80 years or older.[23] It also showed poor compliance with care processes known to improve outcomes. Importantly, it confirmed the wide inter-hospital variation noted in earlier studies.

Three prospective studies that used quality improvement techniques demonstrated that compliance with a bundle of individual care standards significantly improved outcomes.[24-26]

These data prompted the Health Quality Improvement Partnership to fund the National Emergency Laparotomy Audit in England and Wales (NELA).[3]

Prior to 2016, there were no Australian data but, prompted by NELA, a number of local studies have since been published. [6,12,27-31] Collectively, these suggested that many of the problems identified overseas are also relevant to Australia.

The ANZELA-QI Working Party was established in September 2017 to determine the feasibility of establishing an emergency laparotomy audit across Australia and New Zealand – ANZELA-QI. While the pilot was fortunate to obtain funding from RACS, ANZCA, GSA, NZAGS, ASA and NZSA, this was seed funding. This minimal funding constrained the scope of ANZELA-QI, which had to concentrate on a small number of achievable goals rather than attempting a larger project that would risk falling short.

The primary goals of ANZELA-QI were:

1. to create an ANZELA-QI database centred around the NELA dataset but modified as required for local practice

2. to identify and record compliance with selected standards of care known to impact on outcome (e.g. KPIs)
   - using the same care standards as NELA would deliver a comparative international baseline to collect data near real time.

3. to download the data around the beginning of each month, to analyse it and return to hospitals in the second week of each month
   - data for the previous month would then be available at monthly mortality and morbidity meetings

4. to return monthly data in different formats:
   - a RAG chart showing overall results for a snapshot period
   - run charts showing every hospital its own results for each KPI, as well as the overall data for all participating hospitals
   - a patient report for each hospital showing which patients had achieved, or not achieved, each KPI

5. to generate reports by named individual hospitals so all could identify and learn from the best

6. to report the traditional benchmarks of in-hospital mortality and average LOS at least once a year.

1.1 Standards of care

The 'bundle of care' concept was originally developed by the Institute for Healthcare Improvement (IHI).[32] It was also adopted by the Surviving Sepsis Campaign for management of severe sepsis and septic shock, as it sought to promote the early identification of sepsis, the prompt delivery of antibiotics and timely source control. [33]

In 2011, the Royal College of Surgeons of England (RCS) published, *The higher risk general surgical patient: towards improved care for a forgotten group*.[34] The recommended standards of care were based on the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) and other organisations such as the Surviving Sepsis Campaign.

The bundle of care concept underpinned the 3 emergency laparotomy audits that used quality improvement methodology.[24-26]

In 2018, the RCS updated its recommendations using the lessons learned from NELA and other emergency laparotomy projects.[2] The 2018 document states '*it is the opinion of this expert group that implementation of the new key recommendations should be mandatory in all acute hospitals with adult surgical services and that doing so would save lives and make further appreciable differences to patient outcomes. All those managing the emergency general surgical patient should be familiar with its recommendations'*.

In 2021, the Enhanced Recovery After Surgery (ERAS) Society published part 1 of its guidelines.[1]

1.2 Ethical and site-specific assessment approval

ANZELA-QI is confidential to the extent that identifiable patient information is not disclosed. However, within ANZELA-QI, patients will need to be identifiable or re-identifiable to permit linkage to other registers; for example, the death register and to link patients who are transferred between hospitals.

ANZELA-QI obtained Human Research Ethics Committee (HREC) approval with waiver of patient consent. Hospitals still need to obtain site-specific approval (SSA) to participate. Obtaining SSAs has proven to be a major constraint to hospital recruitment. ANZELA-QI is a quality and safety audit collecting readily available data; it is not a research project. Thus, it was the expectation of the Working Party that, having obtained ethical permission, assessment approval and local governance clearance would be rapid and uncomplicated. However, the barriers to SSA approval were numerous, varied and continually changing. The legal issues underlying SSA are not specific to ANZELA-QI and have significant implications for the development of all Australian clinical registries.

The ANZELA-QI Working Party has previously discussed these difficulties with both federal and state jurisdictions, health departments and the Australian Commission on Safety and Quality in Health Care (ACSQHC). The ACSQHC is seeking to establish a national process for ethics and governance that will be valid in all jurisdictions and hospitals, which cannot be rejected on an individual basis.

1.3 Surgical trainee collaboratives

Surgical trainee collaboratives are well established in the United Kingdom and exist in many formats. One of the successes of NELA has been involvement with surgical collaboratives that have used its infrastructure to add value to its data. Several first-class projects have been completed using their data and published in high-impact peer-reviewed journals.

The establishment of such collaboratives has been somewhat slower to eventuate in Australia and New Zealand. However, RACS has now established the Clinical Trials Network of Australia and New Zealand (CTANZ), chaired by David Watson. A separate organisation – the Australian Clinical Trials Alliance (ACTA), chaired by Steve Webb – has also been established. ANZELA-QI has underpinned one ongoing trainee collaborative and at least one other is in preparation.

In 2022, the regulations guiding general surgical training will be changed to include a substantial research component. Surgical trainee collaboratives will provide an ideal way for trainees to obtain the research points they require, and ANZELA-QI is ideally placed to serve this demand. In General Surgery, ANZELA-QI can be a pathfinder audit that will establish the principles of surgical trainee collaboratives.

1.4 ANZELA-QI in New Zealand

A New Zealand arm of ANZELA-QI was established: Care Delivery in New Zealand for the Acute Abdomen (CADENZAA). The development of CADENZAA was led by anaesthetists. The CADENZAA team gained approval from a number of hospitals to begin collecting cases and trialled different approaches for data collection at each site. In several New Zealand hospitals, favourable IT developments occurred to enable delivery of the project in a purely electronic format at the point of care delivery.

CADENZAA was able to complete a national organisational survey including all hospitals that either admit and/or operate on acute abdominal conditions. However, despite initial optimism, CADENZAA itself was never able to get off the ground. Data collection occurred at a handful of sites but ultimately the project has struggled to gain sufficient leadership from the surgical side. Attempts at funding were also sought from multiple areas but a consistent difficulty is that QI projects fall between audit and research endeavours. Additional factors, like the COVID pandemic created further challenges and the project has, unfortunately, been suspended indefinitely.

2 Data collection and management

ANZELA-QI aims to collect real-time data that is then used to drive the care of the individual patient. Monthly feedback is provided to each participating hospital.

2.1 Data inclusion criteria

Data included in this report are from patients who met the following criteria:

- age 18 years or over
- hospital admission date between 1 January 2020 and 31 December 2021
- had an emergency laparotomy or laparoscopy
- required the laparotomy/laparoscopy urgently (within 24 hours).

The full ANZELA-QI inclusion and exclusion criteria can be found here.

2.2 Data collection

Surgeons, anaesthetists and other clinical staff are encouraged to enter data into ANZELA-QI's web-based REDCap database at the time of presentation (https://redcap.surgeons.org/). If the case information is recorded in theatre, it takes about 7 minutes to enter all relevant data, with the only remaining data related to complications and discharge.

If a hospital has already collected data as part of its routine internal prospective data collection process, these data can be provided to ANZELA-QI staff for automatic upload to REDCap. These ANZELA-QI data are then used to create reports that are provided to the participating hospitals.

Preoperative assessment of the patient's risk of death is calculated using the NELA risk calculator (http://data.nela.org.uk/riskcalculator/).

Results of the risk assessment are stratified into 3 risk categories (lower risk, high risk and highest risk). The risk thresholds for the high and highest categories used by the ANZELA-QI differ slightly from NELA (Appendix B).

2.3 Data analysis and feedback to hospitals

Data are exported from REDCap at the beginning of each month. The data are sorted, analysed and visualised using custom templates in QlikView (version 11.20.13607.0 SR17 64-bit Edition [x64]), pandas package (version 1.0.5) for the Python programming language (version 3.7.6), and the R environment for statistical computing and graphics (version 3.6.3) with RStudio 1.2 to generate reports that are sent to the participating hospitals.

ANZELA-QI provides the following reports to participating hospitals using 'traffic light' colours for ease of reference:

1. RAG chart of the 10 KPIs over a defined period (example in Appendix C, Figure C1)
2. individual hospital mini-report that includes run charts (example in Appendix C, Figure C2)
3. patient-level summary (example in Appendix C, Figure C3).

These data are distributed to hospitals during the second week of each month for use at local meetings. As the data are near real time, discussion of individual patients and events can be easily recalled.

2.3.1 Data cleansing

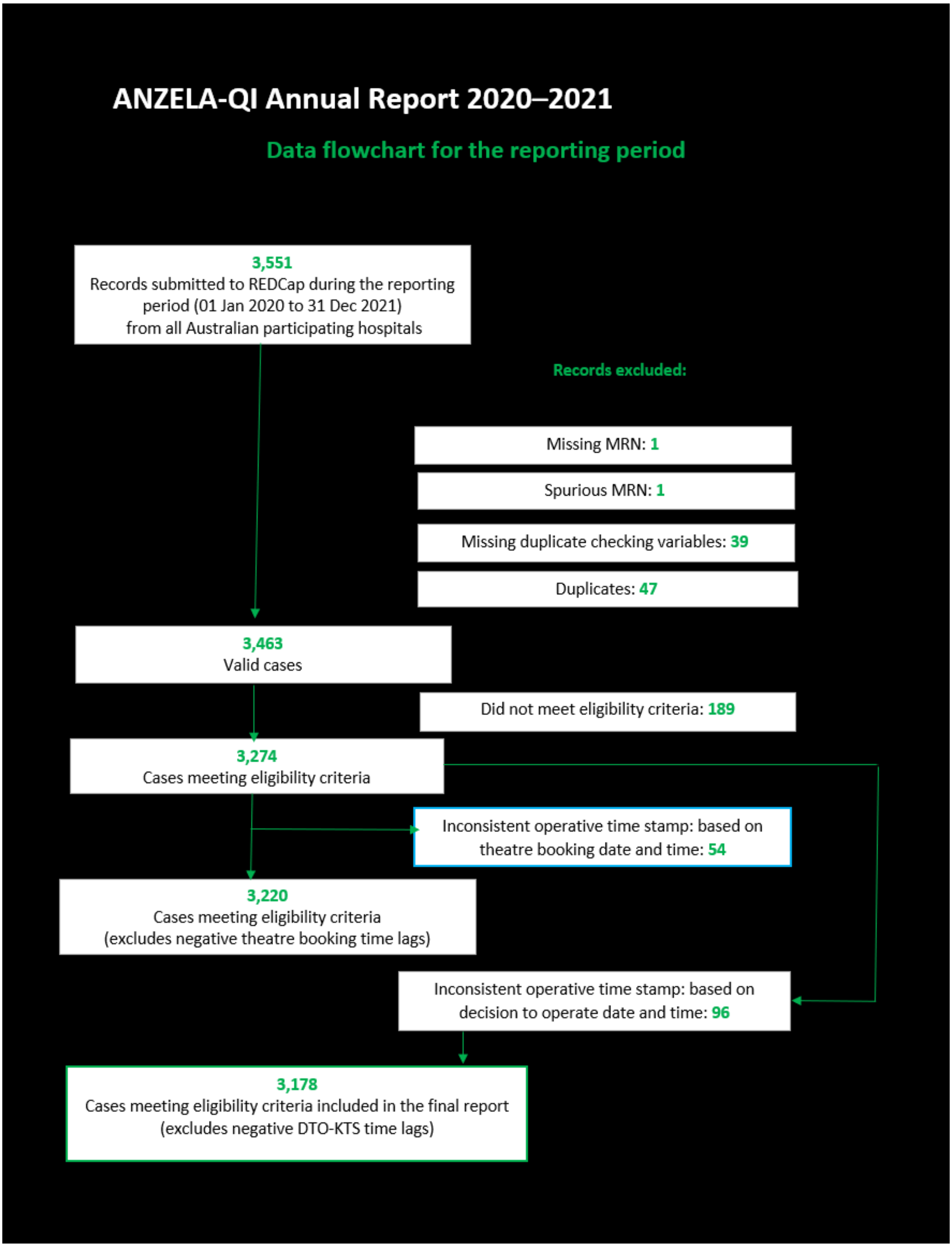
Prior to data extraction for each set of monthly reports, data cleansing is undertaken to ensure the reports provided to participating hospitals are representative of patient care received at each site. When data inconsistencies are identified, a case review request is sent to either the principal investigator or data manager at the participating site to investigate and reconcile the inconsistency. Typical data inconsistencies include duplicates and cases missing eligibility criteria fields. This data cleansing is crucial to ensure that the reported figures are accurate. Occasionally, the ANZELA-QI team delivers presentations on data management to participating sites.

Issues identified during the data cleaning can include:

- missing data for eligibility criteria or variables used to derive mortality estimates
    - Data with missing eligibility fields cannot be included in the analysis, which impacts the true representation of cases managed by the hospital and may bias outcomes.
- missing or unknown dates of diagnostic procedures
    - Cases missing the date and/or time at which diagnostic scans were performed and reported are ineligible for inclusion to assess whether the scans were reported by a consultant prior to surgery (Preoperative (PRE) 1 KPI).
- missing or unknown dates of surgical procedures
    - Cases missing the date on which surgery was performed, or missing times such as knife-to-skin (KTS) time or wheels-in time, or the last-option procedure time, cannot be included to assess arrival in theatre within an appropriate timeframe (Operative (OP) 5 KPI).
- dates not following logical chronological order
    - If the decision to operate (DTO) or date of theatre booking is recorded as occurring after knife-to-skin date/time or wheels-in date/time, or after procedure date/time, this leads to negative time lags when assessing arrival in theatre within an appropriate timeframe (OP 5 KPI)
    - Discharge dates recorded as occurring before the procedure result in negative LOS.
- inconsistencies in the format used to create unique hospital record identifiers and/or missing identifiable variables for correct patient identification, which leads to substantial loss of data.

To improve data quality, new business rules have been proposed, which will be presented to the ANZELA-QI Working Party for review and approval in late 2022. These rules will be implemented in REDCap to prevent and/or flag invalid data entries and alert users of cases with missing data. Case status will be implemented to track cases with missing data and prevent such cases from being closed before all data have been entered. This, in turn, will reduce the time clinicians spend on cleansing records monthly and ensure that complete and accurate data are submitted as early and as efficiently as possible.

Figure 1: Data flowchart for cases included in the analysis for reporting period 2020–2021



__**Abbreviations**__
DTO = decision to operate
KTS = knife-to-skin
MRN = medical record number
REDCap = research electronic data capture,

ANZELA-QI standards of care or KPIs and key associated outcomes collected

Ten standards of care KPIs were categorised by whether they occurred before, during or after surgery (Table 1).

The following additional outcomes of care were analysed for this report:

- mortality
- average (mean) LOS
- destination on discharge from hospital
- return to theatre
- Clavien-Dindo complication grade (Dindo 2004).[35]

2.4 Statistical process control, run charts and quality improvement

The statistical process control (SPC) techniques used in manufacturing were initially described in the 1930s. They are credited with improving the quality of Japanese cars after the Second World War. There have been very few publications reporting the use of SPC in surgery, but there are 3 related to emergency laparotomy. [24-26]

SPC run charts are central to ANZELA-QI, so this section has been included to outline their principles. A full description of SPC techniques is well beyond the scope of this report. Guidelines from the Scottish Patient Safety Programme (National Health Service, Scotland) and Perla *et al* provide a good overview.[36-38]

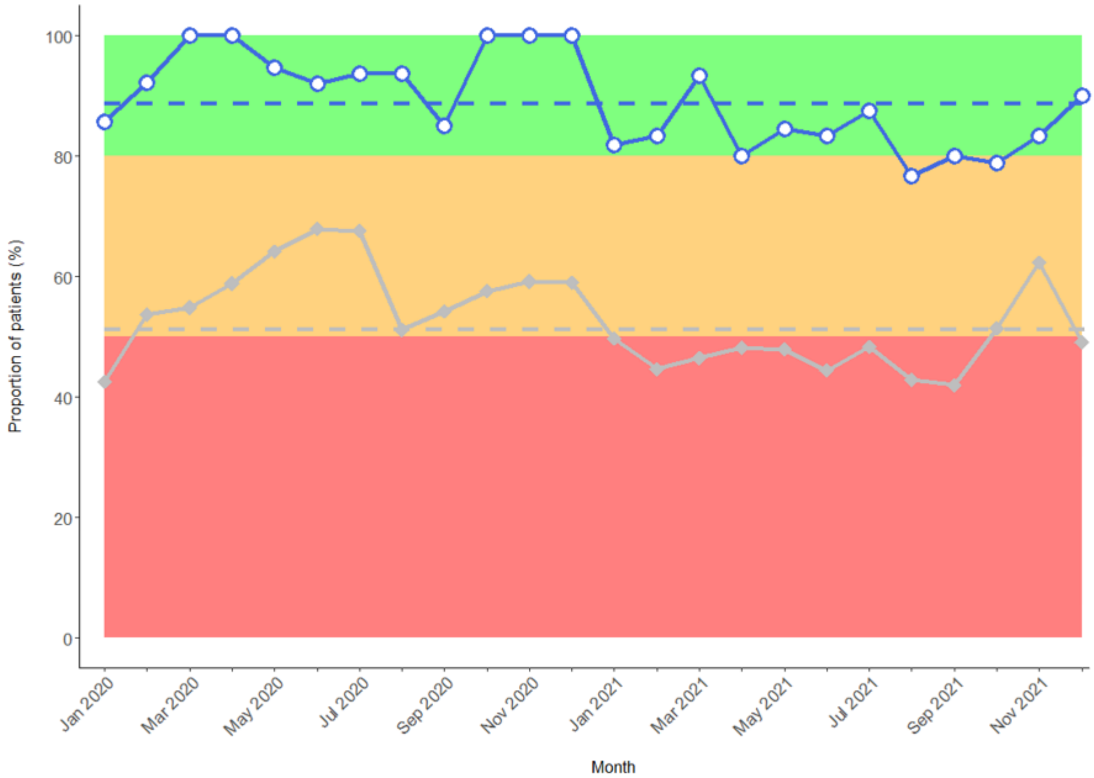
A run chart plots a series of data points (minimum 12 to 15) along the x-axis (typically a time period) and the parameter under review on the y-axis. The median of the data is plotted (shown by a horizontal line) as are the discrete data events. In a normally operating system, the data points will be randomly distributed either side of the median (so-called normal cause variation). It is not normal if the data points are not randomly distributed (so-called special cause variation).

More sophisticated SPC techniques present the data using statistical input to show the upper and lower control limits (2 and 3 standard deviations [SD] from the mean). In this case, the mean rather than the median is used as the baseline.

A worked example of quality improvement using risk assessment

Appendix C has an example of the monthly run charts returned to one of the ANZELA-QI hospitals. PRE 3 KPI – *proportion of patients for whom a risk assessment was performed and documented preoperatively*, is used here as an illustrative example in Figure 2.

Figure 2: Example of risk assessment monthly run chart returned to ANZELA-QI hospital



Notes:
Blue solid line = proportion of cases for which the individual hospital has recorded a preoperative risk assessment score, **dotted blue line** = the individual hospital's yearly median, **grey solid line** = proportion of cases for all hospitals that had recorded a preoperative risk assessment score, **dotted grey line** = the yearly median for all hospitals

The background traffic-light colours show the thresholds as used in the RAG chart. The solid blue line shows the proportion of cases for which that hospital recorded a preoperative risk assessment, and the dotted blue line is that hospital's median. The median is recalculated with the addition of each month. The solid grey line shows the proportion of cases in which all participating hospitals recorded a preoperative risk assessment, and the dotted grey line is the median for all hospitals.

There are a number of relevant observations in this run chart:

1. Each month this hospital usually, but not always, achieves the 80% standard of care.
2. This hospital is obviously performing better than the national average. ANZELA-QI identifies individual hospitals participating in the program. This facilitates contact between hospitals and the ability to share learning.
3. There were 2 periods, both in August, when performance fell. This is likely to be related to the rotation of surgical registrars who were not familiar with risk assessment. As these data are returned each month, this can be detected almost immediately and corrected.
    a. If a standard of care is important, its completion should not be adversely impacted by junior staff rotations.
4. Since ANZELA-QI commenced, the national recording of preoperative risk assessment increased by approximately three-fold, from 20% to over 60% but has now plateaued, suggesting future improvement is possible.
    a. The consecutive series of 7 or more monthly recordings under the median since January 2021 is, in SPC terms, a 'shift'. As there were more than 7, this shift is significant compared to earlier months.
    b. The consecutive series of increasing monthly recordings from July 2021 is, in SPC terms, the start of a 'trend'. If more than 5, the trend is significant, suggesting the hospital is improving its performance.

3 Findings

3.1 Who has emergency laparotomy surgery?

This report is based on 3,178 patients who had an emergency laparotomy at one of 25 Australian hospitals (see list of participating hospitals in Appendix D, Table D1).

- More patients were female (50.7%; 1,612/3,178).
- The median age of the patient population was 66 years (interquartile range [IQR] 52–76).
- Patients age ≥65 years comprised 52.5% of the total population (1,669/3,178) (Table 3).
- Most patients (94.6%; 3,006/3,178) were admitted as an emergency.

Table 3: Characteristics of patients included in this report

Patient characteristic	Patient characteristic group	Patients, n (%)
Sex	Male	1,565 (49.2)
	Female	1,612 (50.7)
	Intersex or indeterminate	1 (<1)
Ethnicity	Aboriginal	77 (2.4)
	Torres Strait Islander	5 (0.2)
	Māori	20 (0.6)
	Pacific peoples	9 (0.3)
	All other ethnicities	2,483 (78.1)
	Missing	584 (18.4)
Age (years)	18–24	62 (2.0)
	25–34	149 (4.7)
	35–44	261 (8.2)
	45–54	421 (13.2)
	55–64	616 (19.4)
	65–74	759 (23.9)
	75–84	643 (20.2)
	85–94	254 (8.0)
	≥95	13 (0.4)
Admission type	Emergency	3,006 (94.6)
	Elective	171 (5.4)
	Missing	1 (<1)
Urgency of EL procedure	0–<2 hours	247 (7.8)
	2–<6 hours	1,104 (34.7)
	6–<18 hours	1,067 (33.6)
	18–24 hours	760 (23.9)
Hours from DTO to theatre	0–<2 hours	632 (19.9)
	2–<6 hours	1,112 (35.0)
	6–<18 hours	371 (11.7)
	18–24 hours	98 (3.1)
	>24 hours	201 (6.3)
	Missing	764 (24.0)
Discharge status	Alive	2,937 (92.4)
	Died	195 (6.1)
	Still in hospital at 60 days after admission	13 (0.4)
	Missing	33 (1.0)
Total		**3178 (100.0)**

Abbreviations
DTO = decision to operate
EL = emergency laparotomy
Notes
Missing = fields left blank**, n** = number of eligible emergency laparotomy patients or cases

The preoperative indications are shown in Table 4. These mainly consist of obstruction or perforation of the bowel.

Table 4: Preoperative indications for surgery as recorded on surgical booking form

Preoperative indications for surgery	Patients, n (%)
Obstruction – small bowel	1,110 (34.9)
Perforation	734 (23.1)
Obstruction – large bowel	314 (9.9)
Peritonitis	307 (9.7)
Ischaemia	288 (9.1)
Hernia – incarcerated	179 (5.6)
Haemorrhage	171 (5.4)
Abdominal abscess	162 (5.1)
Sepsis	163 (5.1)
Phlegmon/inflammatory mass	106 (3.3)
Volvulus	105 (3.3)
Pneumoperitoneum	98 (3.1)
Anastomotic leak	83 (2.6)
Hernia – internal	83 (2.6)
Hernia – incisional	71 (2.2)
Colitis	55 (1.7)
Necrosis	50 (1.6)
Foreign body	45 (1.4)
Iatrogenic injury	35 (1.1)
Intussusception	32 (1.0)
Abdominal wound dehiscence	19 (0.6)
Bile leak	15 (0.5)
Intestinal fistula	15 (0.5)
Pseudo–obstruction	15 (0.5)
Acidosis	13 (0.4)
Abdominal compartment syndrome	8 (0.3)
Planned relook	11 (0.3)
Hernia – hiatus	3 (0.1)
Chyle leak	1 (<1)
Haemobilia	0 (0.0)

Notes
Each patient can have more than one indication.

3.2 ANZELA-QI KPIs

The results for each KPI are discussed under the following headings:

- Importance of KPI
- Findings
- Additional analyses (if relevant)
- Clinical commentary and recommendations.

