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Methods of the 7th National Audit Project (NAP7) of the Royal College of Anaesthetists: peri-operative cardiac arrest

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Summary

Cardiac arrest in the peri-operative period is rare but associated with significant morbidity and mortality. Current reporting systems do not capture many such events, so there is an incomplete understanding of incidence and outcomes. As peri-operative cardiac arrest is rare, many hospitals may only see a small number of cases over long periods, and anaesthetists may not be involved in such cases for years. Therefore, a large-scale prospective cohort is needed to gain a deep understanding of events leading up to cardiac arrest, management of the arrest itself and patient outcomes. Consequently, the Royal College of Anaesthetists chose peri-operative cardiac arrest as the 7th National Audit Project topic. The study was open to all UK hospitals offering anaesthetic services and had a three-part design. First, baseline surveys of all anaesthetic departments and anaesthetists in the UK, examining respondents' prior peri-operative cardiac arrest experience, resuscitation training and local departmental preparedness. Second, an activity survey to record anonymised details of all anaesthetic activity in each site over 4 days, enabling national estimates of annual anaesthetic activity, complexity and complication rates. Third, a case registry of all instances of peri-operative cardiac arrest in the UK, reported confidentially and anonymously, over 1 year starting 16 June 2021, followed by expert review using a structured process to minimise bias. The definition of peri-operative cardiac arrest was the delivery of five or more chest compressions and/or defibrillation in a patient having a procedure under the care of an anaesthetist. The peri-operative period began with the World Health Organization 'sign-in' checklist or first hands-on contact with the patient and ended either 24 h after the patient handover (e.g. to the recovery room or intensive care unit) or at discharge if this occurred earlier than 24 h. These components described the epidemiology of peri-operative cardiac arrest in the UK and provide a basis for developing guidelines and interventional studies.

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Accepted: 15 August 2022

Keywords: cardiac arrest; NAP7; operating theatre; peri-operative; resuscitation

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Introduction

Cardiac arrest during the peri-operative period is a complication feared by patients, anaesthetists and surgeons [1, 2]. Estimates put the incidence of cardiac arrest between 2 and 13 per 10,000 anaesthetics, with approximately 1 in 3 patients dying before discharge from hospital [3, 4]. Applying these values to the approximately 4 million annual cases performed in the UK annually [5] suggests some 2000 events and 600–700 deaths. However, as there is currently no systematic reporting system for cardiac arrests during anaesthesia in the UK, the incidence, management and outcomes of peri-operative cardiac arrest are unknown. These issues and others [6], form the drive for the Royal College of Anaesthetists' (RCoA) 7th National Audit Project (NAP7), which studied peri-operative cardiac arrest in the UK.

The RCoA National Audit Projects examine rare complications of anaesthesia that are incompletely studied, important to patients and anaesthetists on account of their severity, and which cannot be reliably studied by other methods [7]. Previous projects have investigated major anaesthesia-associated complications of neuraxial block (NAP3) [8], airway management (NAP4) [9], accidental awareness during anaesthesia (NAP5) [10] and peri-operative anaphylaxis (NAP6) [11, 12]. The projects have evolved to include three core components: a baseline survey assessing anaesthetists' experiences and attitudes on the topic of interest and departmental organisation related to the audit topic; an activity survey reporting anaesthesia practice, caseload and events relevant to the topic; and a case registry and expert review of the events of interest. The review process includes quantitative and qualitative analysis leading to consensus recommendations for improving practice based on the project findings.

This paper describes the methods for the baseline survey, activity survey and case reporting components of NAP7. It also describes the modifications made to the project due to the COVID-19 pandemic.

Methods

The Health Services Research Centre (HSRC) of the RCoA invited proposals for the topic of NAP7 in 2017, receiving around 80 applications. Following a competitive presentation stage, the HSRC Executive Management Board, representatives of the RCoA and lay members selected the subject of 'peri-operative cardiac arrest' (proposed by JS and separately by FO and RA).

The NAP7 Clinical Lead (JS, appointed by competitive interview) and the RCoA Director of National Audit Projects (TC, appointed by the RCoA) co-chair the steering

panel and are overseen by the Director of the HSRC and RCoA representatives. The RCoA Director for the NAPs and NAP7 Clinical Lead assembled a steering panel for NAP7 to plan and implement the project and provide an expert review of peri-operative cardiac arrest cases reported to the registry. The HSRC appointed clinical research fellows (RA, AK, EK) through an open competitive interview process. Stakeholder organisations, including the RCoA Lay Committee, were identified and invited to nominate a representative to form part of the panel.

