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Determining the top research priorities in UK prehospital critical care: a modified Delphi study

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Handling editor Jason E Smith

► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/emered-2022-212622>).

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Received 30 May 2022

Accepted 12 December 2022

ABSTRACT

Background Prehospital critical care is a rapidly evolving field. There is a paucity of evidence relating to its practice, with limited progress in answering those research questions identified over a decade ago. It is vital that evidence gaps are identified and addressed. This study aimed to define the current research priorities in UK prehospital critical care.

Methods This modified national Delphi study was coordinated by the Pre-HOspital Trainee Operated research Network and conducted in four rounds between October 2021 and April 2022. Rounds 1 and 2 were conducted online with clinicians involved in prehospital critical care delivery and non-clinical prehospital researchers. Rounds 3 and 4 were completed online by a subject matter expert (SME) panel.

Results In round 1, 78 participants submitted 394 research questions relating to prehospital critical care delivery in the UK. These were refined and categorised into 192 questions, which were scored for importance in round 2. Fifty questions were discussed and scored by the SME panel in round 3. Round 4 created a ranked top 20 list. The top research priority was 'Which cardiac arrest patients should critical care teams be dispatched to; how do we identify these patients during the emergency call?'. Other priorities included dispatch optimisation, out-of-hospital medical cardiac arrest management, optimising resuscitation in haemorrhagic shock, improving traumatic brain injury outcomes and optimising management of traumatic cardiac arrest.

Conclusions This modified Delphi study identified 20 research priorities where efforts should be concentrated to develop collaborative prehospital critical care research within the UK over the next 5 years.

BACKGROUND

Within the UK, prehospital critical care teams provide enhanced care to critically ill and injured patients, supplementing care delivered by ground ambulance services. Critical care teams comprise clinicians working at the level of an advanced prehospital practitioner¹ capable of delivering level 2 and 3 critical care interventions,² including within Helicopter Emergency Medical Services (HEMS), ground-based services such as those within the British Association for Immediate Care (BASICS) and in advanced paramedic practitioner roles. Services often use a doctor-paramedic model, but variations include double and single critical care paramedic models and solo physician responders.

Prehospital critical care practice lacks a robust evidence base.^{3,4} Prehospital emergency medicine

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Prehospital critical care delivery in the UK often lacks evidence due to factors such as the time critical nature of patient encounters and challenges around patient recruitment and consent.
- ⇒ The last consensus report defining research priorities in physician-delivered prehospital critical care in Europe was published in 2011.
- ⇒ Current literature suggests that there is still a paucity of evidence in several of the previously prioritised areas. Additionally, as this is a rapidly evolving field, it is likely that there are emerging areas requiring attention.

WHAT THIS STUDY ADDS

- ⇒ This modified Delphi study identified current research priorities in UK prehospital critical care.
- ⇒ Key areas include management of cardiac arrest and improving post return of spontaneous circulation care, management of patients with moderate-to-severe head injury and major haemorrhage and improvement of dispatch and triage decisions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Results can help direct efforts for research and funding in prehospital critical care in the UK over the coming years.

as a subspecialty is relatively new, with formal subspecialist qualification available only within the last decade.⁵ Other factors hindering research relate to challenges around patient recruitment and consent in prehospital trials, in-hospital follow-up data acquisition⁶ and ascertaining a causal link between prehospital interventions and longer-term outcomes. However, notable large prehospital studies have now been conducted successfully in the UK.^{7,8}

Previous reports have described prehospital research priorities, including a 2011 European Consensus report which outlined five areas for future development in prehospital physician-provided critical care delivery,³ appropriate staffing and training and effect on outcomes, advanced airway management, time windows for key prehospital interventions, role of prehospital ultrasound and defining dispatch criteria. The Netherlands



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To cite: Ramage L, McLachlan S, Williams K, *et al.* *Emerg Med J* Epub ahead of print: [please include Day Month Year]. doi:10.1136/emered-2022-212622



national research agenda concerning wider prehospital emergency medical services⁹ was updated in 2021¹⁰ and again highlighted several priority areas necessitating further research. Despite these reports, there has been limited demonstrable progress.^{11–13} More recently, the top five research priorities for a single UK HEMS organisation were published,¹⁴ but generalisability to other organisations is unknown.