3.2.1 Radiology

PRE 1 – Proportion of all emergency laparotomy patients for whom a CT scan was performed and reported by a consultant radiologist before surgery

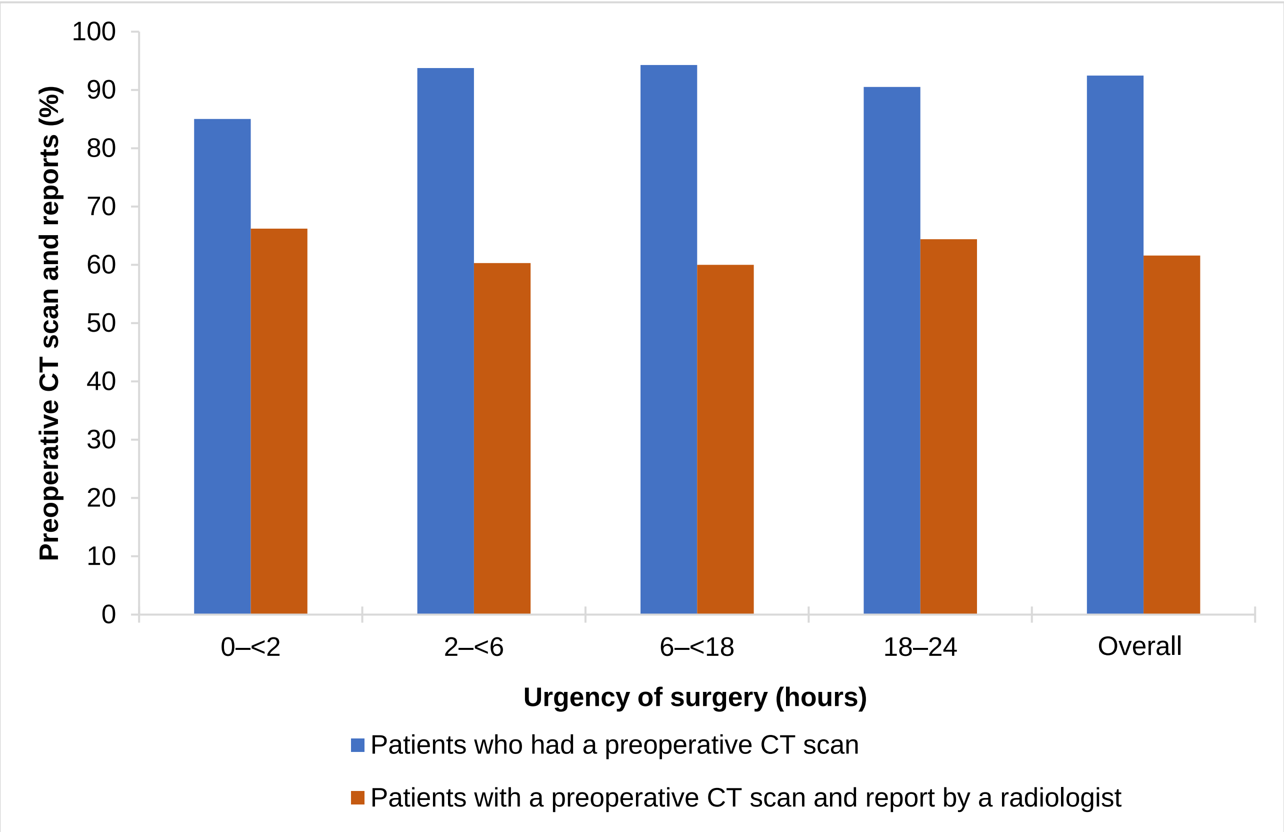
Importance of KPI

Patients being considered for an emergency laparotomy should have a preoperative CT scan.[2] Ideally, a consultant radiologist should report CT scans prior to surgery.

Findings:

- An abdominal CT scan was performed prior to surgery in 92.5% (2,939/3,178).
- Of the patients who had a CT scan prior to surgery, a report from a consultant radiologist was available for 61.6% (1,809/2,939; Figure 2).
- Only 66.2% (139/210) of CT scans in patients with an urgency of <2 hours were reported by a consultant radiologist prior to surgery.
- For patients with a surgical urgency of 18–24 hours, 64.4% (443/688) of CT scans were reported by a consultant radiologist prior to surgery (Figure 3).

Figure 3: Preoperative CT scan and report by consultant radiologist by category of surgical urgency



Abbreviations
CT = computed tomography

3.2.2 Lactate level available

PRE 2 – Lactate level available to the surgeon at the time of surgical referral for patients admitted via the emergency department

Importance of KPI

In September 2021, the availability of a lactate level to the surgeon at the time of referral for patients admitted via the emergency department (ED) was added as a regularly reported metric. Hospitals were unaware of their comparative performance prior to this time.

In this reporting period (January 2020–December 2021), 88.6% of emergency laparotomy patients were admitted via the ED.

Identifying septic patients in the ED is a critical starting point. The recording of lactate was a key recommendation in the recently published ACSQHC Sepsis Clinical Standards.[39]

Findings

The lactate level available at the time of surgical referral for patients admitted via the ED was 65.3% (1,835/2,809)

NELA comparison

NELA does not specifically report on availability of lactate measurement at the time of surgical assessment. In hospitals contributing to the 3-year Emergency Laparotomy Collaborative, the recording of lactate levels increased from 63.9% in the baseline period to 75.0% in months 28 to 39, a statistically significant improvement.[26]

3.2.3 Preoperative risk assessment

PRE 3 – Proportion of patients for whom a risk assessment was performed and documented preoperatively

Importance of KPI

Identifying high-risk patients preoperatively will permit their care to be appropriately escalated. It may also aid discussion with patients, their families and carers regarding the DTO, goals of care and postoperative ceilings of care. The NELA risk assessment score is appropriate for Australia.[31]

Findings (Table 5):

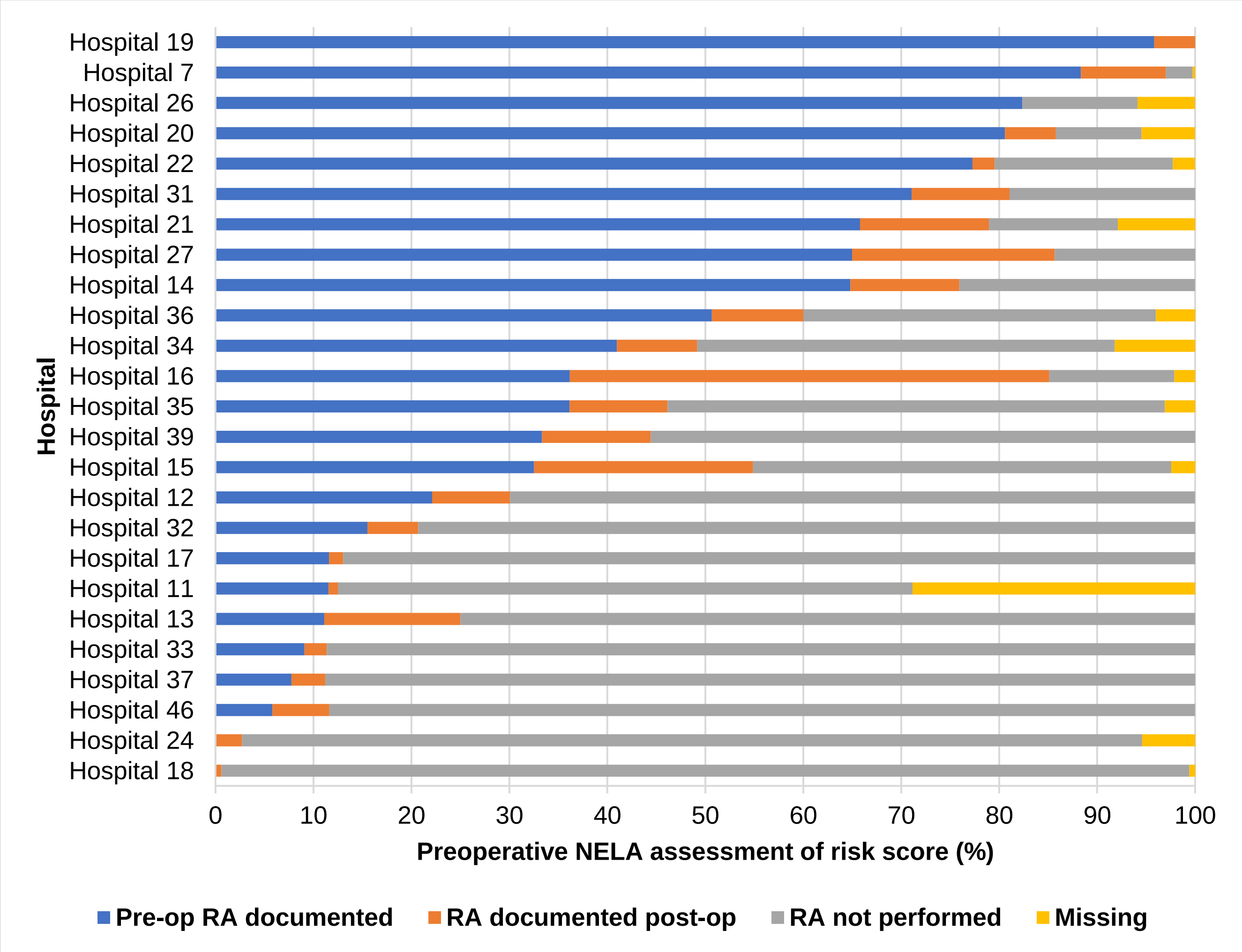
- 52.0% (1,653/3,178) had a documented preoperative risk assessment.
- 9.1% (289/3,178) had a risk assessment calculated postoperatively.
- Median scores within each preoperative risk category were 1.5% (lower risk), 7.0% (high risk) and 20.1% (highest risk) (data not shown).

Table 5: Documentation of NELA risk of death scores

		Patients	
	Predicted risk (%)	**n**	**%**
Documented preoperatively		**1,653**	**52.0**
Lower risk of death	<5	829	26.1
High risk of death	5–<10	297	9.3
	10–<25	322	10.1
Highest risk of death	25–<50	149	4.7
	≥50.0	38	1.2
	Missing score	18	0.6
Documented postoperatively		**289**	**9.1**
Lower risk of death	<5	164	5.2
High risk of death	5–<10	50	1.6
	10–<25	39	1.2
Highest risk of death	25–<50	19	0.6
	≥50.0	7	0.2
	Missing score	10	0.3
Score not documented		**1,236**	**38.9**
Total		**3,178**	**100**

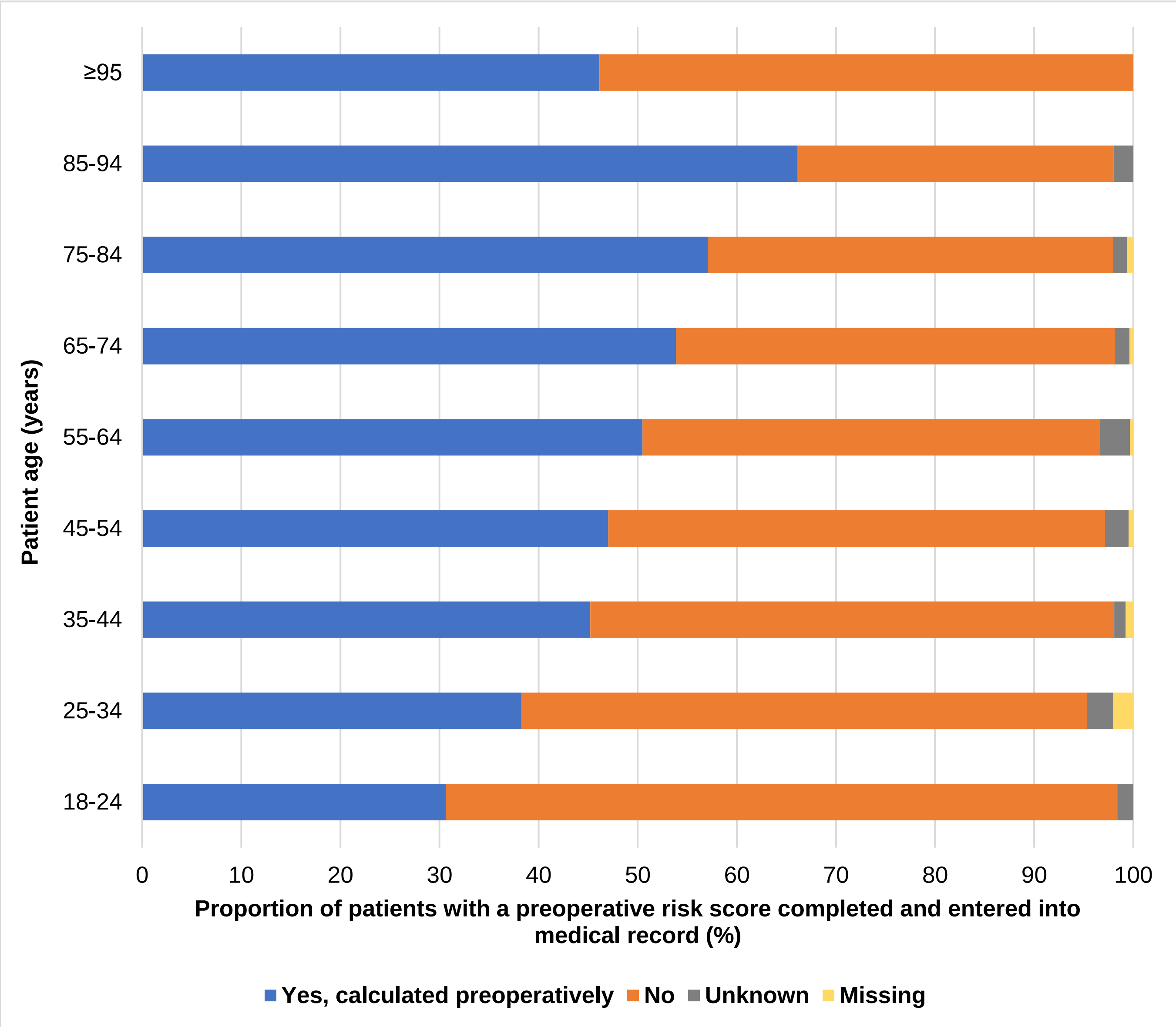
Notes
n (%) = number (percentage) of patients. Percentages in this table are of the total number of subjects (n = 3,178). The total for score documented preoperatively includes 'missing' category, which represents 18 cases of which the risk score was calculated preoperatively but was not recorded (n = 18) or n = 10 where the score was calculated postoperatively but not recorded.

Figure 4: Documentation of risk assessment by hospital



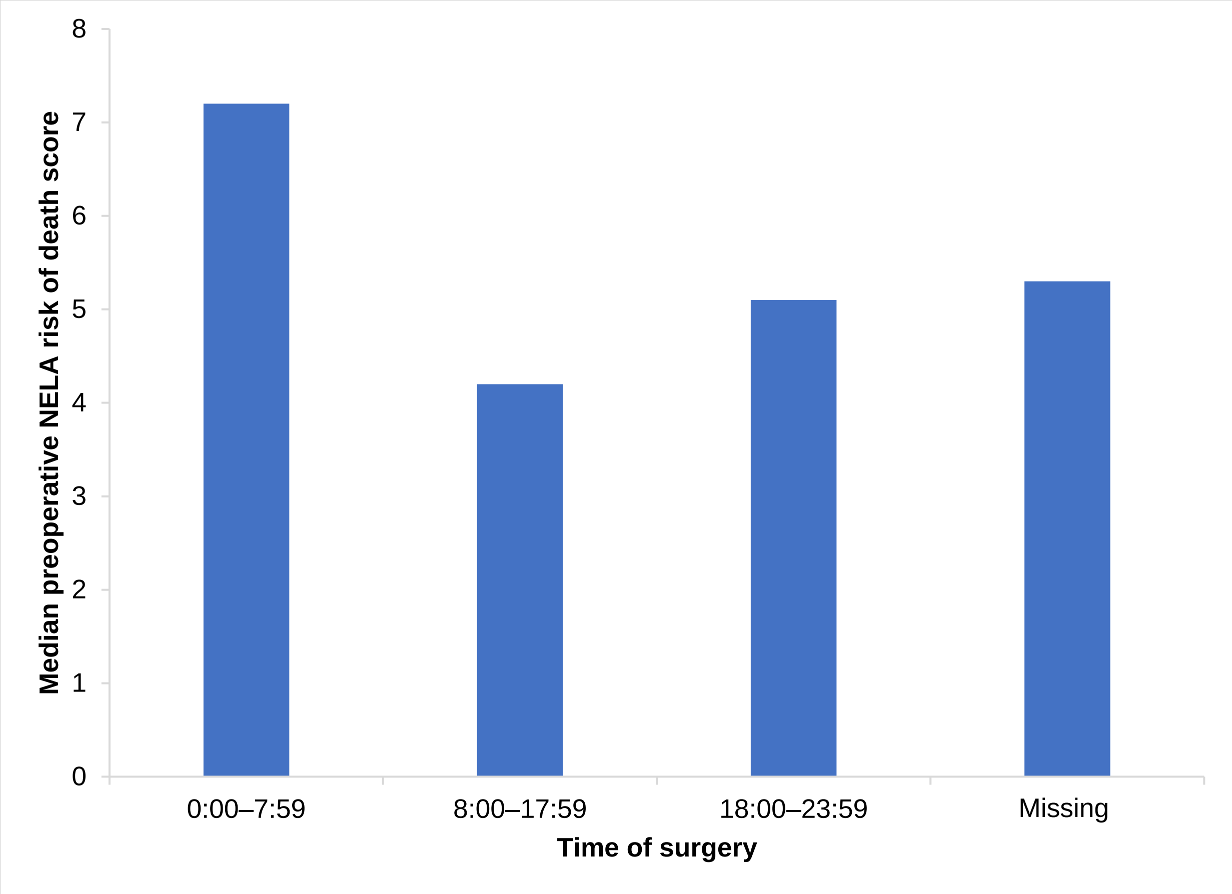
Abbreviations
Post-op = postoperative
Pre-op = preoperative
RA = risk assessment

Figure 5: Risk of death assessment completion across different age groups



<u>Notes</u>
Missing = score is missing or field is left blank (n = 16)
No = calculated and entered into the medical record postoperatively (n = 166) or calculated but not entered into the medical records (n = 123) or no not calculated and no option selected (n = 1,158)
Unknown = it is not known whether a risk-of-death score for the patient was calculated (n = 62)
Yes = a risk of death score for the patient calculated and entered into medical record preoperatively (n = 1,653)

Figure 6: Median preoperative risk-of-death score, by time of surgery for emergency laparotomy



Notes
Time of surgery refers to the time of day that the surgery took place (e.g. time provided for knife to skin or wheels in operating theatre, depending on what is typically collected at each hospital).

Comment

Patients who had surgery overnight or in the evening had the highest median predicted risk (Figure 6). This may be a reflection of surgeons using the risk assessment to justify out-of-hours surgery in the highest-risk patients.

Studies have shown patients who did not have a risk assessment have a worse outcome.[6] A risk assessment should be a routine part of the theatre booking process.

3.2.4 Preoperative frailty assessment

PRE 4 – Preoperative frailty assessment performed for patients age ≥65 years

Importance of KPI

Frailty is now recognised as a major determinant of outcome after emergency laparotomy. The assessment of frailty is one of the 5 key recommendations in the last (seventh) NELA report.

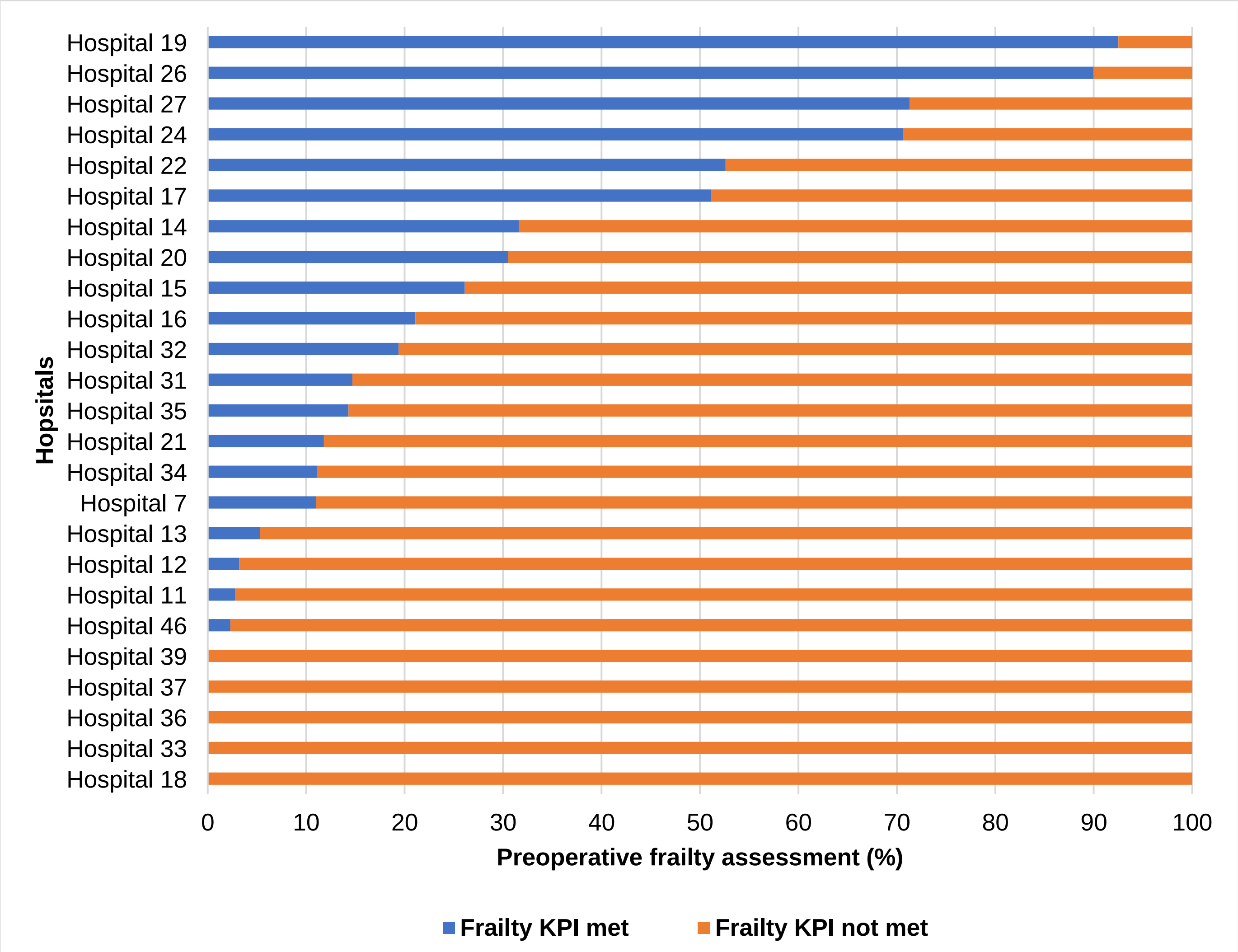
Along with lactate levels, frailty assessment has recently been added to ANZELA-QI monthly reporting.

Findings

Despite this KPI being formally reported only since September 2021, some hospitals were already routinely reporting it. Given this background, compliance rates prior to September 2021 are reported where available. However, these previous results should be interpreted with caution.

- Of 669 patients age ≥65 years, 468 (28.0%) had their frailty assessment done preoperatively.
- The inter-hospital variation is shown in Figure 7.

Figure 7: Preoperative frailty assessment for patients age ≥65 years by hospital



Abbreviations
KPI = key performance standard

3.2.5 Timeliness of arrival in theatre

PRE 5 – Proportion of patients arriving in theatre within a time appropriate for the urgency of surgery (documented urgency 24 hours or less)

Importance of KPI

For many patients undergoing an emergency laparotomy, time to surgery has a direct impact on outcome. Septic patients should have surgery in <6 hours, and within 3 hours if there is septic shock.[2]

ANZELA-QI stratified surgical urgency into 4 categories: less than 2 hours, 2–<6 hours, 6–<18 hours and 18–24 hours from hospital admission. PRE 5 KPI is based on the 3 most urgent categories.

Findings (Figure 8):

- 76.1% (2,418/3,178) had a surgical urgency of <18 hours.
- 1,238 of 2,418 (51.2%) arrived in theatre within the appropriate timeframe
    - urgency of <2 hours: 60 of 247 (24.3%) arrived in theatre within the appropriate timeframe
    - urgency of 2–<6 hours: 566 of 1,104 (51.3%) arrived in theatre within the appropriate timeframe.