The first meeting of the full NAP7 steering panel was on 26 September 2019, and meetings were held monthly after that. The project was ready to launch on 13 May 2020; however, this was delayed due to the COVID-19 pandemic. No full panel meetings were held between March 2020 and July 2021 due to the pandemic and lack of availability of panel members. Smaller group meetings continued during this period, and the NAP7 local co-ordinator network and infrastructure were used to undertake the Anaesthesia and Critical Care COVID Activity Survey to study the impact of COVID-19 on anaesthesia and critical care services in the UK [13]. NAP7 was launched on 16 June 2021 and monthly steering panel meetings restarted in August 2021 to review submitted cases.

Eligibility to contribute to NAP7 included all UK NHS and independent hospital sites undertaking anaesthetics. Sites were contacted in advance of the project start date by the NAP7 co-ordinator using details held by the RCoA from previous NAP cycles. In each department, a local co-ordinator (usually a consultant or SAS anaesthetist) was appointed to oversee the project at their site(s). A handbook was produced to facilitate local co-ordinators in this role. The NAP7 co-ordinator was available by email and telephone for queries from local co-ordinators. The NAP7 co-ordinator did not participate in case reviews to reduce the risk of de-anonymisation. Participating sites and local co-ordinators are listed on the NAP7 website (<https://www.nationalauditprojects.org.uk/NAP7-Home>). During the project, the NAP7 team updated the 'frequently asked questions' on the website as needed.

There were three arms to the project: baseline surveys of anaesthetists and departments; an activity survey of the anaesthetic caseload in all sites; and a case registry of peri-operative cardiac arrests. The baseline survey had two components. First, an online survey of anaesthetists examining knowledge, training and personal experiences of peri-operative cardiac arrest (see online Supporting Information, [Appendix S1](#)). The NAP7 co-ordinator sent a survey link to local co-ordinators, who forwarded the survey locally to all department members. Anaesthetists informed

their local co-ordinators when they had completed their survey to enable the calculation of a response rate. All anaesthetists in the UK, including consultants, specialty, specialist, staff grade and SAS grades, trainees and anaesthesia associates, were invited to participate. The second baseline survey assessed departmental organisation concerning peri-operative cardiac arrest. Survey questions focused on staff mix, case mix, procedures for summoning emergency help, access to emergency guidelines, resuscitation equipment, including defibrillator availability and governance structure (see online Supporting Information, [Appendix S2](#)).

The scope of the individual anaesthetist and departmental baseline surveys were formulated and agreed upon by the NAP7 steering panel. Both surveys were tested internally within the panel, with multiple iterations leading to final versions. The surveys were distributed before the launch date of the case registry component of NAP7. They remained open for approximately 4 and 9 months, respectively. The surveys were undertaken using an electronic survey tool (SurveyMonkey[®], Momentive.ai, San Mateo, CA, USA). Data were extracted and cleaned using Microsoft Excel 2022 (Microsoft Inc., Redmond, WA, USA) and checked for duplicates. Quantitative analysis was performed using Microsoft Excel, and qualitative data analysis was undertaken after importing on Pulsar v2022 (Pulsar TRAC, first-party data tool, Pulsar Platform, Los Angeles, CA, USA). The activity survey comprised a cross-sectional observational study to collect denominator data about anaesthetic activity, patient characteristics and adverse events during anaesthesia care, building on the previous methodology [5, 10]. The survey enables the incidence of events occurring during the one-year case reporting phase of the project to be compared against the caseload.