Therefore, the aim of this study was to ascertain the research priorities for UK prehospital critical care using a modified Delphi process.

METHODS

This study was designed and conducted between October 2021 and April 2022 by the Pre-Hospital Trainee Operated research Network (PHOTON), in collaboration with the National HEMS Research and Audit Forum (NHRAF) and Essex and Herts Air Ambulance. Although conducted by a trainee-led organisation, study participants involved the wider prehospital critical care community.

The Delphi method is a structured and iterative approach to achieving consensus to address a particular problem or issue, typically comprising identification of an expert panel, repeated rounds of data collection and structured feedback to participants following each round.¹⁵ This current study adopted a modified Delphi methodology, incorporating a subject matter expert (SME) meeting.

This Delphi has been reported according to the Conducting and Reporting Delphi Studies criteria¹⁶ which was originally developed to allow appraisal of the Delphi method in creating best practice guidelines in palliative care and consists of recommendations to improve rigour and transparency in the conduct and reporting of studies employing the Delphi method.

Participant recruitment

To be eligible to participate in rounds 1 and 2, participants were required to be either a UK-based clinician working in a prehospital critical care role with at least 6 months full-time experience or have a non-clinical role within a prehospital critical care team involving an active research component.

The term 'clinician' included anyone working in a clinical role within a prehospital critical care team; in the UK, such clinicians are typically doctors and paramedics but could be any other relevant healthcare provider. Clinicians working within BASICS were included were eligible. The study was advertised to all UK HEMS organisations through established communication channels, to NHRAF members and on social media channels by PHOTON. To maintain participant anonymity during rounds 1 and 2, a mailing list was generated to facilitate blanket communication to all who expressed interest. Those who expressed interest were encouraged to share details of the study with others eligible to participate using a snowballing technique. As a result, the denominator of those invited to participate is unknown.

All further correspondence and invitations to participate in successive rounds were communicated through the mailing list, with instructions regarding how to opt out if they no longer wished to be included.

SMEs for rounds 3 and 4 were defined as having clinical experience of working within prehospital critical care (HEMS or land-based) at a senior grade for at least 2 years, and/or research and/or substantial leadership responsibilities within a prehospital team capable of delivering critical care interventions or being selected specialists who have previously documented areas of interest in the development of prehospital research.

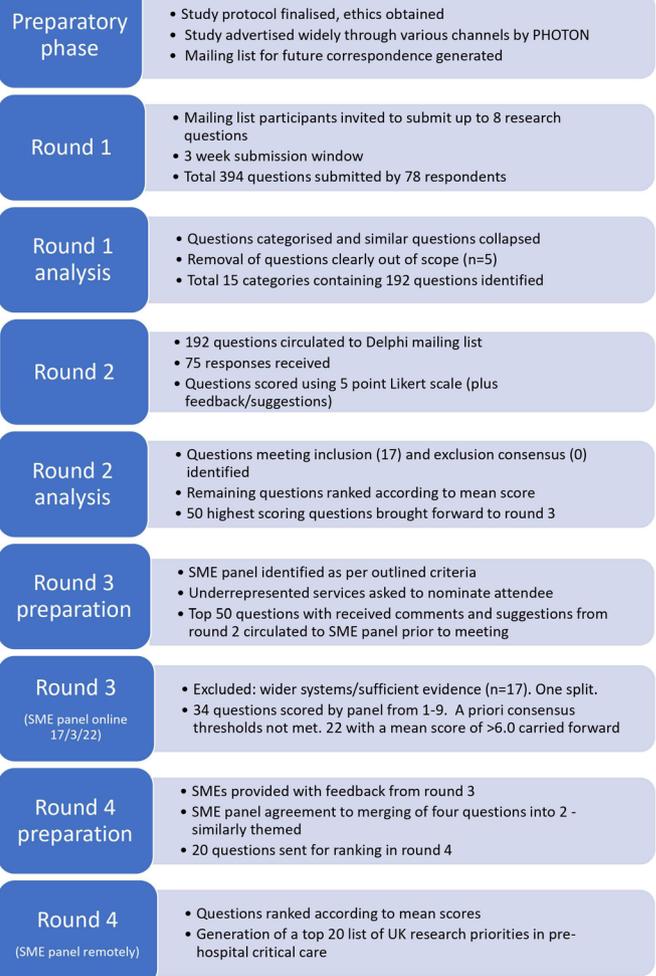


Figure 1 Flowchart documenting modified Delphi process. SME, subject matter expert.