Figure 8: Proportion of patients arriving in theatre within the appropriate timeframe

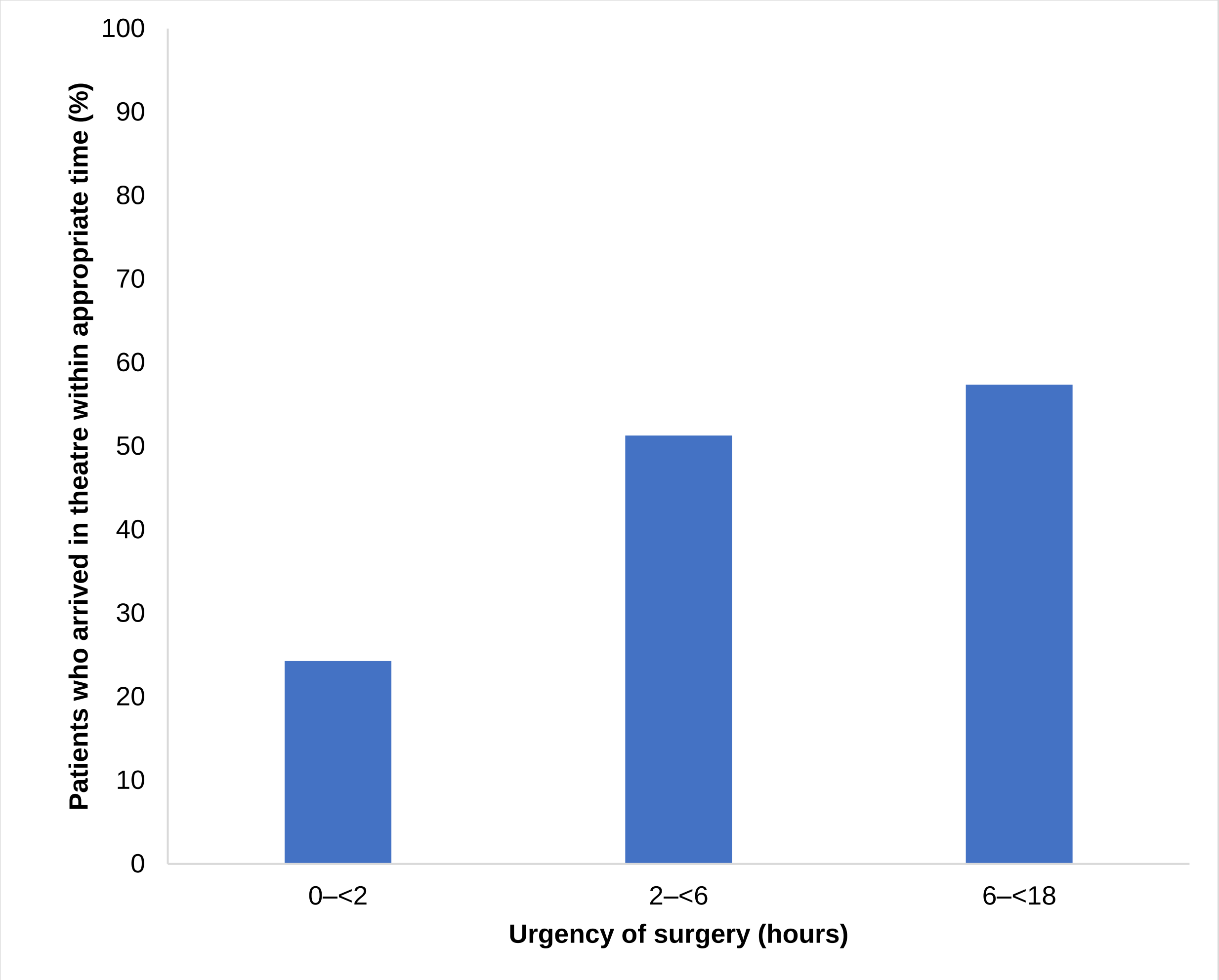
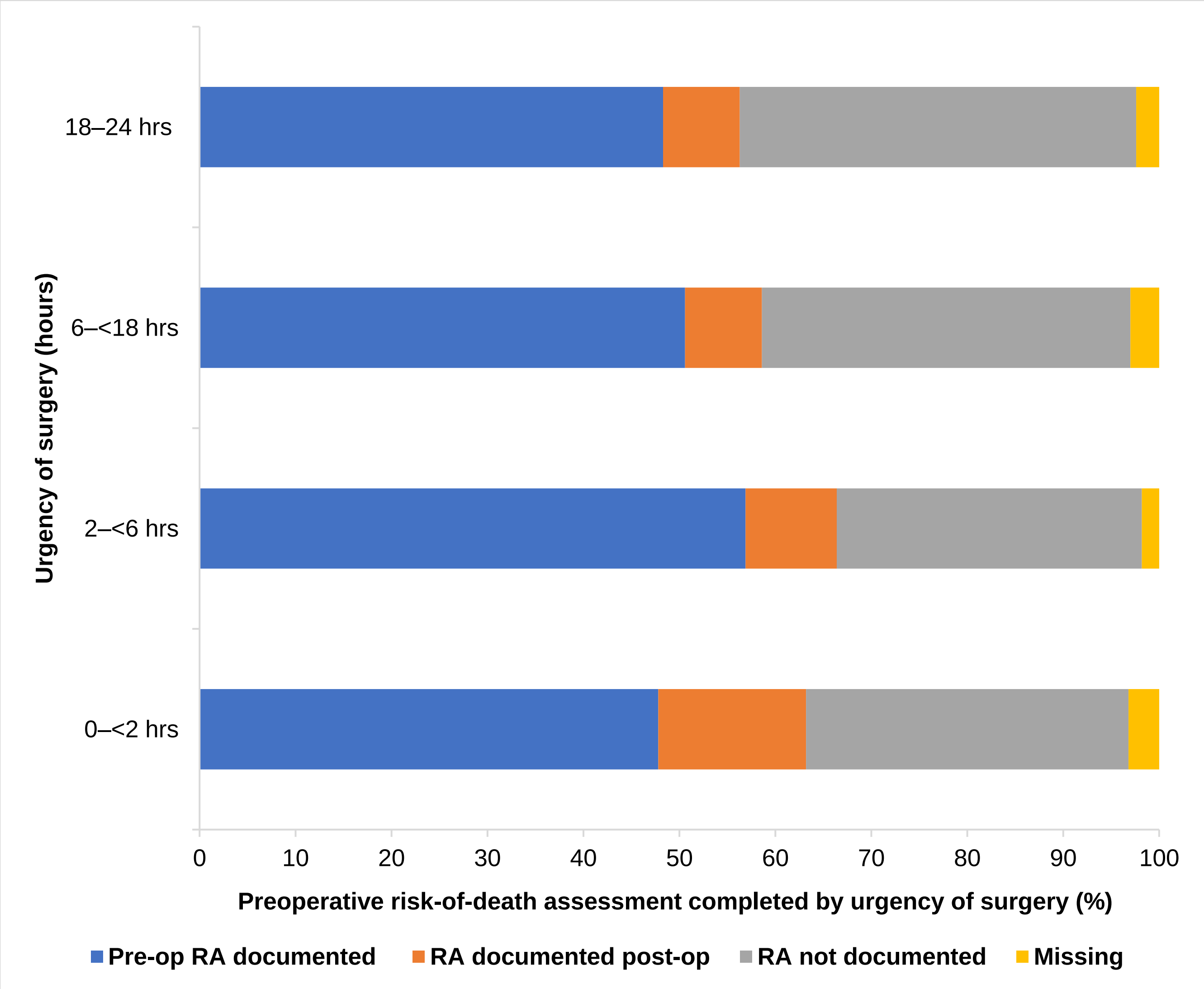
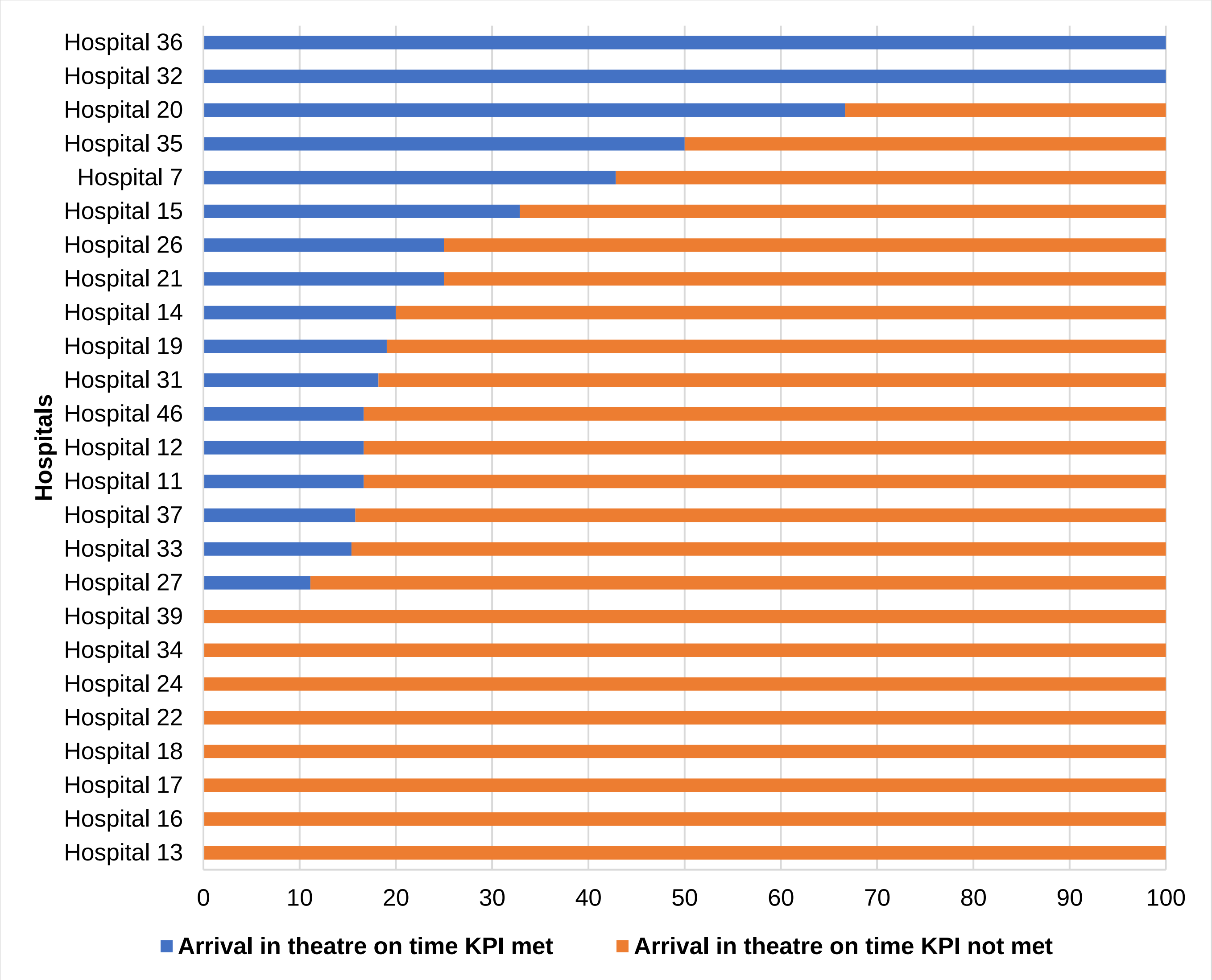


Figure 9: Proportion of patients with preoperatively documented risk-of-death, by documented urgency of surgery



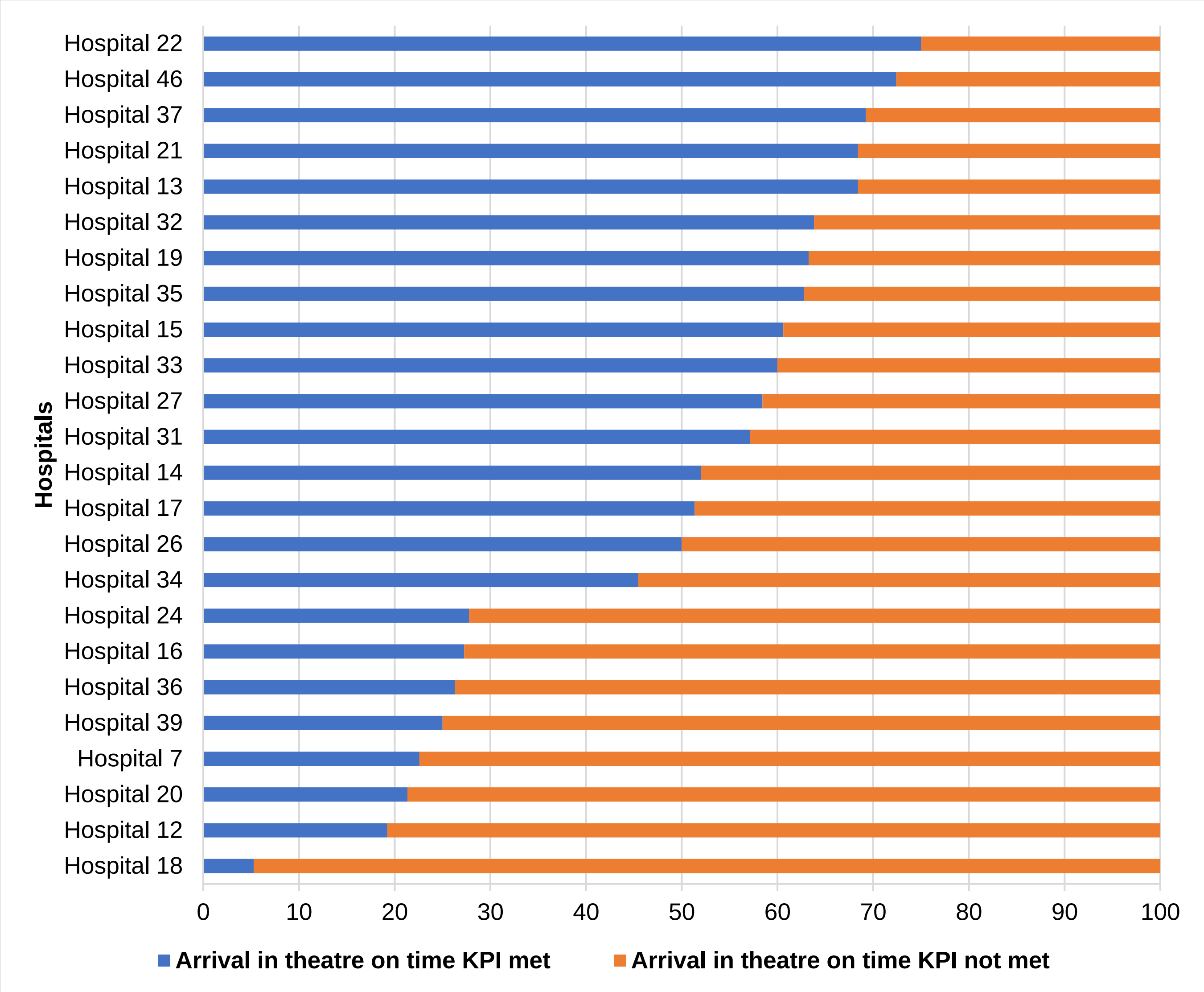
<u>**Abbreviations**</u>
Post-op = postoperative
Pre-op = preoperative
RA = risk assessment

Figure 10: Proportion of patients arriving in theatre on time for urgency 0–<2 hour by hospital



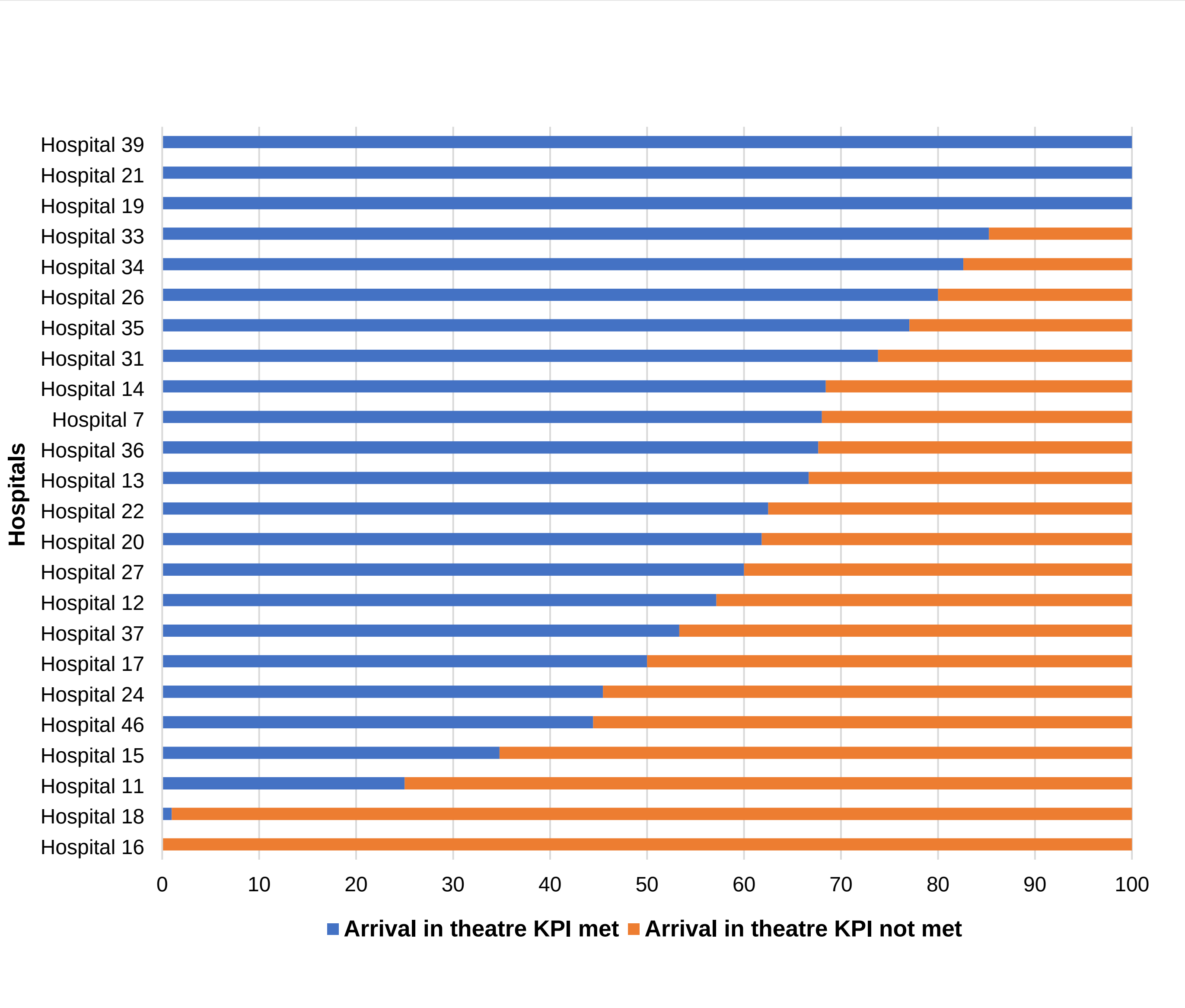
Abbreviations
KPI = key performance standard

Figure 11: Proportion of patients arriving in theatre on time for urgency 2–<6 hours by hospital



Abbreviations
KPI = key performance standard

Figure 12: Proportion of patients arriving in theatre on time for urgency 6–<18 hours by hospital



Abbreviations
KPI = key performance standard

Comment

Numerous studies have demonstrated that the mortality from sepsis rises approximately 7% with each additional hour of delay. There are clearly defined standards of care.[2]

Only 24% of the most urgent patients (surgery in <2 hours), and by definition the most unwell, achieved this standard. Hospitals that have not met this KPI need to review their theatre access processes.

3.2.6 Consultant input during surgery

OP 1 – Proportion of patients with a calculated preoperative risk of death ≥5% for whom a consultant surgeon and consultant anaesthetist were present in theatre

OP 2 – Proportion of patients with a calculated preoperative risk of death ≥5% for whom a consultant surgeon was present in theatre

OP 3 – Proportion of patients with a calculated preoperative risk of death ≥5% for whom a consultant anaesthetist was present in theatre

Importance of KPI

It would be normal practice for both a consultant surgeon and a consultant anaesthetist to be present in theatre for a high-risk elective general surgical patient. The same standard of care should be delivered to high-risk emergency general surgical patients.

Findings (Table 6):

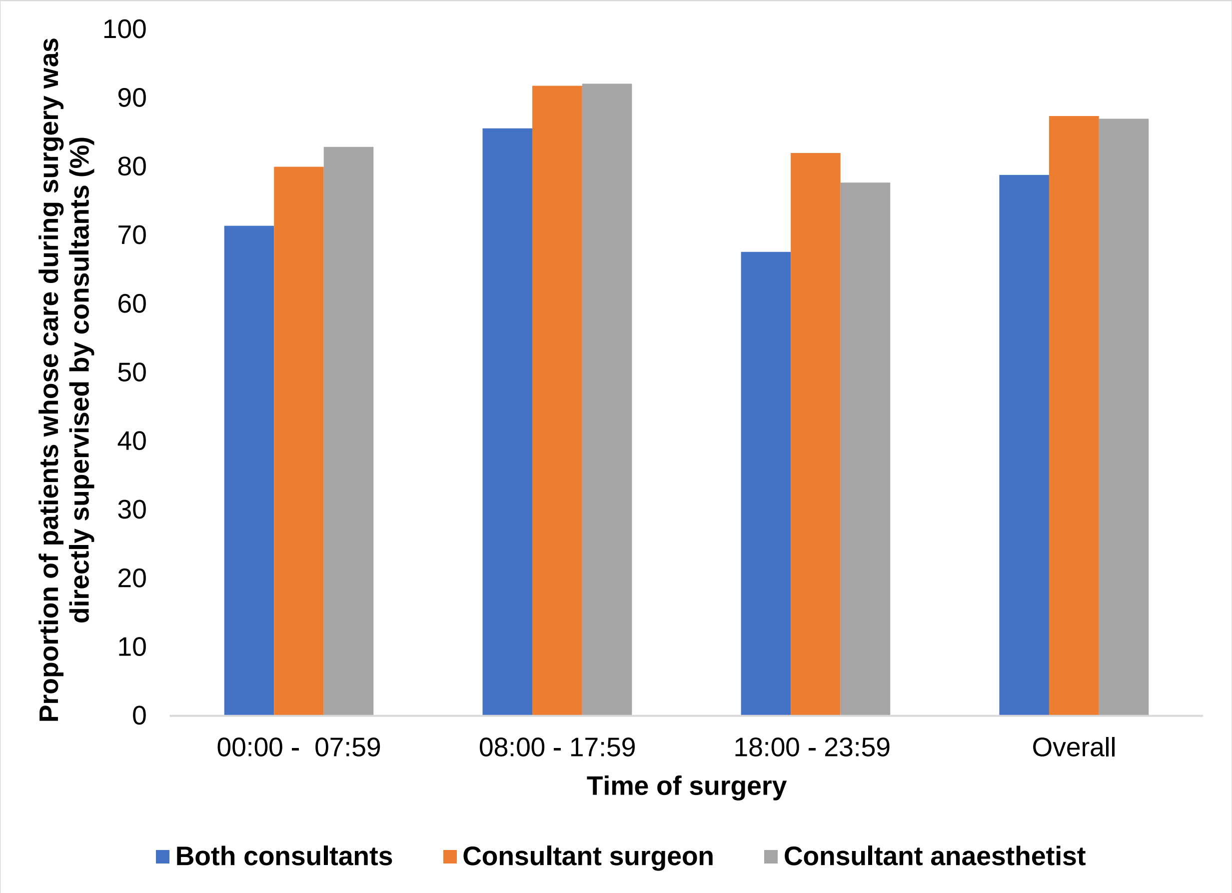
- Consultant presence in theatre was recorded for 97.8% (806/824) of those who had a documented preoperative risk of death of ≥5%.
- More patients in the highest-risk group (77.2%; 393/509) than in the high-risk group (72.4%; 215/297) had both consultants present during their surgery.
- 5.1% (41/806) of the high- and highest-risk patients had neither consultant present during their surgery.

Table 6: Consultant presence during surgery for high-risk patients (preoperative risk-of-death score ≥5%)

		Consultant(s) present during surgery			
	Patients at risk	**Both consultants n (%)**	**Consultant surgeon n (%)**	**Consultant anaesthetist n (%)**	**Neither consultant n (%)**
High (≥5%–9.9%)	297	215 (72.4)	247 (83.2)	240 (80.8)	19 (6.1)
Highest (≥10%)	509	393 (77.2)	427 (83.9)	442 (86.8)	22 (4.3)
Overall	806	608 (75.4)	674 (83.6)	682 (84.6)	41 (5.1)

Notes
n (%) = number (percentage) of patients
This table does not include n = 18 patients who had a preoperative high-risk score but consultant presence during their surgery was not recorded.