All sites were assigned randomly a continuous 4-day data collection period, with an equal chance of starting on any day of the week. Case collection included all cases that started from 00.00 on day 1 until 23.59 on day 4 of the local collection period. Local co-ordinators were advised to capture all cases under the care of an anaesthetist during the period, including cases requiring general anaesthesia, regional anaesthesia/analgesia, sedation, local anaesthesia or monitored anaesthesia care (i.e. care by anaesthetist without administration of anaesthetic drugs). Local co-ordinators were reminded to include: emergency and trauma theatres; labour ward and obstetric theatres; procedures occurring away from their main site (e.g. day surgery unit, electroconvulsive therapy unit); interventional pain procedures in operating theatres or pain clinics; diagnostic and interventional radiology; emergency

anaesthesia or sedation in the emergency department (if administered by an anaesthetist); out of hours work; and regional anaesthesia. Any patient returning to theatre for a second procedure was entered as a separate case. Similarly, obstetric patients could be entered separately for each encounter. The following scenarios were not studied: sedation or anaesthesia solely for critical care or procedures on critical care; newborn resuscitation; inter- or intra-hospital transfers.

Question design combined building on previous iterations of the activity survey used in previous NAPs and collecting individual case data pertinent to understanding peri-operative cardiac arrest. Data fields included: patient characteristics; comorbidities; resuscitation status; frailty; anaesthetic technique; monitoring; and complications during anaesthesia (see online Supporting Information, [Appendix S3](#)). Where questions had been asked in previous activity surveys, the format of the question was kept, thus enabling trends over time to be assessed. The stakeholder panel tested the activity survey internally before final approval. Local co-ordinators were provided with a link to the survey via SurveyMonkey for distribution at their site, and a QR code on the help sheet provided direct access. Respondents were advised to complete the survey at the end of each case. After analysis, data will be presented as summary measures of raw data. Where frequencies of events within groups are shown, they may be normalised to the population size. Confidence intervals will be calculated as appropriate. Where appropriate, the differences within groups will be assessed by appropriate statistical tests.

An annual caseload will be estimated by multiplying the number of cases by a scaling factor, which accounts for scaling the 4-day survey to a year and accounts for missed data and uninterpretable forms [5]. To exclude erroneous data and data entry mistakes, we will examine the data to ensure the fields are compatible for low-frequency events [14, 15]. For example, a ‘malignant hyperthermia’ report without ‘hyperthermia’ or metabolic complications is likely to be a mistake. Two reviewers will assess these events and refer discrepancies to a third for overall decision-making. Reports will be removed if judged to be a mistake. The study undertook a registry of peri-operative cardiac arrest cases. The registry was open for cases occurring between 00.00 on 16 June 2021 and 23.59 on 15 June 2022, with a plan to remain open for approximately 3 months to allow data entry.

To be reported, the NAP7 steering panel defined peri-operative cardiac arrest as ‘five or more chest compressions and/or defibrillation in a patient having a procedure under the care of an anaesthetist’ (Table 1).

There must be at least five compressions, which may be direct compression of the heart, mechanical chest compression or extracorporeal cardiopulmonary resuscitation (eCPR) started during cardiac arrest. Defibrillation was defined as an unsynchronised direct current (DC) shock for ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT). It included external or internal defibrillation, manual or automated external defibrillation (AED), shocks by implanted cardioverter defibrillators (ICDs) for VF/pVT and/or a precordial thump. Synchronised DC shock for cardioversion does not represent defibrillation. The steering group chose a cut-off of five compressions to exclude cases with a very brief period of chest compression in which cardiac arrest was unlikely to have occurred.

Patients under the care of an anaesthetist include those undergoing general anaesthesia, regional anaesthesia/analgesia, sedation, local anaesthesia or monitored anaesthesia care with an anaesthetist or anaesthesia associate present.

The peri-operative period was defined as from either the WHO sign-in or first hands-on contact with a patient to 24 h after the handover of the patient to recovery or another clinician (e.g. ICU, ward care) or hospital discharge. In addition to these core definitions, there are several special inclusion circumstances. We included: critically ill children anaesthetised for retrieval or awaiting transfer to another hospital; emergency department cases in whom a procedure was planned but in whom cardiac arrest occurred before this is possible; cases of regional block performed by anaesthetist outside the operating theatre; and obstetric analgesia (including remifentanyl patient-controlled analgesia). Cases where a patient was already in cardiac arrest before an anaesthetist attends will not be studied (Table 2). Other exclusions include defibrillation during electrophysiological procedures when this is a planned, normal, or expected part of the procedure (e.g. during VT ablation) and ASA physical status 6 patients (patients being prepared for, or undergoing, organ donation after diagnosis of death using neurological criteria).