Potential SMEs were identified using several means. We aimed to have representation from all UK HEMS services, other relevant land-based resources such as BASICS and an approximately equal split of critical care paramedics and doctors. At the point of enrolment onto the mailing list, participants were asked to self-identify if they fulfilled the criteria above and if so, to indicate their willingness to participate in round 3. Services without representation were approached and service leads were asked to nominate someone from their team to attend. Additionally, several UK-based specialists with a known reputation in prehospital critical care research, based on publication of at least three papers in the field, were approached. A meeting date was set and all those identified as potential SMEs were invited.

Patient and public involvement

The original study design sought patient involvement to ensure the output was representative of patients' perspectives. Despite exhaustion of several channels of potential recruitment, no patient volunteers were identified which is recognised as a significant limitation.

Modified Delphi process

This modified Delphi was conducted in four rounds (figure 1). The fourth round was not planned within the original study protocol and was added to address a lack of consensus and the

requirement for further refinement to the wording of research questions following round 3. All protocol amendments were approved by the ethics committee.

Round 1: qualitative assessment

The first round was delivered online using Online Surveys (Jisc), a survey tool that is General Data Protection Regulation (GDPR) compliant and certified to ISO 27001 standard, and with anonymity. Participants were invited to identify up to eight research questions or areas of equipoise they felt most important to the development of prehospital critical care delivery. A limit of eight questions was set to encourage participants to prioritise questions they perceived as most important and was less conservative than limits set in previous studies using consensus approaches to establish research priorities.^{3 14 17} Round 1 remained open for 3 weeks, with regular reminders sent to those on the mailing list. Subsequent additions to the mailing list were permitted to maximise participation. Round 1 participants were asked to self-generate an anonymous study identifier in order to link responses between rounds 1 and 2.

After closure of round 1, submitted questions were categorised into broad themes, and similar questions amalgamated. The initial process was undertaken separately by two subgroups within the study team (LR and KW, and SM), before jointly confirming question categories and the questions to be distributed in round 2. Extreme care was taken not to inadvertently lose content of submitted questions during the process. Five questions clearly outside the scope of prehospital critical care were removed (online supplemental file 1).

Round 2: importance ratings

Round 2 was conducted online over 3 weeks. Participants individually rated the questions developed in round 1 on a 5-point Likert scale anchored by 1: 'not important' and 5: 'very important'. Each question received one score, with participants asked to consider scientific merit, significance to prehospital critical care delivery, innovation, relevance and feasibility of further study when assigning the score, as well as whether sufficient evidence existed within existing literature. Participants could add comments or suggest amendments for each question. There was no requirement for participation in the previous round; recent research demonstrated that allowing participation in subsequent rounds regardless of prior participation results in better representation of the invited panel and does not affect the outcome of the Delphi process.¹⁸ All received responses were anonymous. A priori consensus thresholds for round 2 were defined as follows: If a research question scored 4 or greater from 75% or more respondents, it was automatically included in round 3. If a research question scored 2 or less from 75% or more respondents, it was automatically excluded from round 3.

Questions not meeting the automatic inclusion or exclusion criteria were ranked by overall score by the study team and those ranking highest were taken forward, along with those meeting the automatic inclusion criterion to give a total of 50 questions for discussion at the round 3 panel meeting. A cut-off of 50 questions was felt to be a manageable number to be discussed by the panel within the time constraints of the meeting.

Round 3: SME meeting

The meeting was held online on the 17 March 2022 using Zoom. Prior to the meeting, SMEs received a copy of the results from round 2, including mean scores and comments or suggestions pertaining to individual questions received from participants.