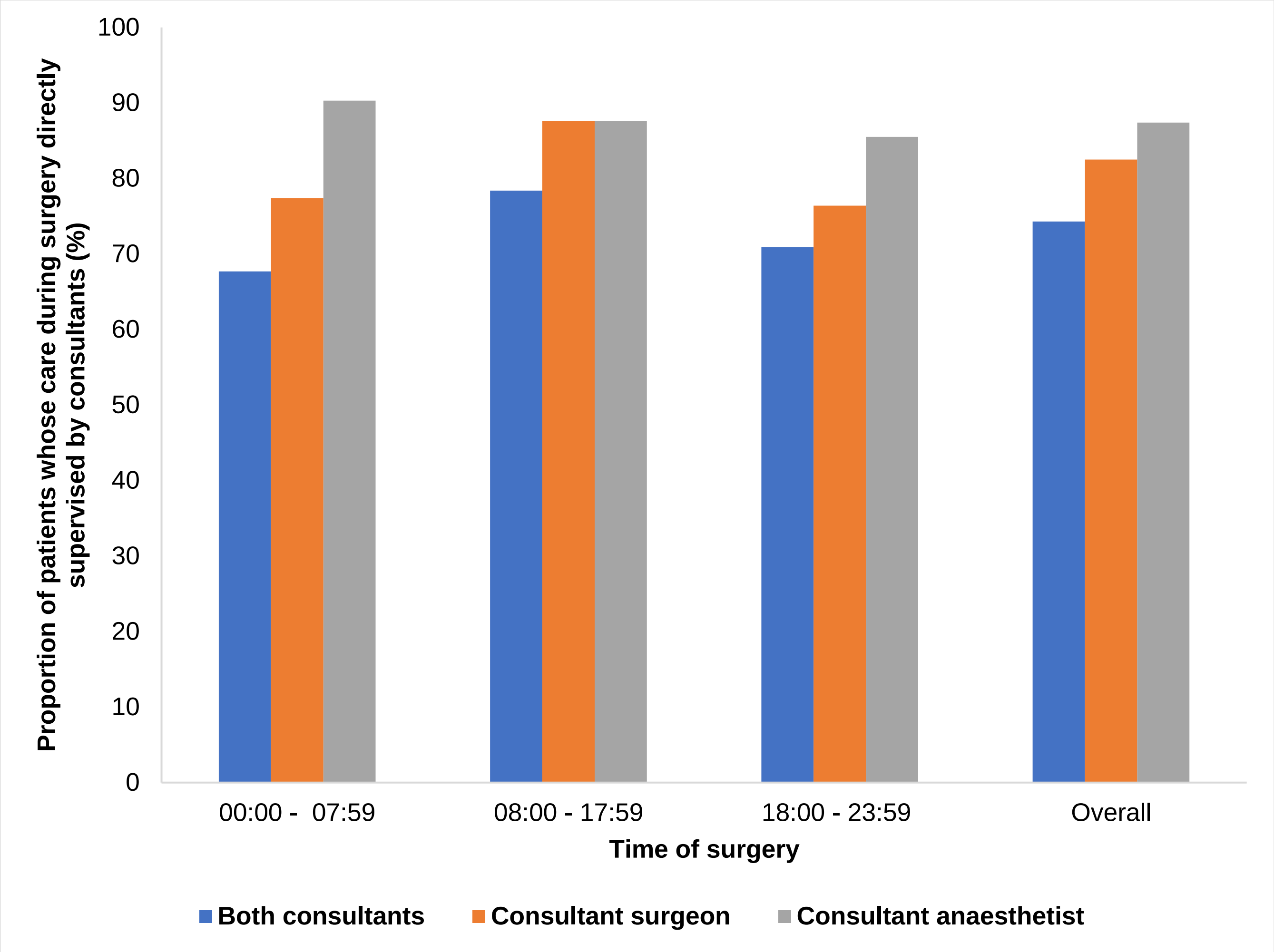
Figure 13: Consultants present in theatre on a weekday for patients with a preoperative risk-of-death score ≥5%, by time of emergency laparotomy



<u>Notes</u>

Time of surgery refers to the time of day that the surgery took place (e.g. time provided for knife-to-skin or wheels in operating theatre, depending on what is typically collected at each hospital). In some hospitals, consultants are paid fee for service, and they would attend for almost every operation. This means that in other hospitals consultant attendance would be less than the average that appears in the figure.

Figure 14: Consultants present in theatre on a weekend for patients with a risk-of-death score ≥5%, by time of emergency laparotomy



Notes
Time of surgery refers to the time of day that the surgery took place (e.g., time provided for knife-to-skin or wheels in operating theatre, depending on what is typically collected at each hospital). In some hospitals, consultants are paid fee for service, and they would attend for almost every operation. This means that in other hospitals consultant attendance would be less than the average that appears in the figure.

Comment

During the week, only patients with the greatest risk would have surgery after hours and only those requiring 'life and limb' saving surgery would have it overnight. These patients were the least likely to have a consultant present.

These data display the average consultant presence. In Australia, a consultant will be present for all (100%) occasions if they are paid fee for service (FFS), either because the patient is private or because they are a visiting medical officer. These cases are included in this analysis. To 'balance' this 100% attendance means that consultant attendance in many public hospitals, where consultants are not paid FFS and there are junior staff, must be less than the average. At present, ANZELA-QI is not able to undertake a more detailed analysis, but the clear implication is that consultant attendance in public hospitals could be lower than as displayed in Figures 14 and 15. As hospitals with junior staff are more likely to manage the most unwell patients, and many will have been transferred for that reason, this has important implications.

3.2.7 Postoperative admission to critical care

POST OP 1 – Proportion of patients with a preoperative risk of death ≥10% who were directly admitted to critical care postoperatively

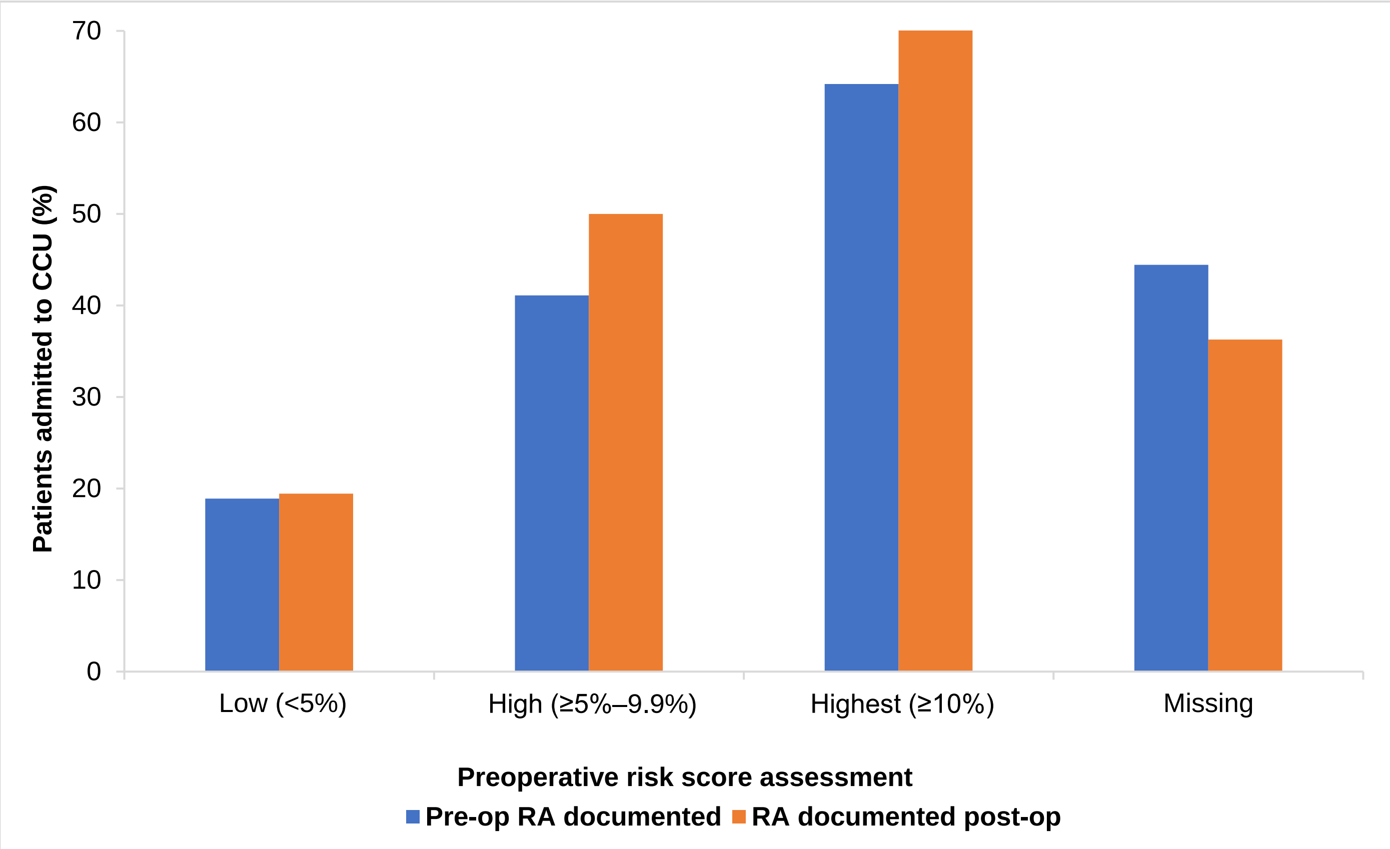
Importance of KPI

The overall risk-adjusted mortality rate was 6.2%, and 16.0% for patients who had a predicted mortality of ≥10%. Many of these patients should have their initial postoperative care in a critical care (CCU).

Findings:

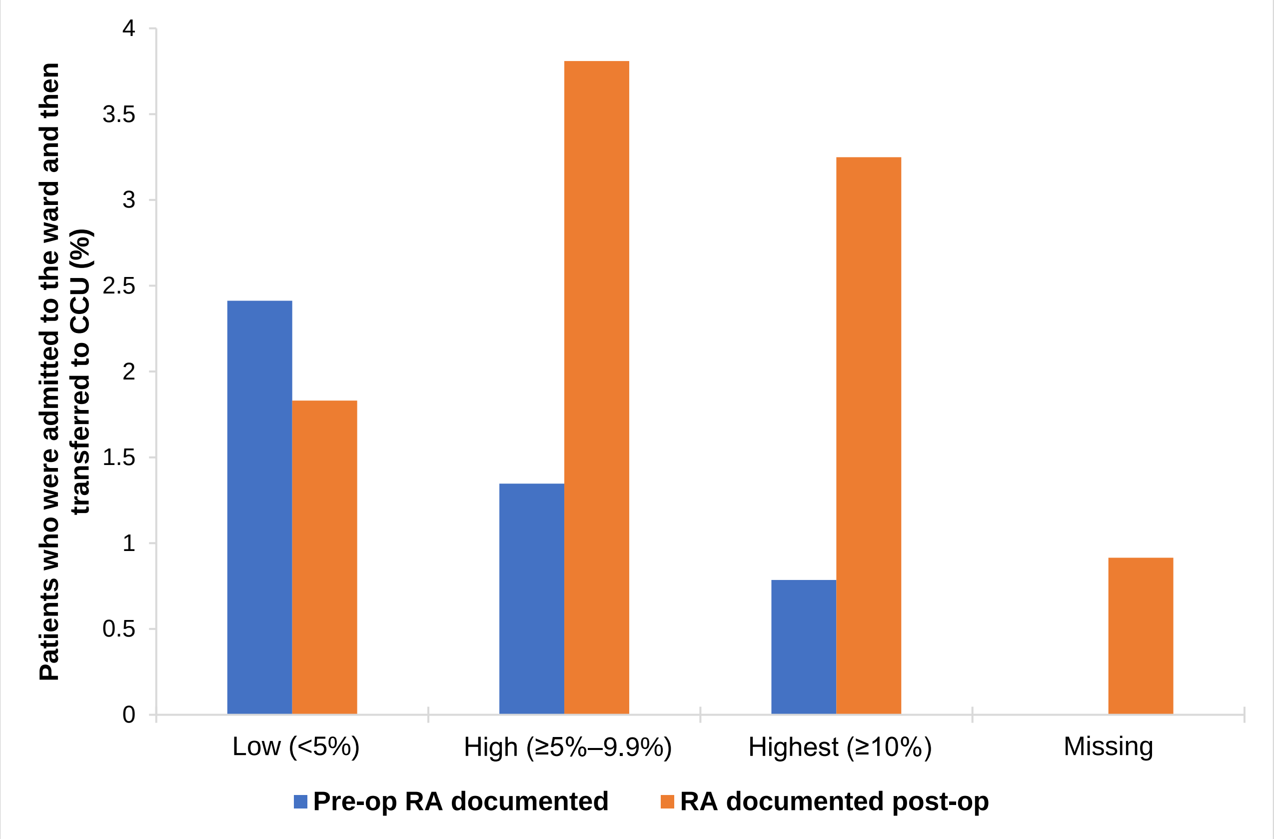
- 327 of 509 (64.6%) patients with a preoperative NELA risk assessment score of ≥10% were admitted to critical care following surgery. Admission to critical care after surgery was associated with higher preoperative risk of death scores (Figure 15).
- 61 of 3,178 (1.9%) patients had an unplanned postoperative transfer from the ward to unit CCU (data not shown). Of the patients who had a risk assessment, the highest-risk patients were most likely to be admitted to CCU (Figure 15).
- Patients who had not had a preoperative risk assessment were more likely to have an unplanned admission to CCU (Figure 16).

Figure 15: Proportion of patients admitted directly to CCU, by documented preoperative risk assessment score



<u>**Abbreviations**</u>
Post-op = postoperative
Pre-op = preoperative
RA = risk assessment

Figure 16: Proportion of high-risk patients admitted to the ward and then transferred to CCU by preoperative risk assessment score



<u>**Abbreviations**</u>
Post-op = postoperative
Pre-op = preoperative
RA = risk assessment

Comment

All patients undergoing an emergency laparotomy should have a preoperative risk assessment score and if ≥10% should be routinely admitted into CCU. The recommendation of NELA is that patients with a preoperative risk assessment score ≥5% should be admitted into CCU.

3.2.8 Patients age ≥65 years having emergency laparotomy

POST OP 2 – Proportion of patients age ≥ 65 years who were assessed by a specialist in elderly medicine

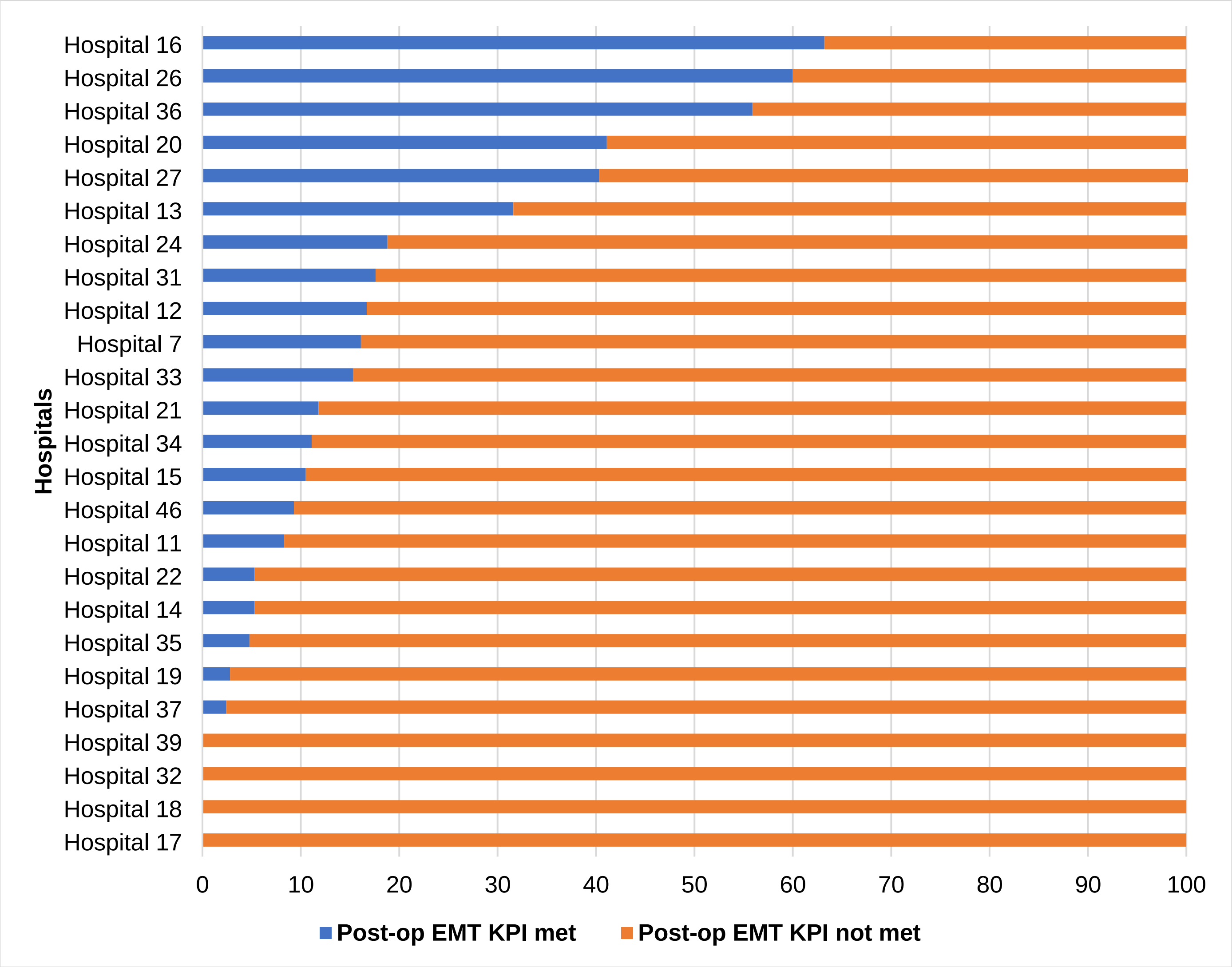
Importance of KPI

There are multiple studies that show elderly patients will benefit from pre-emptive multidisciplinary care, including from a specialist in gerontology.

Findings (Figures 17 and 18):

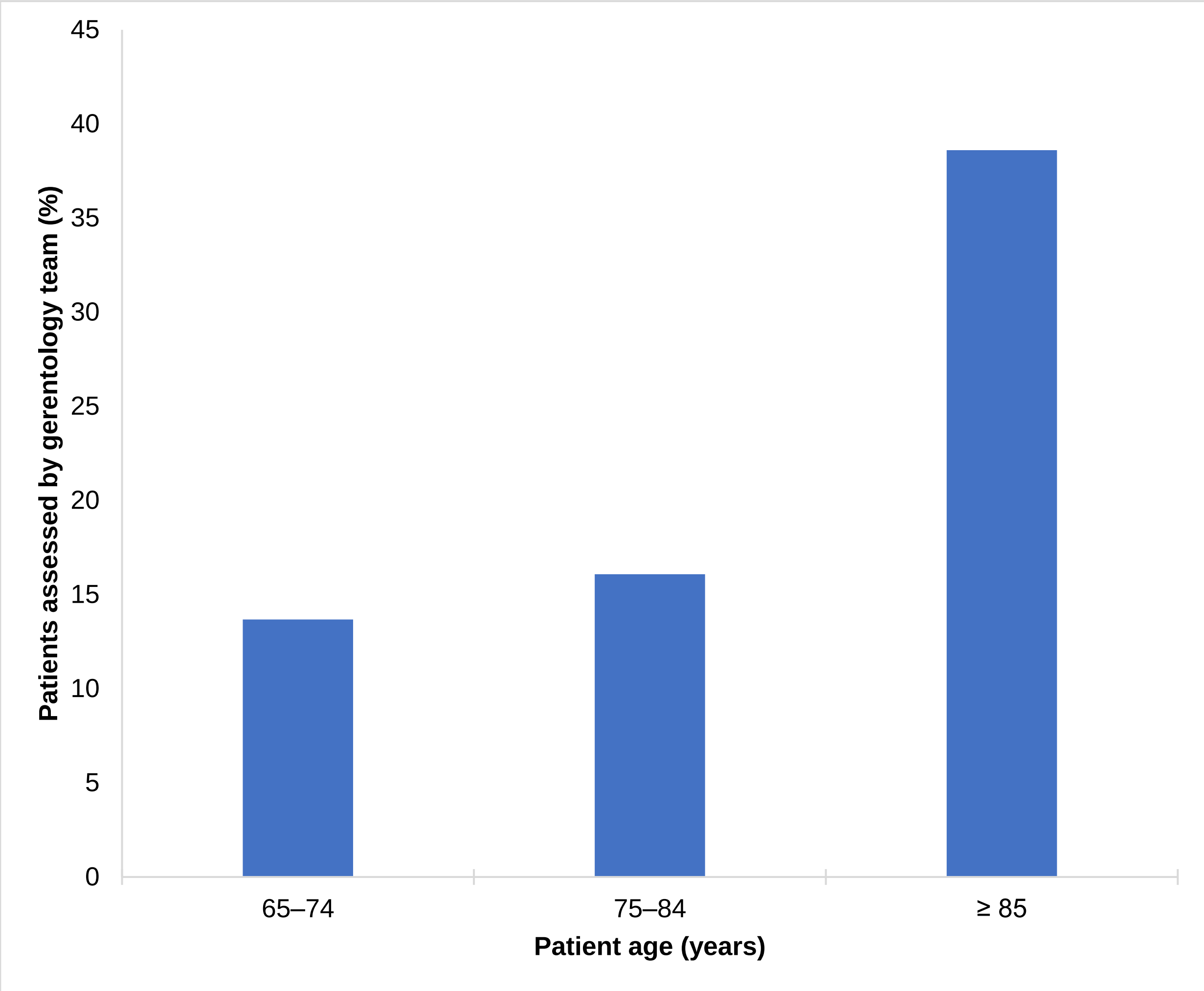
- Data were collected from 1,612 patients age ≥65 years.
- 280 (17.4%) received a postoperative assessment by a specialist in gerontology or a gerontology team.
- There was wide inter-hospital variation.
- Patients age 65 to 84 years were half as likely to receive an assessment by the gerontology team as were patients aged ≥85 years (13.0% vs 4.3%).

Figure 17: Proportion of patients age ≥65 years assessed after surgery by a specialist in gerontology or a gerontology team, by hospital



Abbreviations
EMT = elderly medicine team, **KPI** = key performance indicator

Figure 18: Proportion of patients age ≥65 years assessed after surgery by a specialist in gerontology or a gerontology team



Comment

Overall, this was the most poorly met KPI.

3.3 Additional patient outcomes

In addition to the 10 standard of care KPIs, an additional 5 outcomes were assessed:

- mortality
- LOS
- destination on discharge from hospital
- return to theatre
- Clavien-Dindo complication grade.

3.3.1 Mortality

Explanation of ANZELA-QI mortality analysis and the importance of case ascertainment

Mortality after an emergency laparotomy is a key outcome. There will inevitably be comparisons with other reports and within ANZELA-QI. This section outlines some of the issues when interpreting this section. They have general application.

The 6.2% risk-adjusted mortality in ANZELA-QI is the 30-day, in-hospital mortality, not 30-day mortality. This is a consequence of the privacy legislation and cost in Australia that prevents the easy data sharing required to establish 30-day mortality, and now the more relevant 90-day mortality. In many studies, 30-day and in-hospital mortality are the same, but in others, in-hospital mortality may under-record 30-day mortality by up to 1%. If allowance is made for this, the mortality in ANZELA-QI is little different to the 7.2% mortality for COVID-19 negative patients included in the seventh NELA report.

Only about 11% of all the estimated Australian emergency laparotomies are included in ANZELA-QI, so this data may not be fully representative.

No-Lap

During the last few years there has been an increasing awareness that postoperative mortality may be impacted by those who do not have surgery. The true emergency laparotomy mortality denominator is all who were eligible for an emergency laparotomy regardless of whether they had surgery or not (now termed No-Lap). Of the 5 studies that have reported the No-Lap rate, [6-7,10] 3 are from Australia. The No-Lap rate seems to be higher in Australia than overseas.

Australia is the only country with a national mortality audit. The Australian and New Zealand Audit of Surgical Mortality (ANZASM) has had a long-term interest in the avoidance of ‘futile’ surgery, and the lower mortality in ANZELA-QI may reflect the lessons learned from ANZASM.[40] The avoidance of potentially futile surgery in high-risk patients will reduce post-surgery mortality.

It is normal practice to present mortality outcomes after appropriate risk adjustment. If there is poor case ascertainment and/or missing data, it may be difficult to make proper risk adjustment. The dangers associated with poor case ascertainment and missing data have been strongly emphasised.[17,21] This is not unique to ANZELA-QI, and all CQRs have to address missing data.

This section is an opportunity to present specific examples to demonstrate the importance of complete case ascertainment. Hopefully this will lead to a better understanding of the importance of more complete data.

Missing data can be addressed in a number of ways:

1. Unadjusted mortality can be presented.
2. Patients with missing data can be excluded from the analysis.
3. Fields with missing data can be given average data. The average may be derived from the whole dataset or from more local data; for example, the average ASA of the hospital in which patients with missing data had their operation.
4. The most likely value can be allocated to the missing field.
5. Complex algorithms can be used to impute a value.
6. The business rules for the management of missing data can be defined in advance. This almost always allocates a ‘worst’ outcome as this encourages more complete data completion.