Case reporting was confidential, and all patient, hospital, and clinician details were anonymised at the source by the reporting clinician or the local co-ordinator. When a local co-ordinator or other anaesthetist needed to report a case, they contacted the NAP7 administrator. The reporter confirmed that this was a peri-operative cardiac arrest as defined above and that the case occurred during the data collection period. After confirmation that the case met inclusion criteria, the reporter was issued a unique identifier and password to a secure encrypted case

submission website. Before accessing the secure webpage, the reporter was required to change their password. The steering panel designed the structured case report form (see online Supporting Information, [Appendix S4](#)) to capture the breadth and depth of data needed for each case whilst minimising the risk of patient, clinician or hospital identification. No patient, clinician or hospital data will be admissible on the form. Neither the project team nor the RCoA can identify which local co-ordinator entered which case(s). The reporting site reminds reporters to check for identifiers before submitting and locking an entry to the registry. Once completed and finalised ('locked'), the submitted form was automatically transferred to the clinical lead to enable analysis.

In cases where it was not clear that a case may or may not have met inclusion criteria, an independent moderator was available to discuss this. If there is still doubt, the default was to report the case. The moderator(s) were not on the review panel and had no contact with the review panel throughout the project. They were not permitted to discuss cases with review panel members. This process was vital to maintain confidentiality between reports and reviewers.

The NAP7 review panel met monthly to review and classify a representative sample of submitted cases using the methodology established in previous NAPs [7, 10, 12]. Each case was reviewed by a group of three to five clinical and patient representative panel members, with several groups performing reviews concurrently. The outputs of the reviews are used to populate a structured output form (see online Supporting Information, [Appendix S5](#)). This report form guides review groups through assessment of anaesthetic care, management during cardiac arrest, post-resuscitation care, case debrief and anaesthetist well-being, contributory and causal factors to the event. The severity of harm was assessed according to the National Patient Safety Agency (NPSA) grading [16]. After the case review in small groups was complete, review groups presented cases and analyses to the whole review panel (typically 12–15 members) at the end of each session to moderate the findings and note points of interest. Key lessons and keywords from each case are recorded. Case reviewers were not permitted to discuss case details outside the review meetings. If a review panel member had any knowledge of a case from direct involvement or indirect means (e.g. local morbidity and mortality meetings), they were not permitted to highlight this or bring that knowledge to the process as either of these actions would risk de-anonymising the case record.

Table 1 Extended definition of cardiac arrest.

	Includes	Excludes
Under the care of an anaesthetist	<ul style="list-style-type: none"> • General anaesthesia, regional anaesthesia/analgesia, sedation, local anaesthesia or monitored anaesthesia care with an anaesthetist present • Patients who are directly managed by an anaesthesia associate 	<ul style="list-style-type: none"> • Sedation or local anaesthesia where an anaesthetist is not present
Chest compressions	<ul style="list-style-type: none"> • There must be at least 5 compressions. • Includes: <ul style="list-style-type: none"> ◦ direct compression of the heart; ◦ mechanical chest compression; and ◦ extracorporeal cardiopulmonary resuscitation started during cardiac arrest 	<ul style="list-style-type: none"> • Four compressions or fewer
Defibrillation	<ul style="list-style-type: none"> • Defibrillation is an unsynchronised direct current (DC) shock for ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) • Includes: <ul style="list-style-type: none"> ◦ External or internal defibrillation ◦ Manual or automated external defibrillation ◦ Shocks by implantable cardioverter defibrillators for VF/pVT ◦ Precordial thump 	<ul style="list-style-type: none"> • Synchronised DC shock for cardioversion.

The review panel refers to published guidelines as indications for current best practices, including, but not limited to, those from the Resuscitation Council (UK) and European Resuscitation Council for adult and paediatric advanced life support [17–21], Association of Anaesthetists Quick Reference Handbook [22], and specialist society guidelines (e.g. Cardiac Advanced Life Support [23]), and guidance covering treatment escalation plans and end-of-life care (e.g. ReSPECT) [24]. The panel judged overall quality of care as ‘good’, ‘poor’, ‘good and poor’ or ‘unclear’ based on guidelines, the specific circumstances of the case, and ultimately by panel consensus.