Within the meeting, the 50 questions were discussed, including review of any comments received in round 2, revision of wording and exclusion of any questions not felt by the SME panel to fall directly within the remit of prehospital critical care research.

Remaining questions were voted on in terms of their priority for future research using the anonymous live voting software, Slido. Voting used a scoring system drawn from Schneider *et al.*,¹⁷ with a score of 1 being assigned if the individual felt the question should not be studied, and 9 if they felt it was of the highest priority.

Predefined consensus threshold for retention of questions was that 100% of SMEs scored the research question as a 7, 8 or 9.¹⁷ Questions meeting this threshold would automatically be brought forward for a final ranking exercise. If less than 10 questions met this criterion, then it was planned a priori that questions with the highest mean scores would be taken forward for final ranking.

None of the questions met the predefined consensus threshold, therefore an unplanned fourth round was added where the SME panel ranked the highest scoring questions from round 3 and made final amendments to the wording. Questions scoring a mean of 6.0 (indicating 'slightly high priority') or more in round 3 were included in the ranking exercise.

Round 4: final ranking

The fourth round was open only to the SMEs who had participated in round 3. Participants were asked to rank the highest scoring questions from round 3 in order of importance. The mean ranking was generated with its corresponding SD for each question. A final opportunity was given for minor amendments to wording prior to publication of results.

RESULTS

A total of 135 people signed up to the mailing list to receive information about the study and links to the online surveys (62% doctors; 31% paramedics; 5% 'other' background; 2% missing data).

Seventy-eight (57.8%) of those on the mailing list participated in round 1, submitting a total of 394 research questions. Of the 78 participants, 74.4% were doctors, 23.1% were Critical Care Paramedics and 2.6% were 'other'. Further participant demographics for rounds 1 and 2 are presented in table 1. Suggested research questions were categorised under the following headings: medical cardiac arrest; prehospital emergency anaesthesia/analgesia/sedation; neurological emergencies; major haemorrhage and blood products; paediatrics; major trauma (including traumatic cardiac arrest); operational; impact or benefit of prehospital critical care teams; dispatch; triage; patient experience; staff well-being; training and education; kit; miscellaneous. After amalgamation of similar questions and exclusion of those not felt to be directly related to prehospital critical care delivery, 192 questions were circulated for round 2 (online supplemental file 2).

Round 2 was completed by 75 respondents; 78.7% had completed round 1. Sixty per cent of respondents were doctors, 12% were CCPs and 4% were 'other'. It was not possible to match 18 (24%) of these participants across rounds 1 and 2, due to discrepancies in their self-generated anonymisation code resulting in missing demographic data for a substantial proportion of round 2 participants.

On review of the results from round 2, 17 questions met the predefined threshold for inclusion in round 3. None met the threshold for automatic exclusion. The remaining questions

Table 1 Participant demographics for rounds 1 and 2

Demographics	Round 1 n (%)	Round 2 n (%)
Role		
Prehospital care doctor	11 (14.1%)	6 (8%)
Hospital doctor	1 (1.3%)	1 (1.3%)
Prehospital care doctor and hospital doctor	46 (59%)	38 (50.7%)
Critical care paramedic	18 (23.1%)	9 (12%)
Other	2 (2.6%)	3 (4%)
Missing	0 (0%)	18 (24%)
Hospital doctor speciality		
Anaesthetics	13 (27.7%)	10 (25.6%)
Emergency Medicine	29 (61.7%)	25 (64.1%)
Intensive Care Medicine	1 (2.1%)	1 (2.6%)
Dual Speciality	4 (8.5%)	2 (5.1%)
Missing	0 (0%)	1 (2.6%)
Years of experience in the prehospital setting		
≥6 months, ≤6 years	26 (33.3%)	21 (28%)
>6 years, ≤12 years	21 (26.9%)	15 (20%)
>12 years	30 (38.5%)	20 (26.7%)
Missing	1 (1.3%)	19 (25.3%)
Country or countries in which participant is based*		
England	70 (89.7%)	51 (68%)
Scotland	6 (7.7%)	4 (5.3%)
Wales	8 (10.3%)	3 (4%)
Ireland	3 (3.8%)	2 (2.7%)
Missing	0 (0%)	18 (24%)
Prehospital research experience*		
None	17 (21.8%)	15 (20%)
Previous involvement with research	0 (0%)	6 (8%)
Currently involved with some prehospital research projects	39 (50%)	26 (34.7%)
Publication of 1–4 peer-reviewed prehospital research papers (any authorship)	18 (23.1%)	12 (16%)
Publication of ≥5 peer-reviewed prehospital research papers (any authorship)	10 (12.8%)	4 (5.3%)
Other (eg, principal investigator on funded project)	6 (7.7%)	2 (2.7%)
Missing	0 (0%)	19 (25.3%)