None of these are ideal – all are a compromise. Any may adversely weight the data in a manner that may lead to a different result to an alternative.

Known variables that are included in any mortality risk adjustment include ASA grade and preoperative risk scores. In this ANZELA-QI mortality analysis, many patients were missing an ASA grade. The options were to give these patients the average or most common ASA grade. Half the patients were missing a preoperative risk score. The options were to give these patients either (i) the average or (ii) the observed mortality of those given a score. Almost 20.0% had no ethnicity recorded. In those for whom ethnicity was recorded, about 3.0% were Aboriginal or Torres Strait Islander.

ANZELA-QI reviewed the missing data and undertook a number of trial analyses. The missing data varied greatly by hospital. Depending on the assumption, the results for some hospitals were very adversely affected; a few even became outliers well beyond the 3SD confidence limits. For those with little missing data, there was minimal change.

This ANZELA-QI mortality analysis has excluded ASA grade and risk assessment. The number with missing data was too great to make any meaningful adjustment.

Ethnicity is a well-recognised variable in Australia. Some 18.7% were missing ethnicity (Table 3). Based on patients in whom ethnicity was recorded, some 97.0% of those with missing ethnicity were likely to be non-Indigenous. Ethnicity had a marginal impact on univariate and multivariate analysis, so all were included and those with missing data considered non-Indigenous.

To balance this, the unadjusted data have also been presented. Previous studies in this area have shown the biggest variables for mortality are admission status (emergency or elective) and age. In this ANZELA-QI data, few were elective admissions, and it had no impact on univariate and multivariate analysis; the age was known for all. This may explain why the differences between the adjusted and unadjusted data are not as great as might be anticipated.

No hospitals were outside the 3SD confidence limits. However, it did change the place on a 'league' table of inter-hospital variation.

Findings:

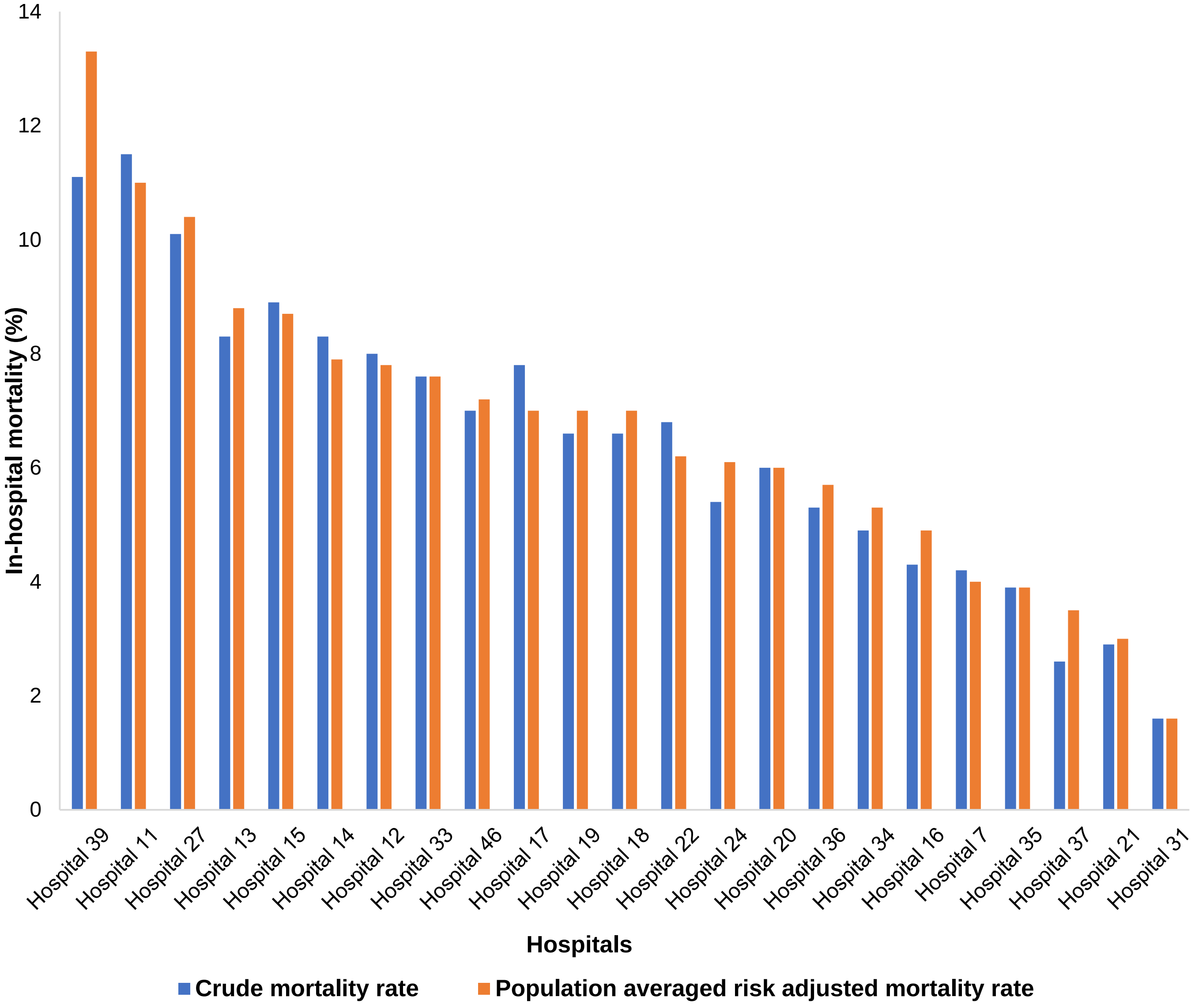
- The overall in-hospital mortality rate was 6.2% (195/3,145) (Table 7).
- After excluding hospitals with no mortality, the inter-hospital variation was between 1.6% and 13.3% – an 8.3-fold variation (Table 8, Figure 19–20).
- Mortality increased with age (Figure 19).

Table 7: Mortality rates by risk assessment

Risk assessment (RA) completed	Patients	Patients deceased on discharge, n (%)
Pre-op RA documented	1,638	113 (6.9%)
RA documented post-op	286	19 (6.6%)
RA not performed	1,221	63 (5.2%)
Overall	**3,145**	**195 (6.2%)**

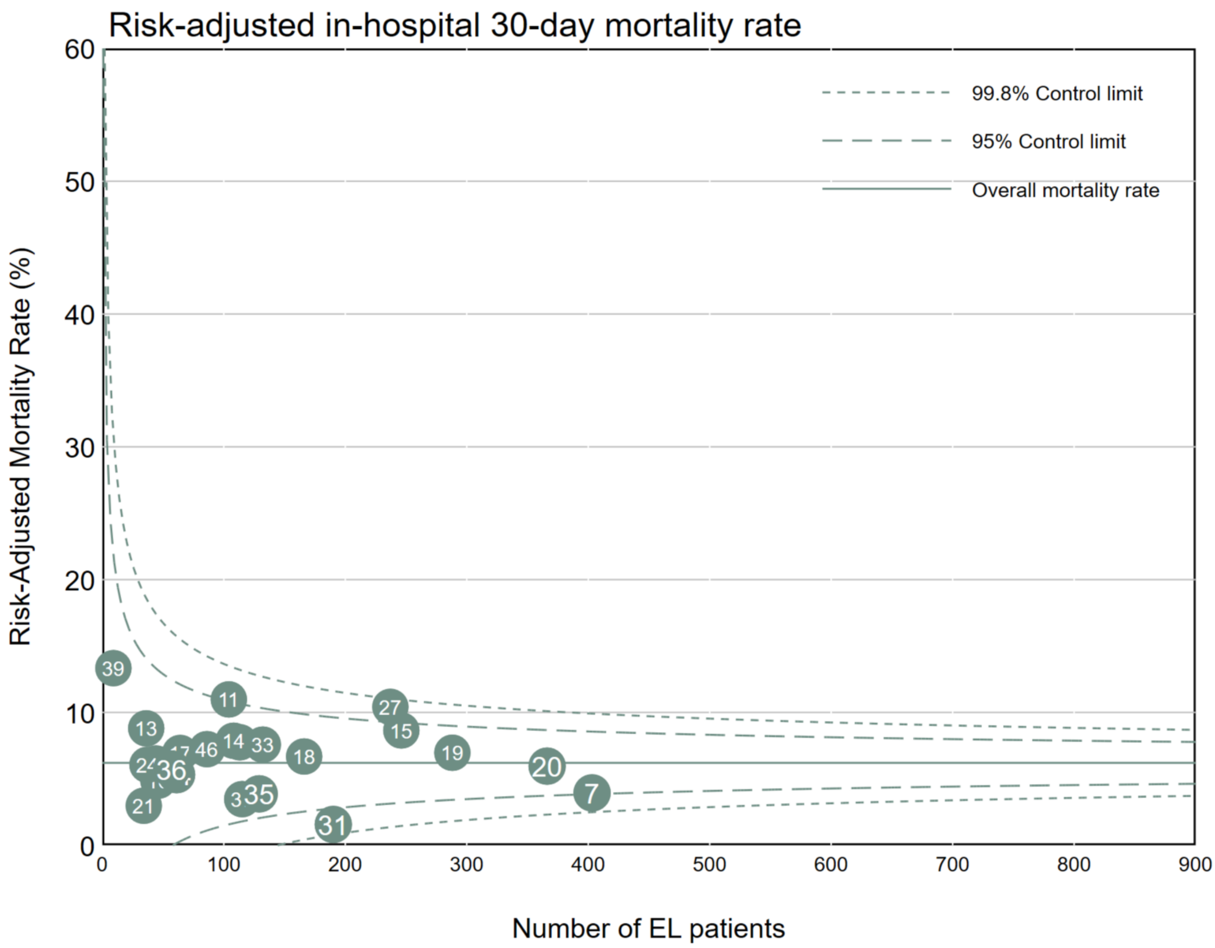
Abbreviations
Post-op = postoperative
Pre-op = preoperative
RA = risk assessment
Notes
3,145 because it does not include n = 33 patients with missing discharge status.

Figure 19: In-hospital mortality rate of participating hospitals



Funnel plots were constructed according to the method outlined by Spiegelhalter.[41] More detail on the method has been included in the appendix. [42-44]The resulting funnel plot is centred around the overall (population-averaged) mortality rate (Figure 20). All national data available for the reporting period (1 January 2020–31 December 2021) were used for the mortality analysis.

Figure 20: Risk-adjusted in-hospital 30-day mortality rate



Notes
Adjusted for age, gender and ethnicity, with all data for 2020 and 2021 included

No hospital fell outside the 99.8% control limit for risk-adjusted 30-day in-hospital mortality.

Note:

- No allowance has been made for transfers.
- Cases missing ethnicity (18.6%) were assumed to be non-Indigenous.
- It is estimated that ANZELA-QI captured ~11% of emergency laparotomies undertaken in this period.

Figure 21: Proportions of patients who died, by age group

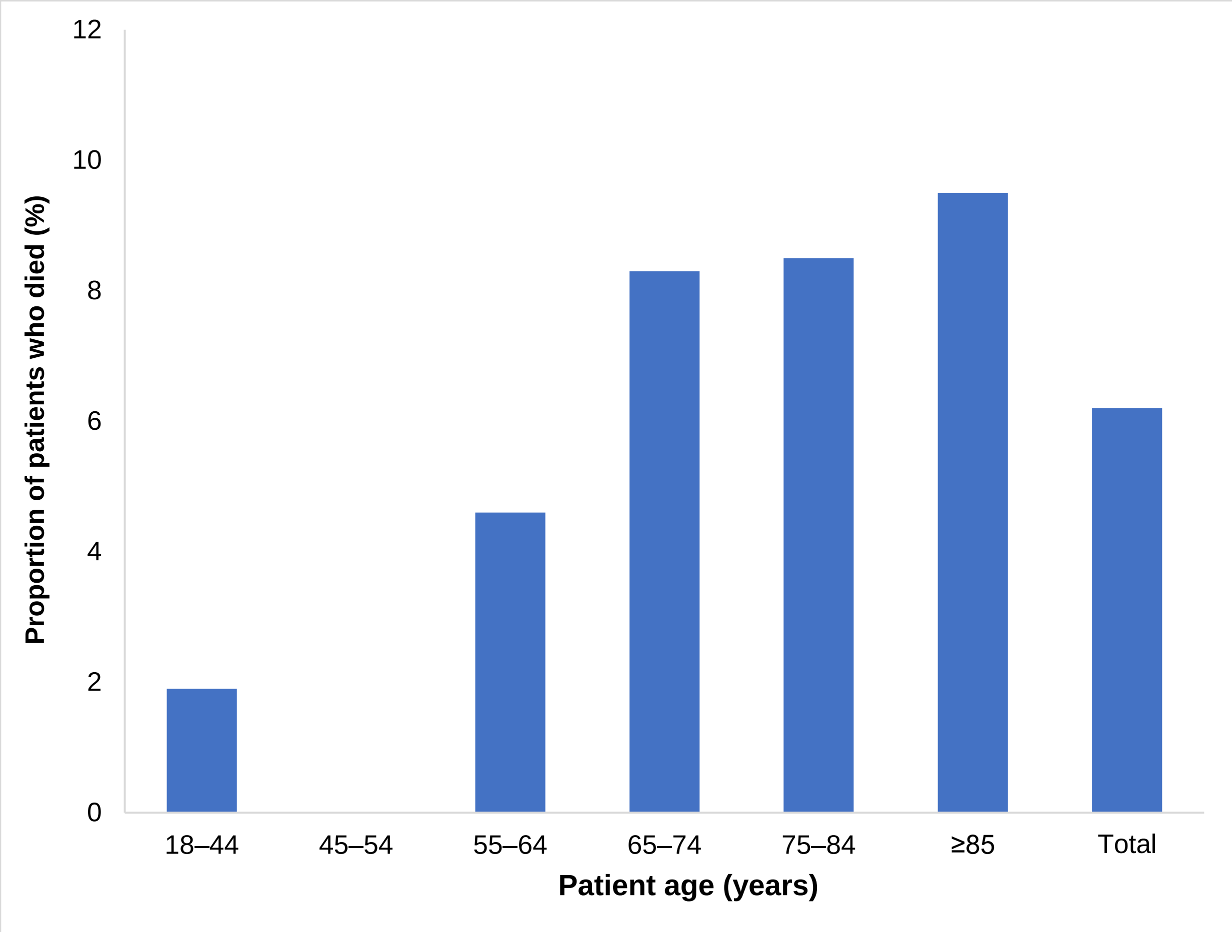


Table 8: Estimates for mortality funnel plots

Hospital ID	Observed	Expected	Total number of patients	Crude mortality rate	Population-averaged risk-adjusted mortality rate
Hospital 39	1	0.5	9	11.1	13.3
Hospital11	12	6.8	104	11.5	11.0
Hospital 27	24	14.3	237	10.1	10.4
Hospital13	3	2.1	36	8.3	8.8
Hospital15	22	15.7	246	8.9	8.7
Hospital 14	9	7.1	108	8.3	7.9
Hospital 12	9	7.2	113	8.0	7.8
Hospital 33	10	8.2	132	7.6	7.6
Hospital 46	6	5.1	86	7.0	7.2
Hospital 17	5	4.5	64	7.8	7.0
Hospital 19	19	16.9	288	6.6	7.0
Hospital 18	11	10.2	166	6.6	6.7
Hospital 22	3	3.0	44	6.8	6.2
Hospital 24	2	2.0	37	5.4	6.1
Hospital20	22	22.9	366	6.0	6.0
Hospital 36	3	3.2	57	5.3	5.7
Hospital 34	3	3.5	61	4.9	5.3
Hospital 16	2	2.5	46	4.3	4.9
Hospital 7	17	26.7	403	4.2	4.0
Hospital 35	5	8.0	129	3.9	3.9
Hospital 37	3	5.3	115	2.6	3.5
Hospital 21	1	2.1	34	2.9	3.0
Hospital 31	3	11.8	190	1.6	1.6

Abbreviations
ID = identity
Notes
Excluded: 3 hospitals with 0 observed deaths

Comment:

The NELA mortality of 7.9% for COVID negative patient data are important for comparative purposes.[5] Because of the constraints imposed on ANZELA-QI, it can only report in-hospital mortality rather than 30-day mortality. Other emergency laparotomy audits have shown little difference between the two.[45]

Although the overall mortality of 6.2% is acceptable, the almost sixfold inter-hospital variation suggests there is much room for improvement.

3.3.2 Length of hospital stay

Of the 3,178 patients, 92.4% were discharged alive (Table 3).

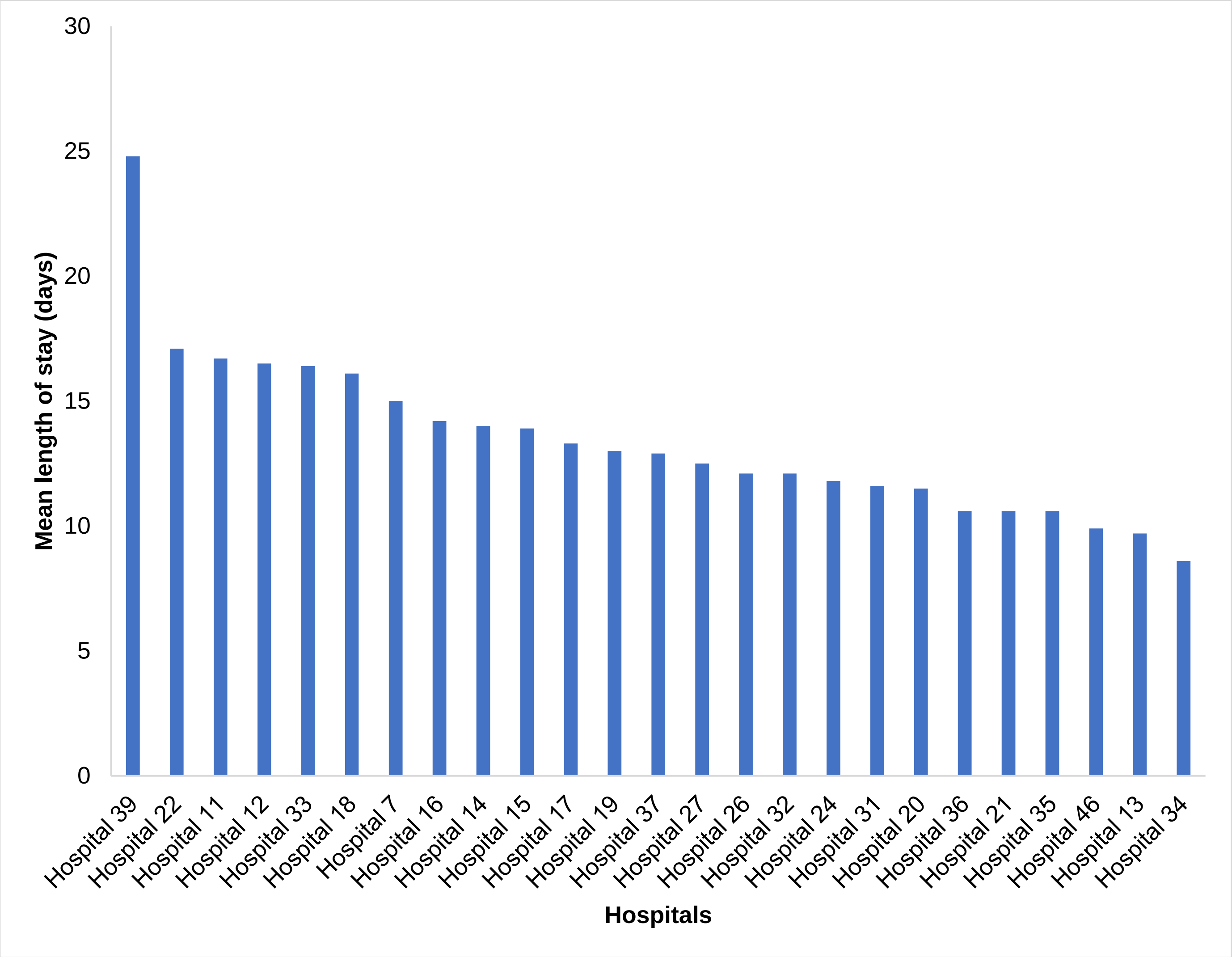
Thirty-three (1.0%) patients had missing discharge data, 195 (6.1%) died in hospital, 13 (0.4%) were still in hospital at 60 days after admission, 11 did not have a discharge date (0.3%) and 2 (<1.0 %) had incorrect discharge dates resulting in negative LOS periods. Of these patients, a total of 254 were excluded from the analysis.

The distribution of LOS was strongly right-skewed due to outlier values for patients with very long LOS.

LOS varied from 0 days to 385 days across all hospitals (outliers not removed; data not shown).

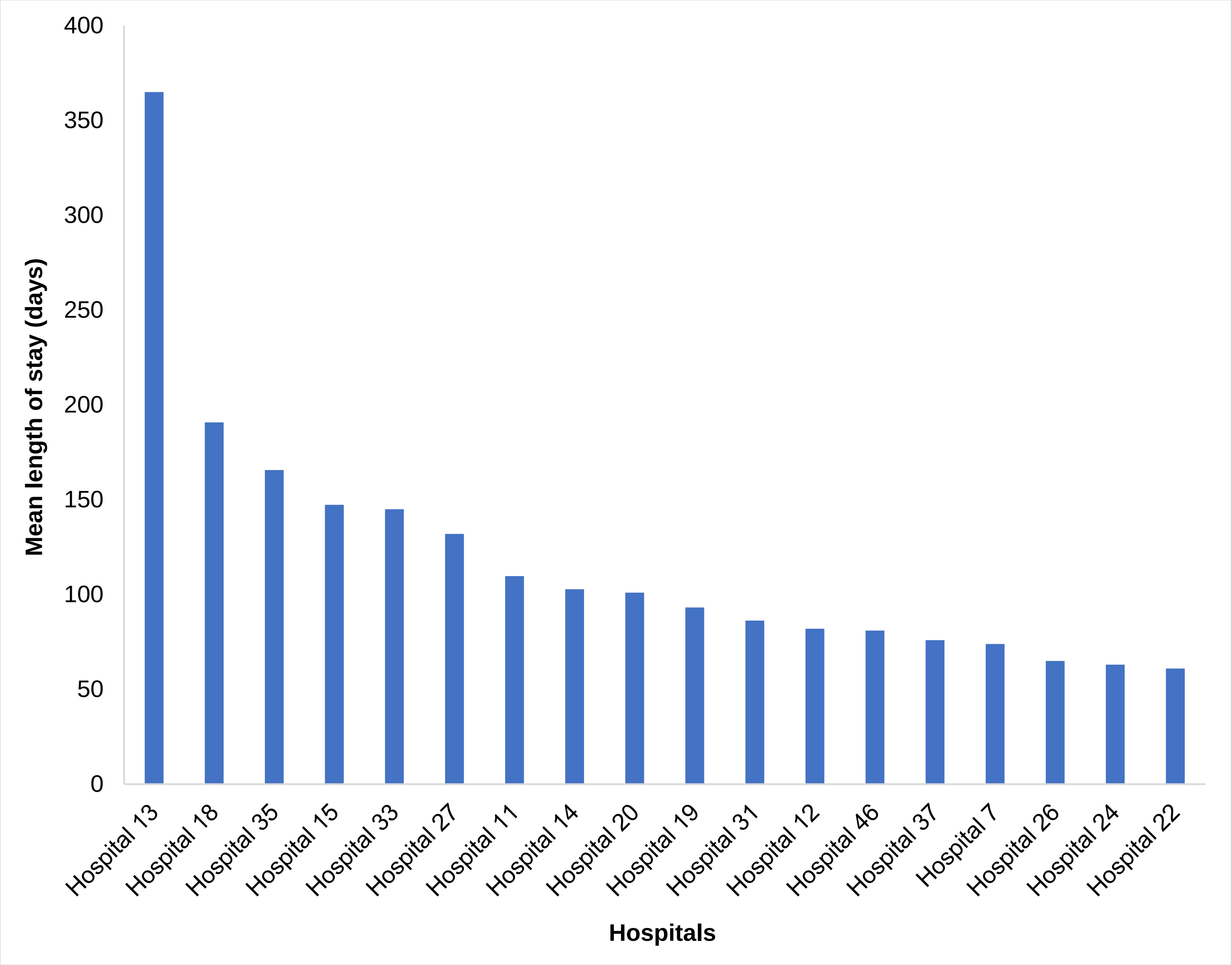
Tables 9–11 and Figures 22–25 show the distribution of LOS at participating hospitals (outliers included), for patients with LOS ≤60 days compared to those with LOS >60 days.