Previous NAPs have reviewed approximately 200 cases. In NAP7, up to 1000 cases may be reported. Once the review process is established, a complimentary rapid review process will be used to allow learning from all cases to be incorporated into the final report. Rapid review cases will be assessed by two panel members independently. Where the case requires subspecialty expertise, one reviewer will be from the relevant stakeholder group. The review outcome will focus on the quality of care and learning points. If either panel member records that the case should be reviewed by the full panel or there is a notable disagreement between panel members in their assessment, the case will be submitted for full panel review.

Descriptive summaries of baseline patient characteristics and clinical variables will be presented with continuous variables as percentiles and discrete variables as frequencies and percentages. Categorical data will be

compared using Chi-squared or Fisher’s exact test as appropriate. The incidence rates of events (e.g. cardiac arrest) will be calculated using denominator data from the activity survey. Logistic regression will be used to calculate ORs and 95% CIs for outcomes of interest. Data analysis will be performed using R (R Core Team, Vienna, Austria). Qualitative analysis will identify emerging themes, potential areas for separate analysis and possible recommendations. These will be revisited and synthesised at the point of report writing. Keywords will be recorded for each case.

For the 12-month case registry, all data will be uploaded via a secure web-based tool using SSL encryption. The NAP7 team at the RCoA will control access to the tool, with security and confidentiality maintained through a registration process and the use of usernames and passwords. No identifiable patient, clinician or hospital information will leave any site; only anonymised data will be received and analysed at the RCoA. The RCoA has established suitable physical, electronic and managerial procedures to safeguard and secure the information collected online (see online Supporting Information, Appendix S6). The project was approved by all four Chief Medical Officers of the UK (see online Supporting Information, Appendix S7).

Discussion

This project is likely to be the largest and most comprehensive prospective study of peri-operative cardiac

Table 2 Specific inclusion and exclusion criteria.

	Includes	Excludes
Cardiology and cardiac surgery	<ul style="list-style-type: none"> Anaesthesia for cardiology and cardiac surgical procedures 	<ul style="list-style-type: none"> Cardiopulmonary bypass from arterial/aortic cannula insertion to removal Defibrillation during electrophysiological procedures when this is a planned, normal, or expected part of the procedure (e.g. during VT ablation)
Obstetrics	<ul style="list-style-type: none"> Patients with obstetric epidural and/or spinal up to 24 h after delivery Patients with remifentanyl patient-controlled analgesia 	<ul style="list-style-type: none"> Cardiac arrest before the start of anaesthesia care (as defined above) or with no anaesthetic intervention
Paediatrics (aged < 18 y)	<ul style="list-style-type: none"> As for adults, with the addition of special inclusion criteria for children anaesthetised for resuscitation before retrieval or transfer to another hospital 	<ul style="list-style-type: none"> Newborn resuscitation
Critical care	<ul style="list-style-type: none"> Patients on critical care within 24 h of the end of their procedure/handover to the critical care team Patients on critical care having an interventional procedure in another location under the care of an anaesthetist (excludes diagnostic imaging) from first hands-on intervention, including transfer 	<ul style="list-style-type: none"> Sedation or anaesthesia solely for critical care Procedures performed in the critical care unit (e.g. percutaneous tracheostomy). Any intra-hospital or inter-hospital transfers originating in critical care.
Extracorporeal cardiopulmonary resuscitation	<ul style="list-style-type: none"> Veno-arterial ECMO started during cardiac arrest Start defined as the initiation of extracorporeal flow to the patient after cannulation and circuit connection to cannulae 	<ul style="list-style-type: none"> ECMO for any other indication
Pain medicine	<ul style="list-style-type: none"> As per general inclusion criteria (includes procedures in pain clinic) 	
Radiology	<ul style="list-style-type: none"> Patients under the care of an anaesthetist for imaging in the radiology department Interventional radiology procedures, as per general inclusion criteria – including stroke thrombectomy/coiling for subarachnoid haemorrhage 	<ul style="list-style-type: none"> Patients transferred for diagnostic radiology from critical care
Regional anaesthesia and analgesia	<ul style="list-style-type: none"> Regional blockade performed by an anaesthetist outside of the theatre Until 24 h after the procedure 	<ul style="list-style-type: none"> Procedures performed on critical care
Emergency Department	<ul style="list-style-type: none"> Patients under the care of an anaesthetist who would meet the general criteria for NAP7 inclusion in whom anaesthesia care for an interventional procedure starts in the Emergency Department 	<ul style="list-style-type: none"> Adult patients who are anaesthetised solely for critical care (paediatric patients may be included as per inclusion criteria above) Patients anaesthetised solely for transfer to critical care
Other locations	<ul style="list-style-type: none"> Electroconvulsive therapy suite, even if in a separate building and/or hospital trust 	<ul style="list-style-type: none"> Patients in the pre-assessment clinic Patients undergoing exercise testing Patients who are not in the hospital Patients in the surgical admissions unit, ward or theatre complex before their procedure