Figure 22: Mean length of stay for patients who were in hospital for ≤60 days, by hospital (n=2,853)



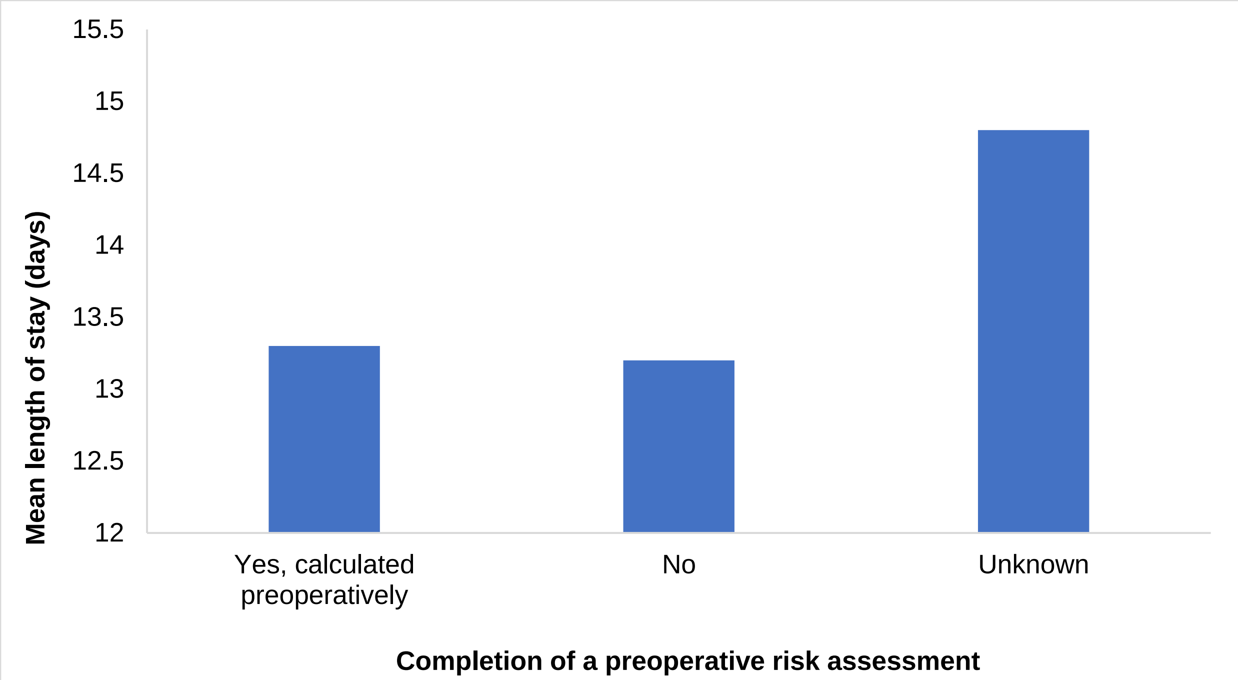
<u>Notes</u>
Mean length-of-stay (LOS) data excludes 195 patients who died during their admission, 2 patients with LOS <0 days, 13 patients who were still admitted after 60 days in hospital, 11 did not have a discharge date and 33 who had not had their discharge data completed.

Figure 23: Mean length of stay for patients who were in hospital for >60 days, by hospital (n=71)



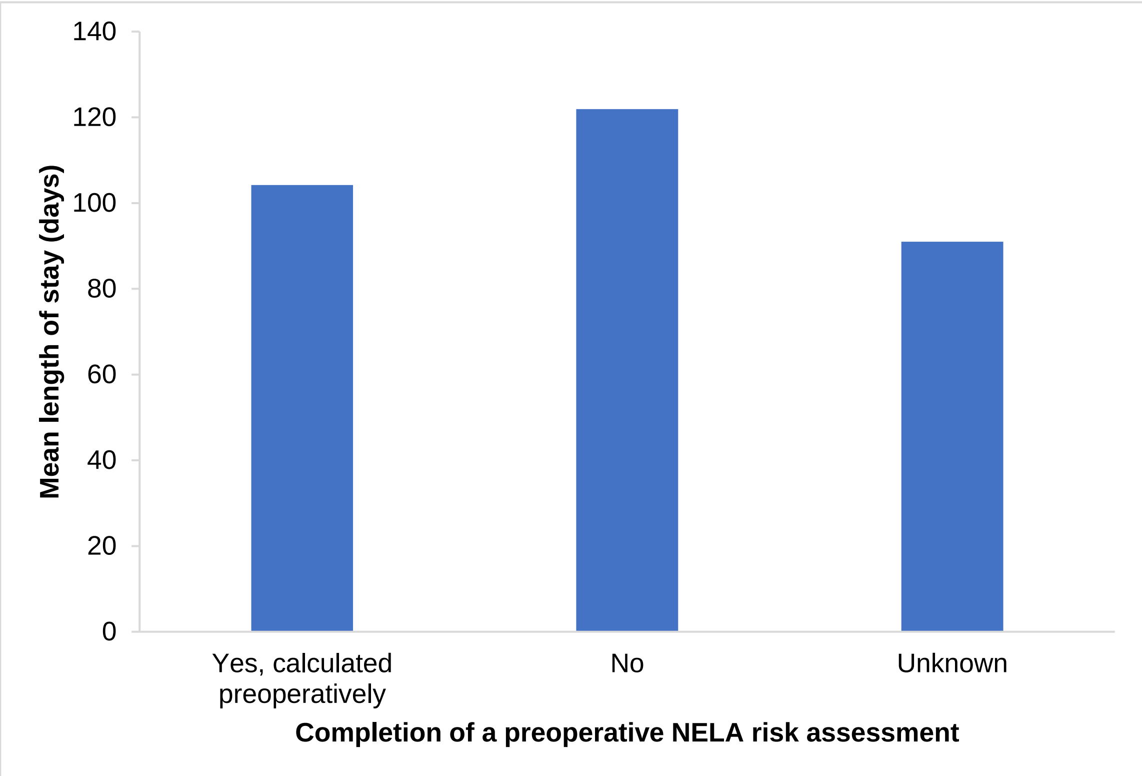
Notes
Mean length-of-stay (LOS) data excludes 195 patients who died during their admission, 2 patients with LOS <0 days, 13 patients who were still admitted after 60 days in hospital, 11 did not have a discharge date and 33 who had not had their discharge data completed.

Figure 24: Mean length of stay in hospital, by risk assessment completion for patients in hospital for ≤60 days (n=2,853)



Notes
Mean length-of-stay (LOS) data excludes 195 patients who died during their admission, 2 patients with LOS <0 days, 13 patients who were still admitted after 60 days in hospital, 11 did not have a discharge date and 33 who had not had their discharge data completed.

Figure 25: Mean length of stay in hospital, by risk assessment completion for patients who were in hospital for >60 days (n=71)



Notes
Mean length-of-stay (LOS) data excludes 195 patients who died during their admission, 2 patients with LOS <0 days, 13 patients who were still admitted after 60 days in hospital, 11 did not have a discharge date and 33 who had not had their discharge data completed.

Table 9: Categorised length of hospital stay for all data (2020–2021)

LOS category	n (%)	Mean	SD	Median	IQR	Min	Max
0–60 days	2,853 (97.6%)	13.3	10.5	10.0	9.0	0	60
>60 days	71 (2.4%)	111.8	81.6	80.0	46.0	61	385

Abbreviations
IQR = interquartile range
LOS = length of stay
SD = standard deviation
Notes
Mean length-of-stay (LOS) data excludes 195 patients who died during their admission, 2 patients with LOS <0 days, 13 patients who were still admitted after 60 days in hospital, 11 did not have a discharge date and 33 who had not had their discharge data completed.

Table 10: Distribution of length of stay for patients who were in hospital for ≤60 days, by hospital, for 2020–2021 (n=2,853)

Hospital ID	n (%)	Mean	SD	Median	IQR	Range	Min	Max
Hospital 39	8 (0.3)	24.8	19.9	18.5	30.5	50	6	56
Hospital 22	40 (1.4)	17.1	14.7	10.5	18.5	55	0	55
Hospital 11	86 (3)	16.7	12.1	11.5	17.0	51	2	53
Hospital 12	98 (3.4)	16.5	14.3	11.0	12.0	60	0	60
Hospital 33	120 (4.2)	16.4	10.3	14.0	13.5	50	2	52
Hospital 18	148 (5.2)	16.1	12.1	12.0	13.0	57	1	58
Hospital 7	376 (13.2)	15.0	10.8	12.0	12.0	60	0	60
Hospital 16	44 (1.5)	14.2	11.1	11.5	10.5	53	3	56
Hospital 14	95 (3.3)	14.0	12.3	10.0	11.0	59	1	60
Hospital 15	214 (7.5)	13.9	10.6	10.0	11.0	56	0	56
Hospital 17	54 (1.9)	13.3	8.5	11.0	9.0	49	3	52
Hospital 19	254 (8.9)	13.0	11.3	9.0	12.0	59	0	59
Hospital 37	110 (3.9)	12.9	12.2	8.0	12.0	58	1	59
Hospital 27	210 (7.4)	12.5	8.6	10.0	8.0	47	0	47
Hospital 26	15 (0.5)	12.1	8.1	10.0	8.0	31	3	34
Hospital 32	56 (2)	12.1	8.8	9.0	7.5	38	2	40
Hospital 24	34 (1.2)	11.8	6.5	11.0	7.0	24	4	28
Hospital 31	184 (6.4)	11.6	8.8	9.0	8.0	51	1	52
Hospital 20	338 (11.8)	11.5	8.6	9.0	8.0	59	0	59
Hospital 36	51 (1.8)	10.6	5.6	10.0	5.0	31	3	34
Hospital 21	30 (1.1)	10.6	8.9	8.0	8.0	45	1	46
Hospital 35	120 (4.2)	10.6	7.7	8.0	7.0	48	1	49
Hospital 46	78 (2.7)	9.9	7.1	8.0	9.0	34	1	35
Hospital 13	32 (1.1)	9.7	7.1	8.0	5.5	28	0	28
Hospital 34	58 (2)	8.6	8.4	6.5	6.0	35	0	35
Total	**2,853 (100)**	**13.3**	**10.5**	**10**	**9.0**	**60**	**0**	**60**

Abbreviations
ID = identity
IQR = inter-quartile range
SD = standard deviation
Notes
Mean length-of-stay (LOS) data excludes 195 patients who died during their admission, 2 patients with LOS <0 days, 13 patients who were still admitted after 60 days in hospital, 11 did not have a discharge date and 33 who had not had their discharge data completed, **n (%)** = number (percentage) of patients.

Table 11: Distribution of length of stay for patients who were in hospital for >60 days, by hospital, for 2020–2021 (n=71)

Hospital ID	n (%)	Mean	SD	Median	IQR	Range	Min	Max
Hospital 7	10 (14.1)	73.9	10	74.5	18	31	61	92
Hospital 11	6 (8.5)	109.7	47	99	57	125	64	189
Hospital 12	4 (5.6)	82	20.8	75.5	30	45	66	111
Hospital 13	1 (1.4)	365	.	365	0	0	365	365
Hospital 14	4 (5.6)	102.8	65.2	74.5	72.5	138	62	200
Hospital 15	7 (9.9)	147.3	109.8	108	115	309	65	374
Hospital 18	5 (7.0)	190.8	172.8	68	310	324	61	385
Hospital 19	11 (15.5)	93.2	32.7	88	44	112	61	173
Hospital 20	4 (5.6)	101	12.2	96.5	14	27	92	119
Hospital 22	1 (1.4)	61	.	61	0	0	61	61
Hospital 24	1 (1.4)	63	.	63	0	0	63	63
Hospital 26	1 (1.4)	65	.	65	0	0	65	65
Hospital 27	3 (4.2)	132	61.5	165	109	109	61	170
Hospital 31	3 (4.2)	86.3	11	81	20	20	79	99
Hospital 33	2 (2.8)	145	111.7	145	158	158	66	224
Hospital 35	3 (4.2)	165.7	177.8	65	310	310	61	371
Hospital 37	3 (4.2)	76	15.7	69	29	29	65	94
Hospital 46	2 (2.8)	81	9.9	81	14	14	74	88
Total	**71 (100)**	**111.8**	**81.6**	**80.0**	**46.0**	**324**	**61**	**385**

Abbreviations
ID = identity
IQR = inter-quartile range
SD = standard deviation
Notes
Mean length-of-stay (LOS) data excludes 195 patients who died during their admission, 2 patients with LOS <0 days, 13 patients who were still admitted after 60 days in hospital, 11 did not have a discharge date and 33 who had not had their discharge data completed, **n** (%) = number (percentage) of patients.

Comment

The impact of transfers is unknown.

A short LOS is a surrogate marker for efficient care that is not associated with complications. LOS is also the major determinant of overall cost.

3.3.4 Return to theatre

A return to theatre (RTT) is always a significant event. This may be unplanned (URTT), planned or both. It is normally associated with a worse outcome including greater mortality and long length of stay. The Failure to Rescue (FTR) rate is those who die after a URTT.

Findings

- The overall RTT rate was 19.4% (617/3,178) (Table 12)
- The overall URTT rate following their first emergency laparotomy was 15.4% (490/3,178) (Table 12)
- The overall FTR rate for those who had any RTT was 10.5% (65/617) (Table 12)
- The overall FTR rate for those who had any URTT was 7.6% (37/490) (Table 12)
- Emergency admissions
  - 18.7% (565/3,006) had any RTT after an initial emergency laparotomy (Table 13)
  - The overall FTR rate for those who had an URTT following initial emergency laparotomy was 7.2% (32/445) (Table 13)
- Elective admissions
  - 171 had an emergency laparotomy following an elective admission. Of these, 51(29.8%) had a RTT (Table 13)
  - The FTR in those who only had one emergency laparotomy after an elective admission (RTT==No or Missing) was 7.5% (9/120) (Table 13)
  - The FTR in those who had an emergency laparotomy and then an URTT was 11.4% (5/44) (Tables 13 and 14)

The overall RTT rate in NELA was 15.7%. The NELA 30- day mortality for those who had an URTT, the FTR rate, was 14.1%.

Comment

The proportion of RTT (URTT, planned or both) differed between NELA and ANZELA-QI being 15.7% in NELA versus 19.4% in ANZELA-QI. For patients who had any URTT there were 12.9% in NELA and 15.4% in ANZELA-QI.

Some patients who had an emergency laparotomy after an elective admission were not admitted under a general surgeon. In these cases, the emergency laparotomy was most frequently for mesenteric ischaemia following an elective operation by another specialty.

Table 12: Patients who had a return to theatre

Return to theatre	Alive	Died	n (%)
Yes - unplanned return	453	37	490 (15.4%)
Yes - planned return	91	23	114 (3.6%)
Both planned and unplanned return	8	5	13 (0.4%)
No	2,175	117	2,292 (72.1%)
Missing/unknown	256	13	269 (8.5%)
Total	**2,983**	**195**	**3,178 (100.0%)**

Notes
n (%) = number (percentage) of patients with returns to theatre

Table 13: Categories of return to theatre by admission type and discharge_status

Died = Yes				
Return to theatre	***Elective**	**Emergency**	**Missing**	**Total**
Yes - unplanned return	5	32	0	37
Yes - planned return	0	23	0	23
Both planned and unplanned return	0	5	0	5
No	9	108	0	117
Missing/unknown	0	13	0	13
Total	**14**	**181**	**0**	**195**

Died = No				
Return to theatre	***Elective**	**Emergency**	**Missing**	**Total**
Yes - unplanned return	39	413	1	453
Yes - planned return	6	85	0	91
Both planned and unplanned return	1	7	0	8
No	103	2,072	0	2,175
Missing/unknown	8	248	0	256
Total	**157**	**2,825**	**1**	**2,983**

Return to theatre = TOTAL	*Elective	Emergency	Missing	Total (n)
Yes - unplanned return	44	445	1	490
Yes - planned return	6	108	0	114
Both planned and unplanned return	1	12	0	13
No	112	2,180	0	2,292
Missing/unknown	8	261	0	269
Total	**171**	**3,006**	**1**	**3,178**

Notes
n (%) = number (percentage) of patients with returns to theatre, ** Elective admissions refer to cases that were initially admitted to the hospital for elective operation but ended up having an emergency laparotomy while in hospital. Any URTT = excludes the "*both planned and unplanned return"* group

Table 14: Categories of return to theatre by FTR

Mortality (Failure to Rescue)				
Return to theatre	**Elective n (%)**	**Emergency n (%)**	**Missing n (%)**	**Total n (%)**
Yes - unplanned return	5 (11.4)	32 (7.2)	0 (0.0)	37 (7.6)
Yes - planned return	0 (0.0)	23 (21.3)	0 (0.0)	23 (20.2)
Both planned and unplanned return	0 (0.0)	5 (41.7)	0 (0.0)	5 (38.5)
No	9 (8.0)	108 (5.0)	0 (0.0)	117 (5.1)
Missing/unknown	0 (0.0)	13 (5.0)	0 (0.0)	13 (4.8)
Total (died)	**14**	**181**	**0**	**195**

Abbreviations
FTR = failure to rescue
Notes
n(%) =number(percentage) of patients with returns to theatre who died

3.3.5 Clavien-Dindo complication grade

- Patients whose preoperative RA was unknown were twice as likely to have a Clavien-Dindo grade of V (Figure 26).
- Patients whose NELA preoperative RA was ≥10% had higher complication rates in each recorded Clavien-Dindo grade (data not shown).
- Elective admissions had lower rates of clinically significant Clavien-Dindo complications (data not shown).
- Patients with an urgency of surgery of <2 hours had the highest proportion of grade IV and V Clavien-Dindo complications.
- Patients needing the most urgent surgery had the greater number of complications (Figure 26). These patients were least likely to arrive in theatre in an appropriate timeframe (Figure 27).

Figure 26: Risk assessment completion, by clinically significant Clavien-Dindo complication grade

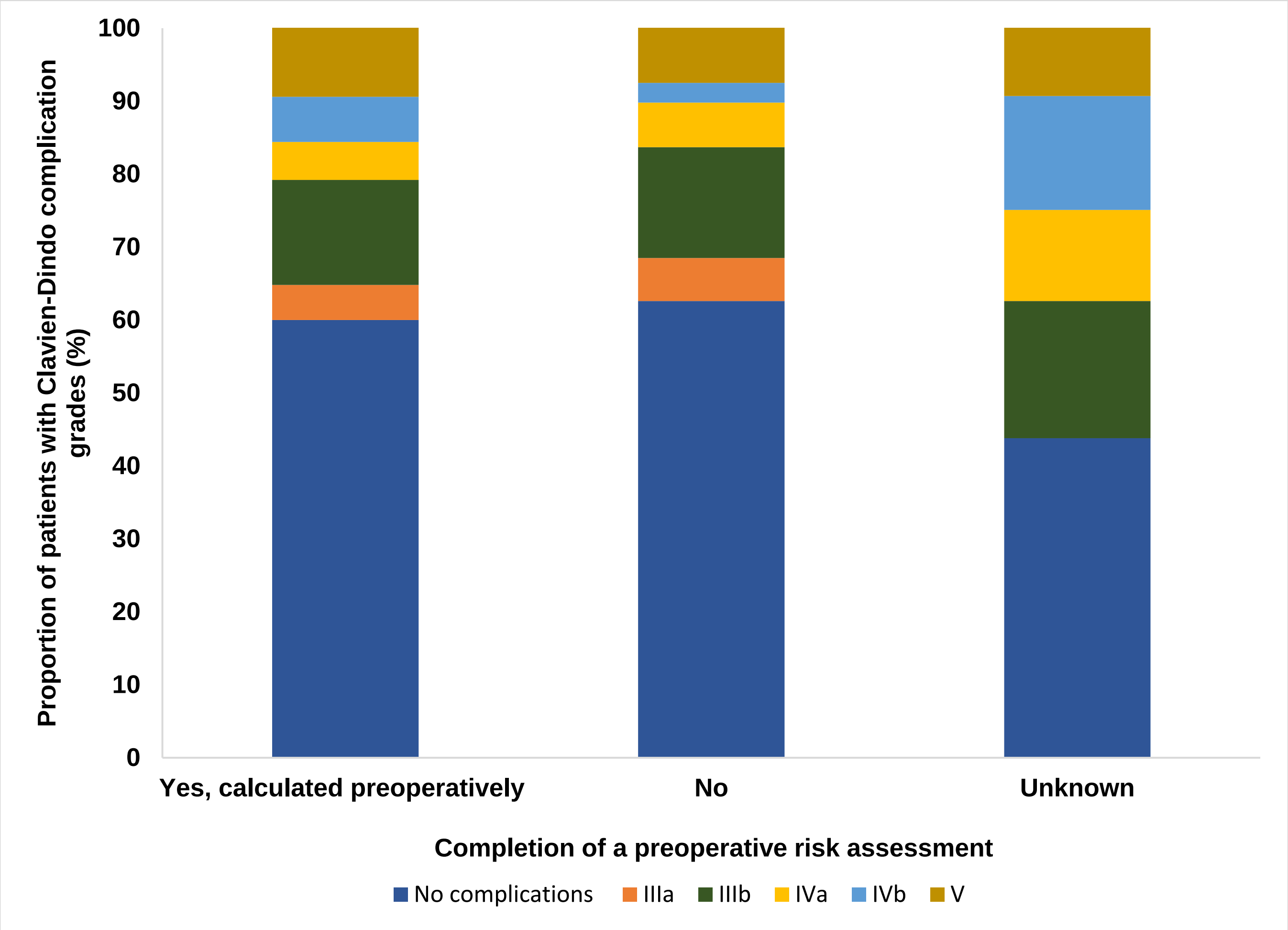
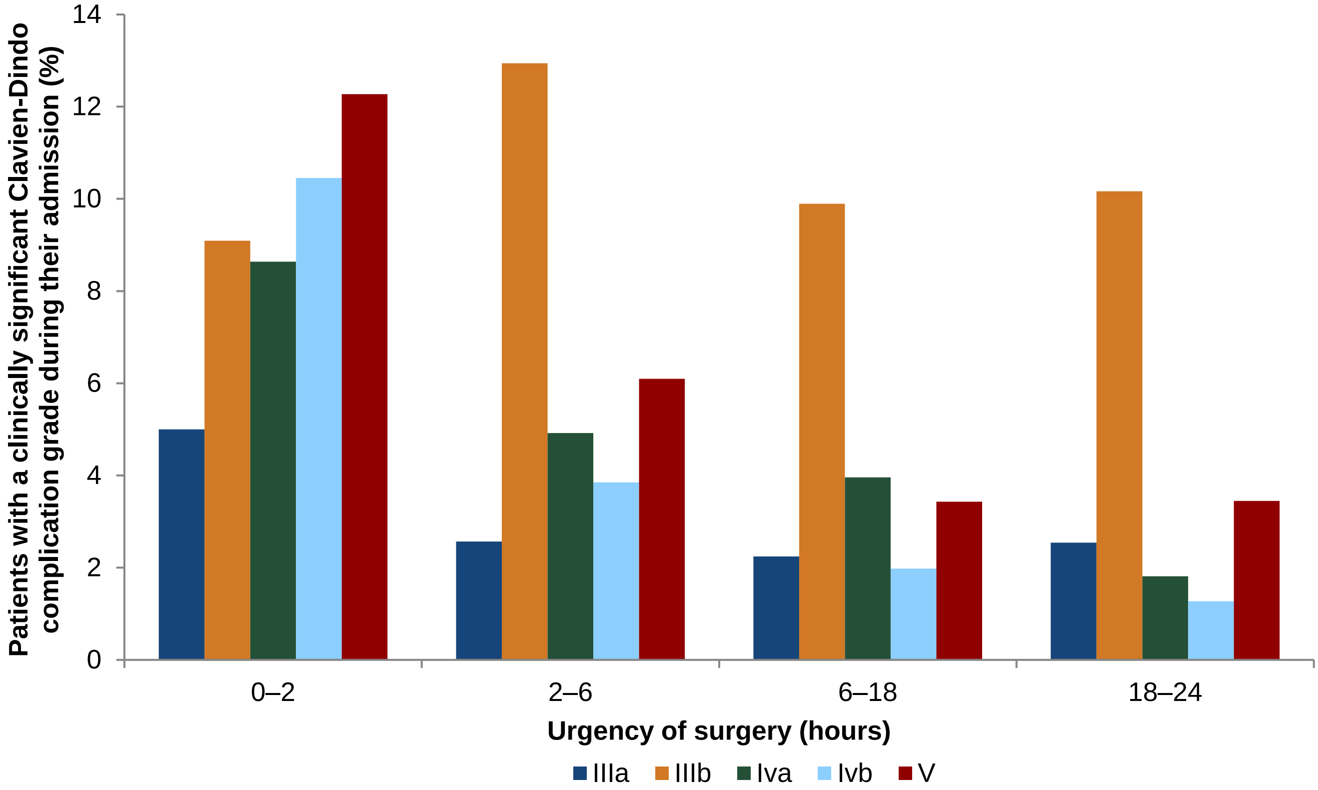


Figure 27: Documented urgency of surgery for patients who had a clinically significant Clavien-Dindo complication grade



3.3.3 Discharge destination

Of the 3,178 for whom there were data, 391 (12.3%) were not discharged to their preoperative place of residence (Table 15).

Table 15: Discharge destination of patients who did not return to prehospital residence

Did the patient return to their prehospital residence?	n	%
Yes	2,310	72.7
No	392	12.3
Missing or unknown	476	15.0
Total	**3,178**	**100**

Discharge destination if patient did not return to prehospital residence	n	%
Residential care	8	2.0
Nursing home	7	1.8
Rehabilitation facility (any)	220	56.1
Other public hospital for ongoing acute	132	33.7
Private hospital for ongoing acute care	7	1.8
New destination	16	4.1
Missing or unknown	2	0.5
Total	**391**	**100**

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Appendix A: Clavien-Dindo scoring system

Clavien-Dindo complication grade is a scoring system that allocates a grade of severity to the various types of complications a patient can have during hospital admission.

GRADE	DEFINITION
Grade I	Any deviation from the normal postoperative course not requiring surgical, endoscopic or radiological intervention. This includes the need for certain drugs (e.g. antiemetics, antipyretics, analgesics, diuretics and electrolytes), treatment with physiotherapy and wound infections that are opened at the bedside.
Grade II	Complications requiring drug treatments other than those allowed for grade I complications; this includes blood transfusion and total parenteral nutrition.
Grade III	Complications requiring surgical, endoscopic or radiological intervention. Grade IIIa – intervention not under general anaesthetic. Grade IIIb – intervention under general anaesthetic.
Grade IV	Life-threatening complications: this includes central nervous systems complications (e.g. brain haemorrhage, ischaemic stroke, subarachnoid haemorrhage) that require intensive care, but excludes transient ischaemic attacks. Grade IVa – single-organ dysfunction (including dialysis). Grade IVb – multi-organ dysfunction.
Grade V	Death of the patient.

Appendix B: Risk assessment score categories for ANZELA-QI and NELA

Risk category label	ANZELA-QI risk threshold (%)	NELA risk thresholds (%)
Lower	<5.0	<5.0
High	5.0–9.9	5.0–10.0
Highest	≥10.0	>10.0

Appendix C: Reports provided to participating hospitals

ANZELA-QI provides the following reports to participating hospitals:

1. RAG chart reporting the 10 currently agreed KPIs over a defined period (example in Figure C1)
2. individual hospital mini-report that includes run charts (example in Figure C2)
3. patient-level summary (example in Figure C3)

Representative report: KPI results categorised by RAG

Figure C1 shows the 10 primary KPIs (columns) selected by ANZELA-QI and the 25 hospitals contributing to the current report (rows). In this example all hospital names have been removed; however, when reports are sent to individual hospitals, those contributing more than 50 cases are identified by name. This allows hospitals not achieving the standard to identify those that are and approach them for assistance, if desired, in understanding how they might improve practices.

Figure C1: RAG chart reporting the 10 currently agreed KPIs between 1 October 2021 and 30 September 2022

Hospital	CT scan performed and reported by a consultant before surgery	Lactate level available to surgeon at time of surgical referral for patients admitted via ED	Risk of death score performed and documented preoperatively	Preoperative frailty assessment completed for patients age ≥ 65 years	Arrival in theatre within an appropriate timeframe where urgency of surgery ≤18 hrs	Consultant surgeon and anaesthetist in theatre when risk of death ≥5%	Consultant surgeon in theatre when risk of death ≥5%	Consultant anaesthetist in theatre when risk of death ≥5%	Direct critical care admission when risk of death ≥10%	Postop review by Elderly Medicine team where age ≥65 years
Hospital A 113 cases	92/98 (94%) incomplete = 2	22/95 (23%) incomplete = 67	12/106 (11%) incomplete = 32	1/36 (3%) incomplete = 26	14/59 (24%) incomplete =41	6/7 (86%) incomplete = 0	6/7 (86%) incomplete = 0	7/7 (100%) incomplete = 0	4/4 (100%) incomplete = 0	3/36 (8%) incomplete = 28
Hospital B 122 cases	80/112 (71%) incomplete = 19	92/110 (84%) incomplete = 1	25/115 (22%) incomplete = 0	3/63 (5%) incomplete = 13	57/91 (63%) incomplete =4	16/17 (94%) incomplete = 0	17/17 (100%) incomplete = 0	16/17 (94%) incomplete = 0	6/14 (43%) incomplete = 0	11/63 (17%) incomplete = 7
Hospital C 48 cases	32/33 (97%) incomplete = 0	14/32 (44%) incomplete = 1	4/36 (11%) incomplete = 0	1/19 (5%) incomplete = 0	20/26 (77%) incomplete =0	4/4 (100%) incomplete = 0	4/4 (100%) incomplete = 0	4/4 (100%) incomplete = 0	2/2 (100%) incomplete = 0	6/19 (32%) incomplete = 0
Hospital D 139 cases	102/107 (95%) incomplete = 1	91/107 (85%) incomplete = 0	75/119 (63%) incomplete = 1	18/64 (28%) incomplete = 11	53/94 (56%) incomplete =6	44/44 (100%) incomplete = 0	44/44 (100%) incomplete = 0	44/44 (100%) incomplete = 0	27/35 (77%) incomplete = 0	3/64 (5%) incomplete = 12
Hospital E 280 cases	182/237 (77%) incomplete = 14	163/242 (67%) incomplete = 12	89/265 (34%) incomplete = 7	40/146 (27%) incomplete = 15	113/234 (48%) incomplete =32	45/57 (79%) incomplete = 0	48/57 (84%) incomplete = 0	50/57 (88%) incomplete = 0	29/44 (66%) incomplete = 0	14/146 (10%) incomplete = 19
Hospital F 56 cases	47/48 (98%) incomplete = 0	38/46 (83%) incomplete = 0	18/49 (37%) incomplete = 1	4/21 (19%) incomplete = 0	11/37 (30%) incomplete =20	7/7 (100%) incomplete = 0	7/7 (100%) incomplete = 0	7/7 (100%) incomplete = 0	3/4 (75%) incomplete = 0	13/21 (62%) incomplete = 0
Hospital G 79 cases	55/60 (92%) incomplete = 4	32/51 (63%) incomplete = 1	8/73 (11%) incomplete = 0	25/47 (53%) incomplete = 0	43/60 (72%) incomplete =5	3/6 (50%) incomplete = 0	3/6 (50%) incomplete = 0	6/6 (100%) incomplete = 0	4/4 (100%) incomplete = 0	0/47 (0%) incomplete = 3
Hospital H 187 cases	13/169 (8%) incomplete = 154	48/162 (30%) incomplete = 97	0/179 (0%) incomplete = 1	0/100 (0%) incomplete = 30	2/179 (1%) incomplete =177	0/0 (%) incomplete = 0	0/0 (%) incomplete = 0	0/0 (%) incomplete = 0	0/0 (%) incomplete = 0	0/100 (0%) incomplete = 35
Hospital I 393 cases	138/345 (40%) incomplete = 188	207/306 (68%) incomplete = 11	306/381 (80%) incomplete = 23	68/221 (31%) incomplete = 47	170/306 (56%) incomplete =85	92/148 (62%) incomplete = 27	98/148 (66%) incomplete = 27	113/148 (76%) incomplete = 23	46/87 (53%) incomplete = 24	70/221 (32%) incomplete = 90
Hospital J 45 cases	14/26 (54%) incomplete = 10	16/36 (44%) incomplete = 1	26/40 (65%) incomplete = 3	2/18 (11%) incomplete = 2	26/35 (74%) incomplete =1	15/15 (100%) incomplete = 0	15/15 (100%) incomplete = 0	15/15 (100%) incomplete = 0	9/10 (90%) incomplete = 0	2/18 (11%) incomplete = 1
Hospital K 49 cases	38/42 (90%) incomplete = 3	34/40 (85%) incomplete = 0	34/44 (77%) incomplete = 1	10/19 (53%) incomplete = 0	28/39 (72%) incomplete =4	9/10 (90%) incomplete = 1	9/10 (90%) incomplete = 1	9/10 (90%) incomplete = 1	4/4 (100%) incomplete = 0	1/19 (5%) incomplete = 0

Notes:

Data refers to Admission Dates from October 2021 to September 2022, for cases entered up to 19 October 2022. Data extracted 19/10/2022 1:05 PM ACST.
The dashboard shows 11 randomly selected hospitals to illustrate their individual performance relative to Red-Amber-Green (RAG) ratings.
Incomplete = cases with incomplete data in any of the variables defining KPI. **N** = Eligible cases for the hospital, **Red** = <50% of patients meet the KPI, **Amber** = 50% to 79% of patients meet the KPI, **Green** = ≥80% of patients meet the KPI, **Grey** = records missing data to define KPI.

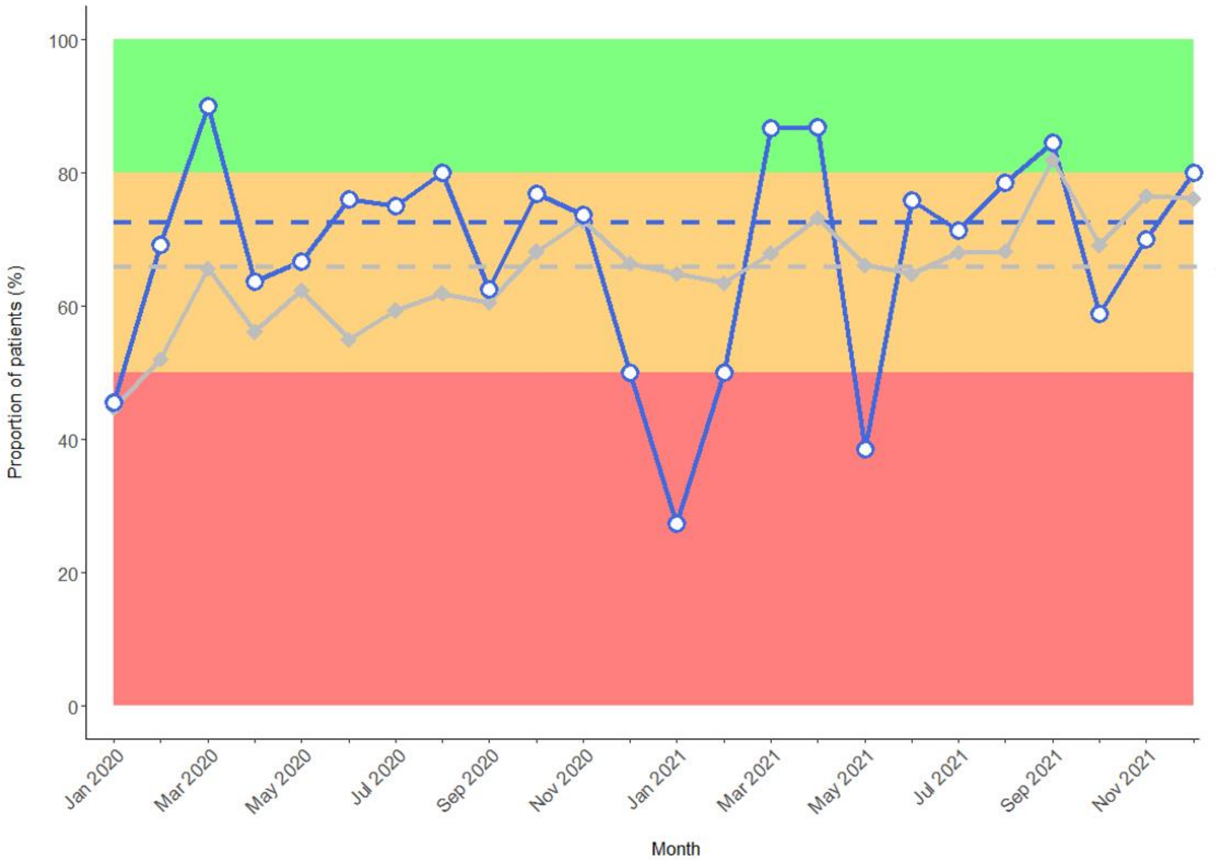
Important: Performance results should be interpreted with caution, especially where the denominator is small (e.g. less than 10 patients). Results will become more reliable as more data is collected.
It is possible that not every eligible case was entered into the database. Analysis is performed only on available data, which may alter results

Representative report: ANZELA-QI monthly summary

Each month, participating sites are provided with a report comparing the hospital's compliance with the KPIs set by the audit and the hospital's performance compared to other hospitals participating in ANZELA-QI. Each hospital receives its own mini-report in the second week of each month. Figure C2 shows a representative example of the monthly KPI run charts for one contributing hospital.

Figure C2: Representative monthly KPI run chart for one contributing hospital

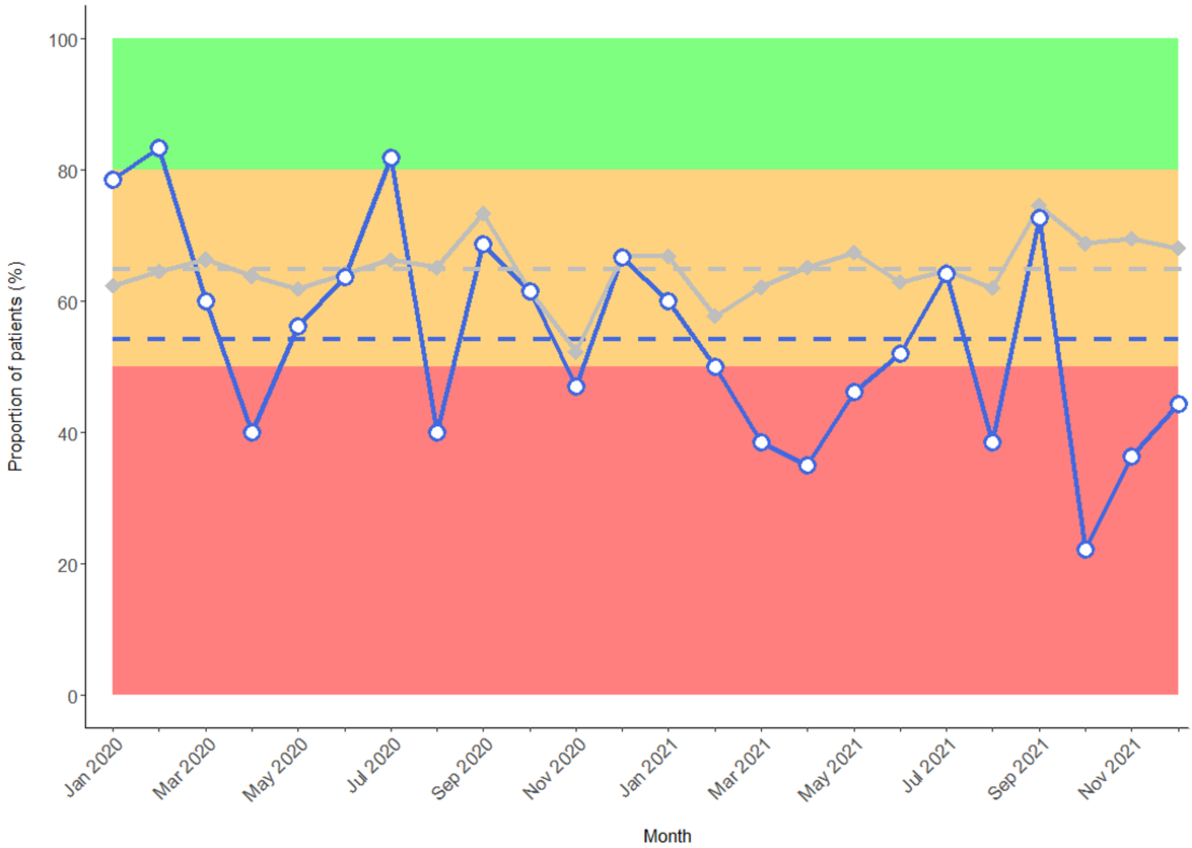
PRE 1 KPI: CT scan performed and reported by a consultant radiologist before surgery



<u>**Notes:**</u>
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 80% of the cases met the KPI this month; 8 of the 10 patients meeting the criteria for this KPI received recommended care.

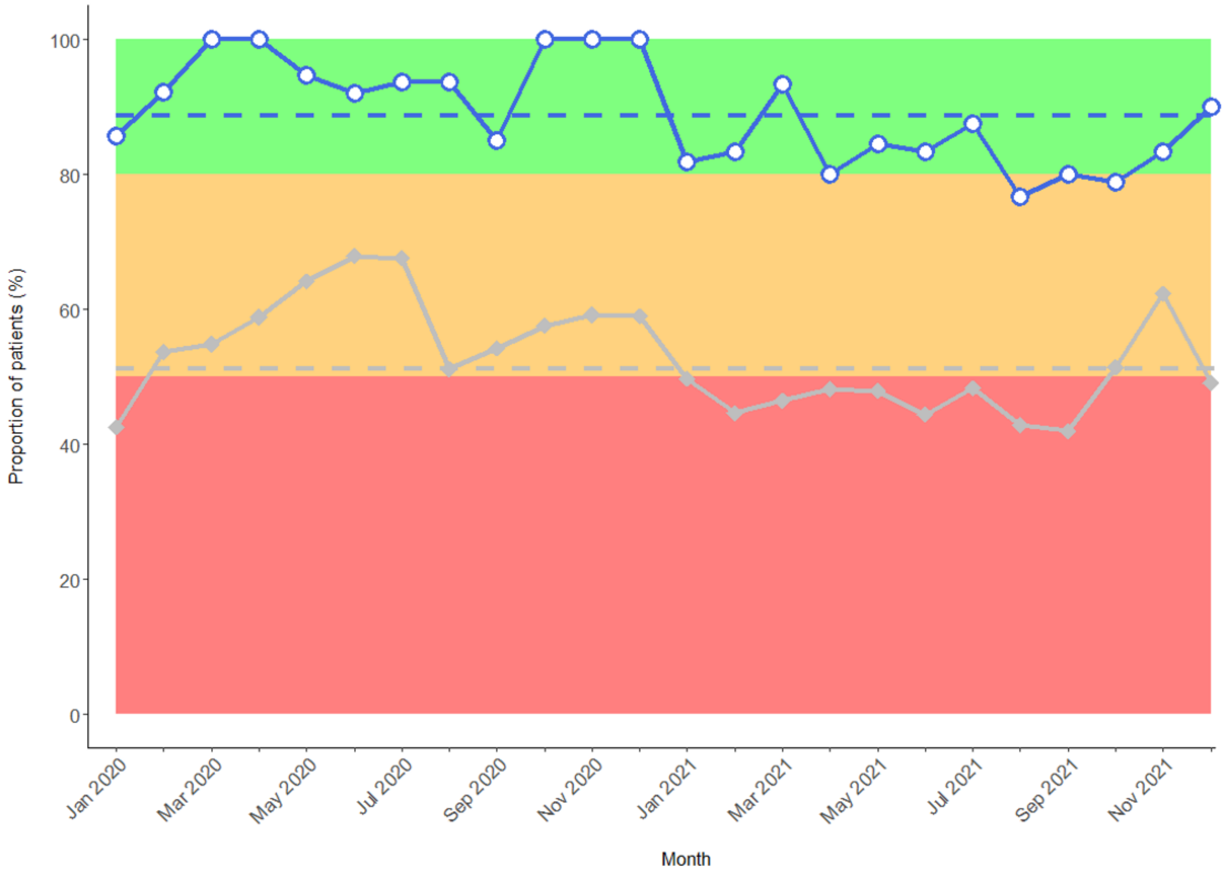
PRE 2 KPI: Lactate level available to the surgeon at the time of surgical referral for patients admitted via the emergency department



Notes:
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 44.4% of the cases met the KPI this month; 4 of the 9 patients meeting the criteria for this KPI received recommended care.

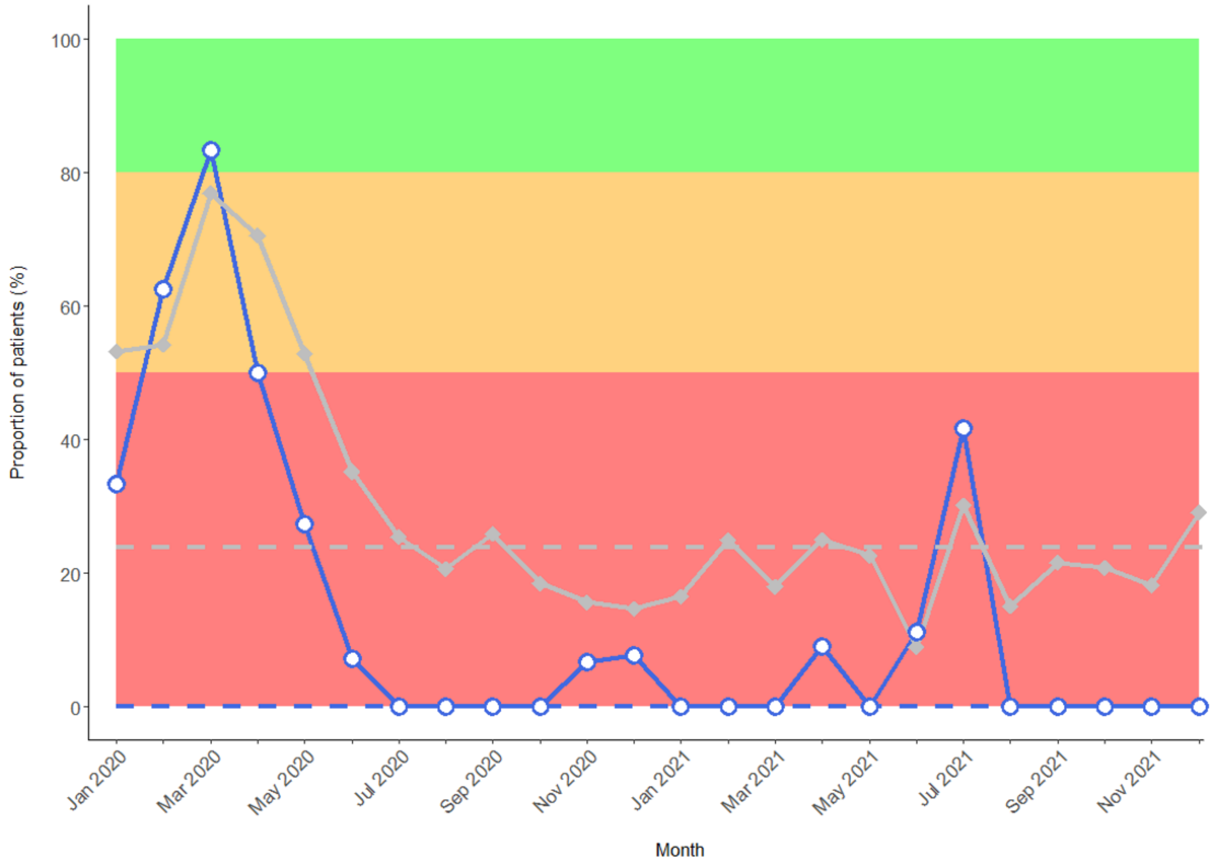
PRE 3 KPI: Risk of death assessment performed and documented preoperatively



__Notes:__
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 90% of the cases met the KPI this month; 9 of the 10 patients meeting the criteria for this KPI received recommended care.

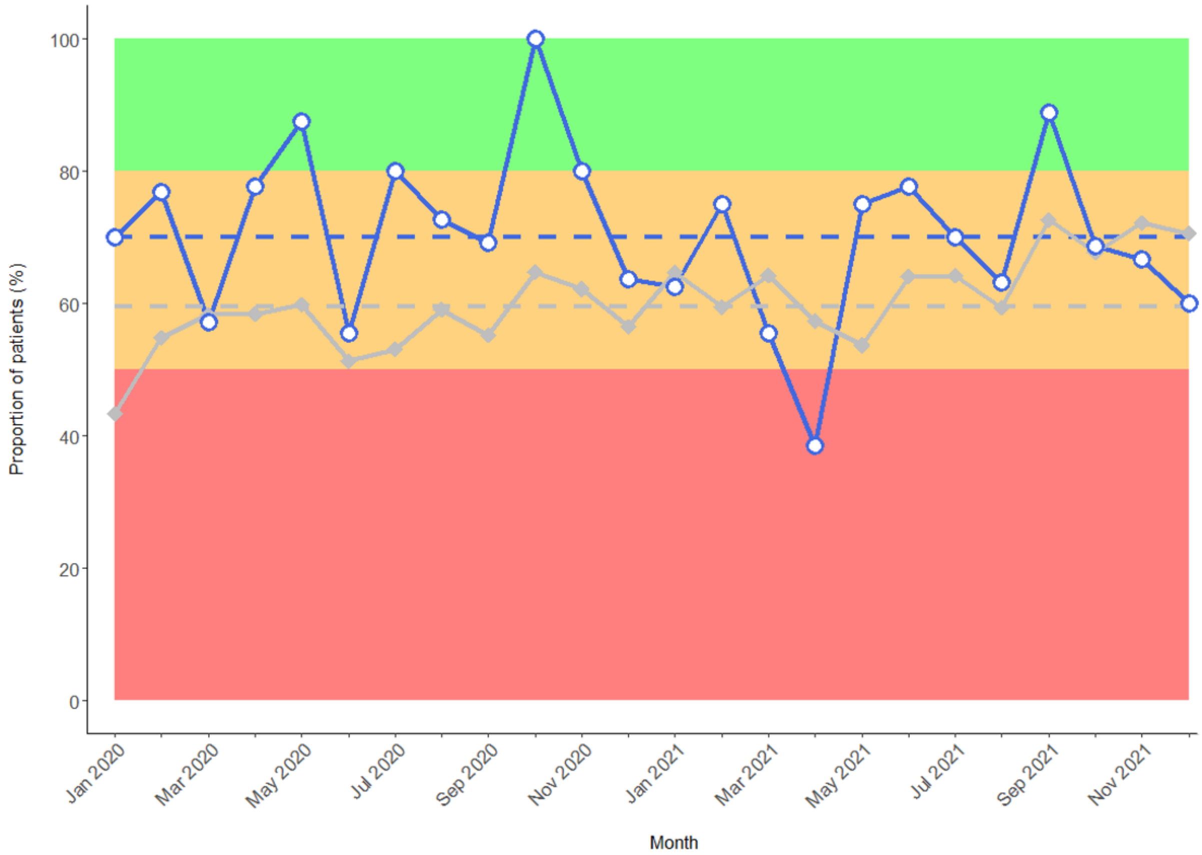
PRE 4 KPI: Preoperative frailty assessment completed for patients age ≥65 years



Notes:
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 0% of the cases met the KPI this month; 0 of the 8 patients meeting the criteria for this KPI received recommended care.