VT, ventricular tachycardia; ECMO, extracorporeal membrane oxygenation

arrest to date. A strength of the NAP methodology is matching numerator (from the case review process) and denominator data (from the activity survey) to provide incidences of events and to enable the calculation of risk estimates. Further, the granularity of the data will enable us to explore how the risks vary with age, sex, ASA physical status, comorbid status, frailty and more. These data will be

contextualised in light of the baseline surveys, giving insight into how individuals and departments train for cardiac arrest and report their experiences.

Central to the project has been how to define what a peri-operative cardiac arrest is. We have adopted the definition of cardiac arrest as ‘chest compressions and/or defibrillation’, and our outcome measures are based on

the internationally agreed Utstein template [25]. We acknowledge that some cases where a cardiac arrest has occurred but chest compressions or defibrillation are not performed will be excluded, e.g. patients with 'do not attempt cardiopulmonary resuscitation' recommendations which have been kept active in the peri-operative phase. Conversely, we may capture events that may not be full cardiac arrests, for example, low flow states, hypotension/unrecordable blood pressure, or where chest compressions are started to aid circulation as a precaution or error. Complete cessation of the circulation and pulselessness is only certain in established VF and asystolic cardiac arrests. In contrast, the inability to feel a pulse may co-exist with a low flow state in VT (pVT VT) or PEA (pulseless electrical activity). All these situations should be treated with chest compressions and/or defibrillation.

Similarly, we have had to define the peri-operative period. The panel has focused the project on examining events happening in the operating theatre and the 24 h following the handover of care. Although cardiac arrest events occurring earlier in the peri-operative pathway (e.g. during cardiopulmonary exercise testing) or more than 24 h after surgery may provide insightful data, the stakeholder panel felt the period needed to focus on events that are likely to be within our direct care, or soon after. The panel decided to include events up to 24 h following care by an anaesthetist, as intra-operative events and management may impact the likelihood of cardiac arrest in this period. The definition of peri-operative is largely in line with that used by the National Institute for Health and Care Excellence [26].

Conversely, we have special inclusion criteria to capture cardiac arrest events that may not be 'peri-operative' but could potentially be high-impact following an intervention by an anaesthetist. These include anaesthetising children who are critically unwell before retrieval or transfer to another hospital for ongoing care, regional nerve blocks performed outside the theatre complex and analgesia for labour (including remifentanyl patient-controlled analgesia). We will include patients who have a cardiac arrest under the care of an anaesthetist in the emergency department under specific circumstances. These include patients where the team caring for the patient is planning a surgical, interventional radiology or cardiology procedure, but the patient has a cardiac arrest before this is possible. In previous NAPs, the emergency department has been a source of significant learning due to the inherent high-risk nature of the patients and situations presented

[27], and there may be similar high-impact learning from NAP7 in this environment.

As with previous NAPs, there is a need to examine a stable healthcare system that is not in fluctuation or crisis. The project was due to launch May 2020, and when the COVID-19 pandemic led to major healthcare disruption, we decided to delay NAP7 by approximately 1 year. The NAP7 team instituted the Anaesthesia and Critical Care COVID Tracking survey (ACCC-track) to monitor the impact of COVID-19 on anaesthetic and surgical activity and determine whether starting NAP7 in mid-2021 was feasible [13]. Given the results of the ACCC-track survey and accepting that healthcare delivery may not return to normal for a significant time, a pragmatic decision was made to start NAP7 in June 2021. The impact of the pandemic-associated disruption on NAP7 will be addressed as part of the NAP7 reporting process, using data from the ACCC-track surveys, activity survey and case registry.

We have built on the established methodology of previous NAPs, including multiple, serial, multidisciplinary reviews incorporating patient representation, formal moderation and a structured output. A review of events that have already happened is always unavoidably prone to the limitations of 'looking backwards', which may be exacerbated when the outcome is known [28, 29]. Our review processes incorporate structured, quantitative and qualitative, dual review, with care benchmarked against current guidelines, and make every effort to produce balanced judgements, accepting these known limitations. The standards of care include current guidance in the UK for immediate resuscitation and specific treatments of adverse peri-operative events [e.g. 17,20,21,30]. Collection of data at scale across four countries and processes to ensure reviewers do not know the source of reports adds to the robustness of the methodology.

As with previous NAPs, NAP7 relies on the openness and altruism of anaesthetists in the UK in reporting experiences, data and cases to the project team. In some of these cases, care may not have proceeded as planned and may have impacted patient safety and clinician experience or resilience. This sharing of 'uncomfortable data' is a notable component of the NAPs and reflects the dedication of anaesthetists to learn from patient critical events, whatever the circumstances. Whilst clinicians do not get direct feedback from reporting cases to NAP7, they do so in good faith that they are contributing to a project that may improve healthcare quality and safety. The NAP7 team acknowledges anaesthetists' generosity in supporting NAP7 and previous NAPs.

Acknowledgements

The project infrastructure is supported financially and with staffing from the Royal College of Anaesthetists. The NAP7 fellows' salaries are generously supported by: South Tees Hospitals NHS Foundation Trust (AK); Royal United Hospitals, Bath (EK); and NIHR Academic Clinical Fellowship (RA). Panel members receive travel expenses and no remuneration. The authors would like to thank K. Williams and J. Goodwin for their contributions. JS and TC's employers receive backfill for their time on the project (4 h per week). IM and SA are Editors of *Anaesthesia*. AK, RA and EK contributed equally as first authors. No other conflicts of interest declared.