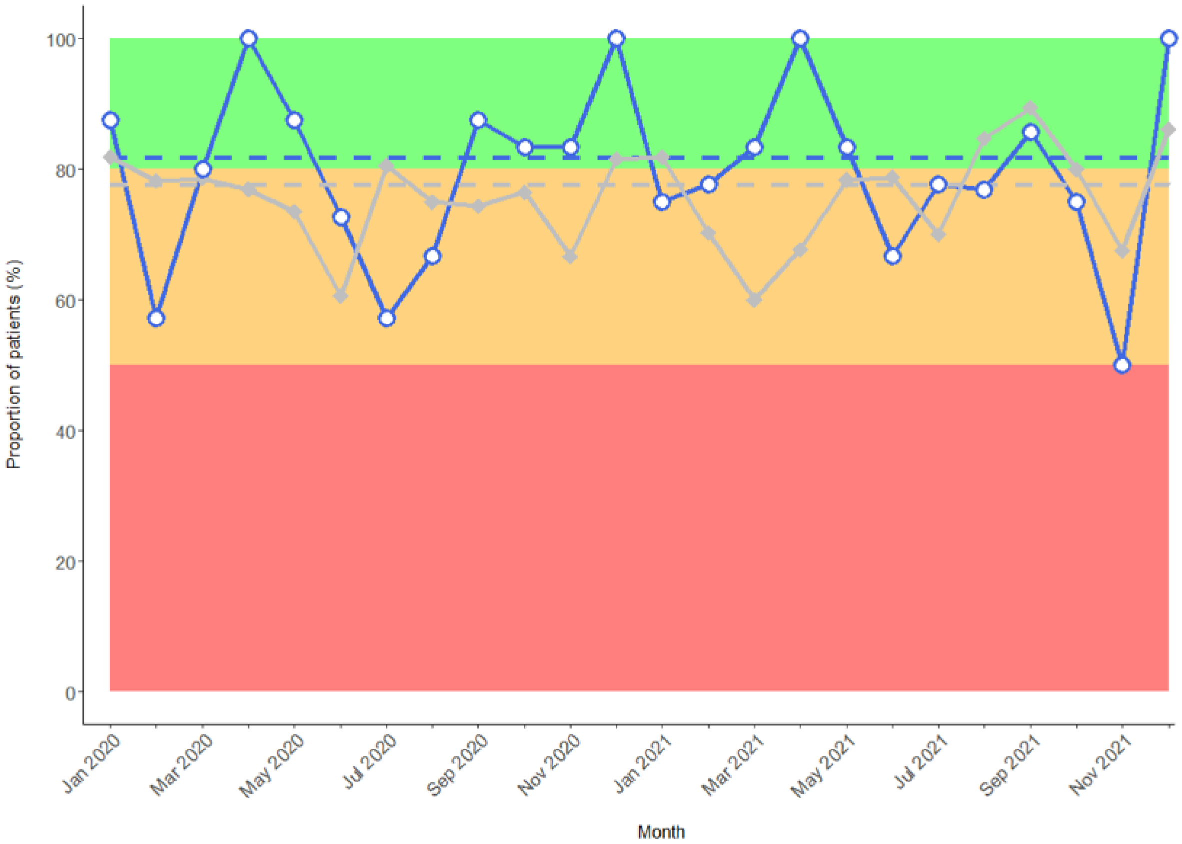
PRE 5 KPI: Arrival in theatre within an appropriate timeframe where urgency of surgery is ≤ 18 hours



Notes:
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 60% of the cases met the KPI this month; 3 of the 5 patients meeting the criteria for this KPI received recommended care.

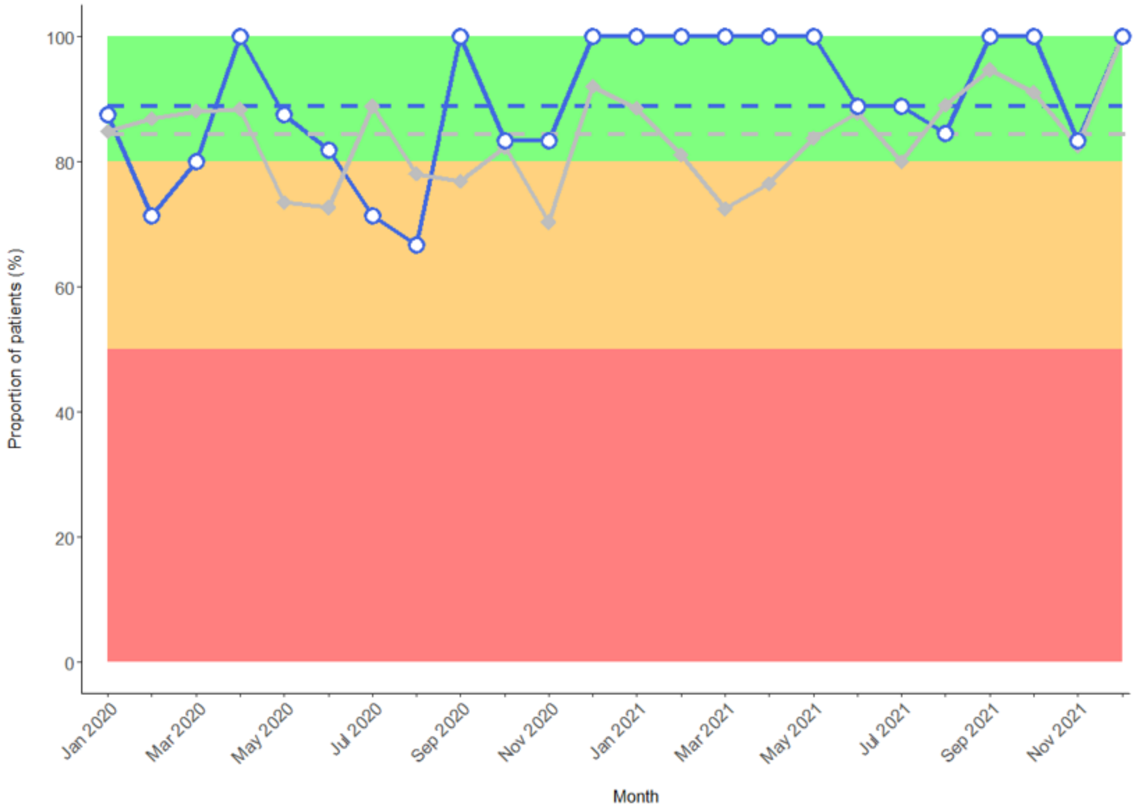
OP 1 KPI: Consultant surgeon and anaesthetist presence in theatre for patients with a preoperative risk score ≥5%



<u>**Notes:**</u>
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 100% of the cases met the KPI this month; 4 of the 4 patients meeting the criteria for this KPI received recommended care.

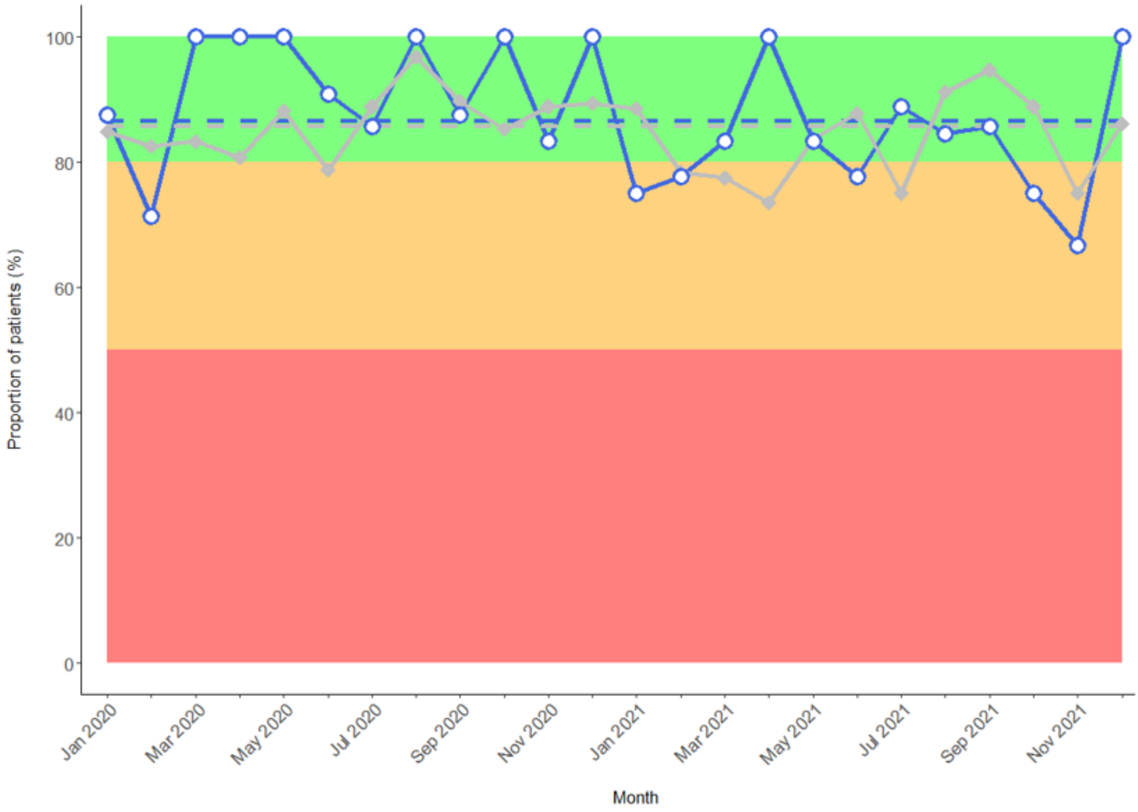
OP 2 KPI: Consultant surgeon presence in theatre for patients with a preoperative risk score ≥5%



Notes:
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 100% of the cases met the KPI this month; 4 of the 4 patients meeting the criteria for this KPI received recommended care.

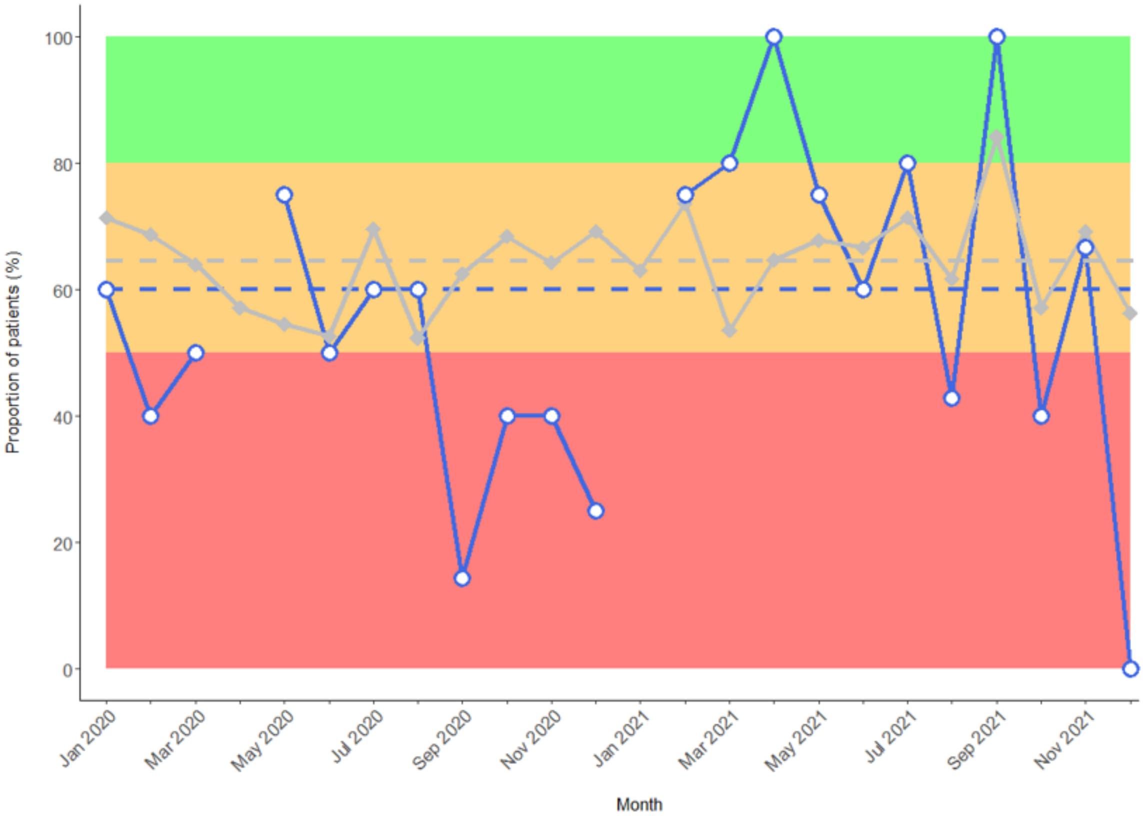
OP 3 KPI: Consultant anaesthetist presence in theatre for patients with a preoperative risk risk score ≥5%



Notes:
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 100% of the cases met the KPI this month; 4 of the 4 patients meeting the criteria for this KPI received recommended care.

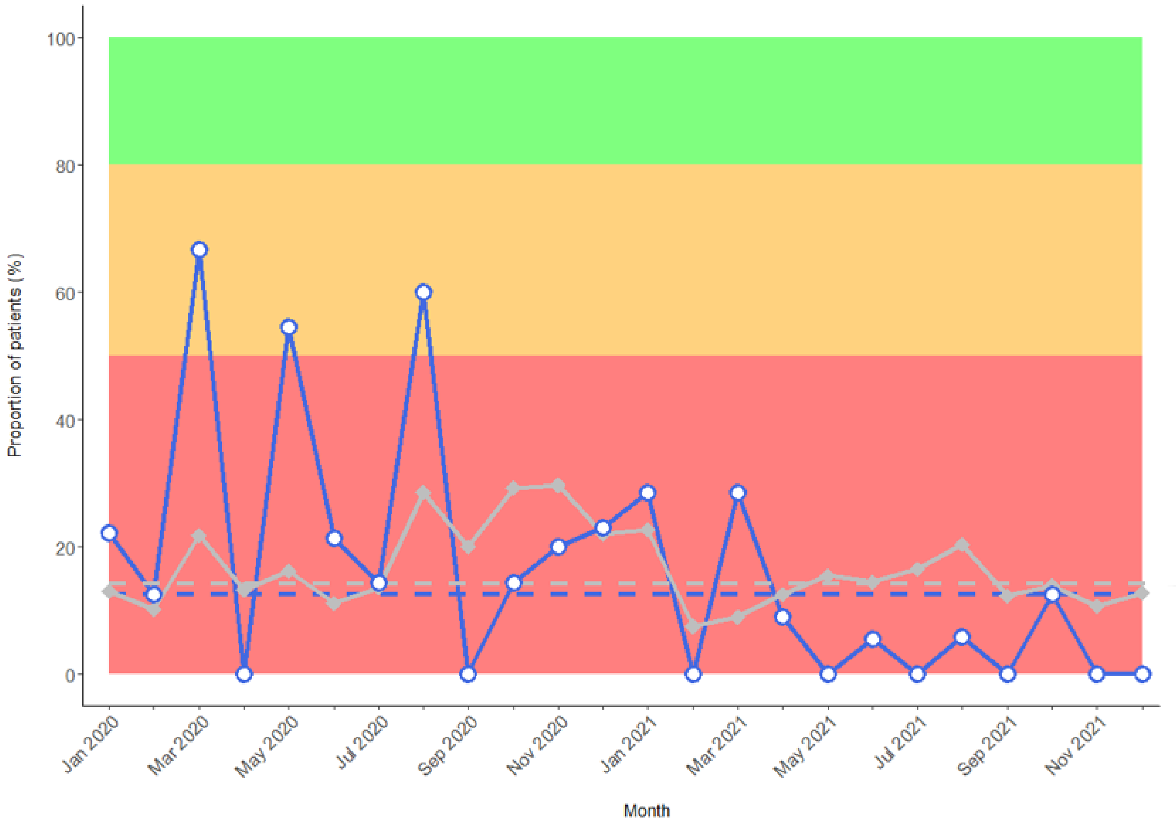
Post OP 1 KPI: Direct admission to critical care after surgery for patients with a preoperative risk score ≥10%



Notes:
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 0% of the cases met the KPI this month; 0 of the 1 patients meeting the criteria for this KPI received recommended care.

POST OP 2 KPI: Postoperative assessment by a specialist in elderly medicine for patients age ≥65 years



Notes:
Blue solid line = proportion of cases meeting the KPI for the individual hospital receiving the report, **blue dashed line** = individual hospital's yearly median
Grey solid line = proportion of cases for all hospitals, **dotted grey line** = yearly median for all hospitals

- 0% of the cases met the KPI this month; 0 of the 8 patients meeting the criteria for this KPI received recommended care.

Representative report: ANZELA-QI patient-level summary

The patient-level summary generated for each individual hospital shows every patient and whether the relevant KPIs were achieved. It is then possible to identify any KPI not met by an individual patient and to undertake a review of care to determine the cause. Patterns within a hospital will also emerge. Hospitals can use these monthly reports to improve care, for example, at monthly morbidity and mortality meetings while the care of a patient can still be recalled.

Figure C3: Representative patient summary chart for one contributing hospital

Admission date	Age (years)	NELA risk score (%)	Discharge status*	CT	Lactate	NELA Risk	Frailty	Theatre	Consultants	Surgeon	Anaest.	CCU	Geriatrician
01/01/2020	46	0.5		Yes	Yes	No	N/A	Yes	N/A	N/A	N/A	N/A	N/A
14/01/2020	93	14.9	Rehab	Yes	Yes	Yes	Yes	No	No	No	No	No	No
16/01/2020	77	10.7	Home	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
06/01/2020	85	8.8	Home	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	Yes
12/01/2020	33	0.8	Home	Yes	Yes	Yes	N/A	Yes	N/A	N/A	N/A	N/A	N/A
09/01/2020	31	3.3	Home	N/A	No	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A
07/10/2021	50		Home	No	No	No	N/A	Yes	N/A	N/A	N/A	N/A	N/A
01/07/2021	45	38	Deceased	N/A	No	Yes	N/A	Yes	No	No	Yes	Yes	N/A
13/12/2021	76	6.1	Home	Yes	N/A	Yes	No	Yes	Yes	Yes	Yes	N/A	No

Notes:
Represents 9 randomly selected patients from an individual hospital.
Deceased = patient was deceased on discharge, **home** = returned to pre-hospital residence, **rehab** = rehabilitation facility (any), **No** = patient did not meet KPI, **Yes** = patient met KPI, **N/A** = cases with incomplete/missing data in any of the variables defining KPI

Appendix D: Participating hospitals

Table D1: Participating hospitals

Hospital or health service	State or territory
Albany Hospital	Western Australia
Albury Wodonga Health, Albury Campus (Hospital)	New South Wales
Albury Wodonga Health, Wodonga Campus (Hospital)	Victoria
Armidale Rural Referral Hospital	New South Wales
Ballarat Base Hospital	Victoria
Bendigo Health	Victoria
Bunbury Hospital	Western Australia
Canberra Hospital	Australian Capital Territory
Fiona Stanley Hospital	Western Australia
Footscray Hospital (Western Health)	Victoria
Gold Coast University Hospital	Queensland
Latrobe Regional Hospital	Victoria
Lismore Hospital	New South Wales
Logan Hospital	Queensland
Mackay Base Hospital	Queensland
Mater Hospital Brisbane	Queensland
Mount Gambier and Districts Health Service (Hospital)	South Australia
Nepean Hospital	New South Wales
Northern Hospital Epping	Victoria
Port Macquarie Base Hospital	New South Wales
Queen Elizabeth Jubilee Hospital	Queensland
Redcliffe Hospital	Queensland
Rockhampton Base Hospital	Queensland
Royal Adelaide Hospital	South Australia
Royal Darwin Hospital	Northern Territory
Royal Hobart Hospital	Tasmania
Royal Melbourne Hospital	Victoria
Royal Perth	Western Australia
Sir Charles Gairdner Hospital	Western Australia
St John of God Midland Public and Private Hospital[a]	Western Australia
St Vincent's Hospital Sydney	New South Wales
St Vincent's Hospital Melbourne	Victoria
The Alfred Hospital	Victoria
The Tweed Hospital	New South Wales
University Hospital Geelong (Barwon Health)	Victoria

Notes:
[a] This is one hospital with ~66% of beds allocated to public patients and ~33% allocated to private patients.
Highlighted hospitals = participating but did not have eligible cases for the current reporting period 1 January 2020–31 December 2021

Appendix E: Method for in-hospital 30-day mortality

Outcome and/or mortality evaluation relies on risk-adjustment techniques based on logistic regression analysis, from which the predicted number of events is used to calculate the standardised mortality ratio (SMR) between the observed and predicted number of events. A naïve approach for this would use the customary logistic regression model utilising the cases from all hospitals as one case mix, and in doing so, assuming all cases examined are independent of each other.

Two important statistical issues are overlooked with the above approach:

- lack of independence of observations—specifically, in the case of this report, of patient cases within the same hospital
- differences in population structures for age and sex among hospitals.

As for the first point, whenever observations are nested within a higher level of the data, the assumption of independence does not hold. Hierarchically, patients sit at a level of data under that of their hospital, and this type of data structure is called ‘clustered’ or ‘nested’. Patients nested within a hospital are more likely to have similar outcomes than patients from different hospitals. This is for a variety of reasons among which are age/sex structure of the population served and other demographic characteristics. Disregarding the existence of the clustering within the same hospital by pooling the data can drastically underestimate the interhospital variation.

As for the second point, SMRs are often used as a metric to compare hospital mortality because of their perceived simplicity. However, comparing mortality rates derived from hospitals situated within different populations requires the knowledge of the population structure. Ignoring these differences leads to erroneous conclusions due to the introduction of confounding and bias. The SMR is a single number that is obtained as a weighted average across populations strata, so it follows that it is a single number for that reference population.[42]

Further, each hospital has a unique mixture of staff, policies and operational synergies that impact patient outcomes in differing ways. The SMR alone effectively compares the observed outcome for the specific distribution of cases at a hospital with the predicted outcome if these patients had been treated by a typical provider in the reference population, as opposed to a suitable reference population.

When utilising funnel plots, an important additional consideration in this audit period is the relatively small number of available cases per hospital. A fundamental criterion for the meaningful use of control limits in funnel plots is having a sufficiently large sample size per hospital.[43]

In this analysis, a tailored approach was used which considered the points raised above, by estimating the population-averaged risk-standardised mortality rates (RSMRs) for each hospital with the method of generalised estimating equations[44] (GEEs), a longitudinal method that allows for the correlation between patients from the same hospital and also allows for the robust estimation of the standard errors used to define the control limits of a funnel plot.

The GEE model utilised in the analysis used the logistic link function to derive risk-adjusted predictions of the number of deaths. The estimates were adjusted for age, sex and indigenous status. When utilising a GEE estimation method, it is necessary to specify a working correlation structure. The correlation structure assumed for the model was exchangeable, which is the simplest type of structure to hypothesise that gives a good compromise between model fit and estimation with sparse data. With this type of correlation, the same correlation value was assumed for any two cases within the same hospital.

The estimated SMRs were multiplied by the population-averaged overall mortality rate to obtain the RSMRs for each hospital.