References

- Mavridou P, Dimitriou V, Manataki A, Arnaoutoglou E, Papadopoulos G. Patient's anxiety and fear of anesthesia: effect of gender, age, education, and previous experience of anesthesia. A survey of 400 patients. *Journal of Anesthesia* 2013; **27**: 104–8.
- Burkle C, Mann C, Steege J, et al. Patient fear of anesthesia complications according to surgical type: potential impact on informed consent for anesthesia. *Acta Anaesthesiologica Scandinavica* 2014; **58**: 1249–57.
- Hur M, Lee HC, Lee KH, Kim JT, Jung CW, Park HP. The incidence and characteristics of 3-month mortality after intraoperative cardiac arrest in adults. *Acta Anaesthesiologica Scandinavica* 2017; **61**: 1095–104.
- Fielding-Singh V, Willingham MD, Fischer MA. A population-based analysis of intraoperative cardiac arrest in the United States. *Anesthesia and Analgesia* 2020; **130**: 627–34.
- Kemp H, Marinho S, Cook TM, et al. An observational national study of anaesthetic workload and seniority across the working week and weekend in the UK in 2016: the 6th National Audit Project (NAP6) Activity Survey. *British Journal of Anaesthesia* 2018; **121**: 134–45.
- Kane AD, Armstrong RA, Kursumovic E, Cook TM, Soar J. The 7th UK National Audit Project (NAP7). The challenges of defining, studying and learning from peri-operative cardiac arrest. *Anaesthesia* 2021; **76**: 1026–30.
- Cook TM, Thomas G. The United Kingdom National Audit Projects: a narrative review. *Southern African Journal of Anaesthesia and Analgesia* 2016; **22**: 38–45.
- Cook TM, Counsell D, Wildsmith JAW. Major complications of central neuraxial block: report on the third National Audit Project of the Royal College of Anaesthetists. *British Journal of Anaesthesia* 2009; **102**: 179–90.
- Cook TM, Woodall N, Frerk C. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: Anaesthesia. *British Journal of Anaesthesia* 2011; **106**: 617–31.
- Pandit JJ, Andrade J, Bogod DG, et al. The 5th National Audit Project (NAP5) on accidental awareness during general anaesthesia: summary of main findings and risk factors. *Anaesthesia* 2014; **69**: 1089–101.
- Harper NJN, Cook TM, Garcez T, et al. Anaesthesia, surgery, and life-threatening allergic reactions: epidemiology and clinical features of perioperative anaphylaxis in the 6th National Audit Project (NAP6). *British Journal of Anaesthesia* 2018; **121**: 159–71.
- Harper NJN, Cook TM, Garcez T, et al. Anaesthesia, surgery, and life-threatening allergic reactions: management and outcomes in the 6th National Audit Project (NAP6). *British Journal of Anaesthesia* 2018; **121**: 172–88.
- Kursumovic E, Cook TM, Vindrola-Padros C, Kane AD, Armstrong RA, Waite O, Soar J. The impact of COVID-19 on anaesthesia and critical care services in the UK: a serial service evaluation. *Anaesthesia* 2021; **76**: 1167–75.
- Curran PG. Methods for the detection of carelessly invalid responses in survey data. *Journal of Experimental Social Psychology* 2016; **66**: 4–19.
- Meade AW, Craig SB. Identifying careless responses in survey data. *Psychological Methods* 2012; **17**: 437–55.
- National Patient Safety Agency. Seven steps to patient safety. The full reference guide. 2004. <https://www.publichealth.hscni.net/sites/default/files/directorates/files/Seven%20steps%20to%20safety.pdf> (accessed 15/08/2022).
- Lott C, Truhlar A, Alfonso A, et al. European Resuscitation Council Guidelines 2021: cardiac arrest in special circumstances. *Resuscitation* 2021; **161**: 152–219.
- Nolan JP, Sandroni C, Böttiger BW, et al. European Resuscitation Council and European Society of Intensive Care Medicine guidelines 2021: post-resuscitation care. *Resuscitation* 2021; **161**: 220–69.
- Resuscitation Council UK. 2021 resuscitation guidelines, 2021. <https://www.resus.org.uk/library/2021-resuscitation-guidelines> (accessed 15/08/2021).
- Soar J, Böttiger BW, Carli P, et al. European resuscitation council guidelines 2021: adult advanced life support. *Resuscitation* 2021; **161**: 115–51.
- Van de Voorde P, Turner NM, Djakow J, et al. European Resuscitation Council Guidelines 2021: paediatric life support. *Resuscitation* 2021; **161**: 327–87.
- Association of Anaesthetists. Quick reference handbook. 2021. <https://anaesthetists.org/Home/Resources-publications/Safety-alerts/Anaesthesia-emergencies/Quick-Reference-Handbook/PDF-version> (accessed 15/08/2022).
- Dunning J, Fabbri A, Kolh PH, et al. Guideline for resuscitation in cardiac arrest after cardiac surgery. *European Journal of Cardio-Thoracic Surgery* 2009; **36**: 3–28.
- Pitcher D, Fritz Z, Wang M, Spiller JA. Emergency care and resuscitation plans. *British Medical Journal* 2017; **356**: j876.
- Nolan JP, Berg RA, Andersen LW, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein resuscitation registry template for in-hospital cardiac arrest: a consensus report from a task force of the International Liaison Committee on Resuscitation. *Resuscitation* 2019; **144**: 166–77.
- National Institute for Health and Care Excellence. Hypothermia: prevention and management in adults having surgery. [CG65]. 2008. <https://www.nice.org.uk/guidance/cg65> (accessed 15/08/2022).
- Cook TM, Woodall N, Harper J, Benger J. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. *British Journal of Anaesthesia* 2011; **106**: 632–42.
- Caplan RA, Posner KL, Cheney FW. Effect of outcome on physician judgments of appropriateness of care. *Journal of the American Medical Association* 1991; **265**: 1957–60.
- Henriksen K, Kaplan H. Hindsight bias, outcome knowledge and adaptive learning. *Quality and Safety in Health Care* 2003; **12**: 46–50.
- Resuscitation Council (UK), Neuroanaesthesia Society of Great Britain and Ireland, Society of British Neurological Surgeons. Management of cardiac arrest during neurosurgery in adults. 2014. https://www.resus.org.uk/sites/default/files/2020-05/CPR_in_neurosurgical_patients.pdf (accessed 15/08/2022).

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Supporting Information

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

Appendix S1. Baseline survey of all anaesthetists.

Appendix S2. Baseline survey of all local co-ordinators.

Appendix S3. Activity survey questions and logic.

Appendix S4. Case review form fields.

Appendix S5. NAP7 structured panel review form.

Appendix S6. Data security.

Appendix S7. Ethics and approvals.