*Some participants reported being based in more than one country of the UK, and some participants selected more than one response for prehospital research experience, therefore total numbers exceed 78 and 75 for rounds 1 and 2, respectively.

were assigned a mean score and the next 33 highest scoring questions brought forward to give a total of 50 questions for review by the SME panel.

A total of 35 subject matter experts (SMEs) confirmed their willingness to participate in the round 3 meeting and 25 SMEs were available to participate. Of those who participated, seven (28%) had been approached separately and invited to participate due to their significant contributions to prehospital critical care research and development. Six (24%) of the participating SMEs were critical care paramedics and 19 (76%) were doctors; 64% of the SMEs had conducted prehospital care research and all had significant clinical experience. Participating SMEs were from 14 of the 22 (63.64%) UK HEMS, including services in England, Scotland and Wales, and several BASICS services.

During the online meeting, 17 questions were excluded from the voting process. Reasons for exclusion included a wider system of healthcare of public health focus, a substantial existing evidence base, being the focus of a current or imminent large-scale study, or some degree of overlap with other questions. One retained question was split into two questions, as it was felt to represent two distinct areas. Therefore, 34 questions were brought forward for voting.

Following the scoring process, none of the questions met the predefined consensus threshold for the final ranking exercise and therefore all 34 questions were ranked according to mean score (online supplemental file 3). A total of 22 questions had a mean score of 6.0 ('slightly high priority') or greater; these were taken forward to round 4. However, following further discussion after the scoring process, it was agreed by the SME panel that four of these retained questions should be collapsed into two questions, resulting in 20 questions for final ranking by the SME panel in round 4.

Twenty-three responses were received in round 4, constituting a response rate of 92% from the SME panel. [table 2](#) contains the top 20 questions with their associated mean ranking and SD.

DISCUSSION

This study has identified the current national research priorities for prehospital critical care through use of an evidence-based modified Delphi process. The top research priority was 'Which cardiac arrest patients should critical care teams be dispatched to, and how do we identify these patients during the emergency call?'

The SMEs agreed that identified priority areas should be presented as broad research questions, permitting several research studies to be conceptualised from within each topic, in keeping with similar previously published outputs such as the James Lind Alliance Emergency Medicine Priority Setting Partnership statement.¹⁹

Three questions in this current top 20 relate to critical care team dispatch, previously identified over ten years ago in the 2011 European Delphi.³ Similarly, questions on the role of prehospital emergency anaesthesia and advanced airway management, and ultrasound use in prehospital critical care persist. There is considerable overlap in identified priorities between this study and the European one, particularly around the impact of prehospital critical care interventions on patient outcomes in head injury and postresuscitation care following out-of-hospital cardiac arrest.¹⁴

Regarding strengths of the study, initial question generation and scoring in rounds 1 and 2 were undertaken by a considerable number of clinicians directly involved in prehospital critical care delivery in the UK as well as non-clinical researchers with relevant expertise. The SME panel involved in the third and fourth rounds comprised experienced prehospital critical care practitioners, representing almost two-thirds of air ambulance services nationally in addition to BASICS schemes.

There are several limitations. Despite considerable efforts, we were unable to identify any patient participants. We plan to address this in a future study focusing on patient and family member experience. Additionally, we cannot be sure that participants were representative of the whole UK prehospital critical care community. Although rounds 1 and 2 included participants from services in England, Scotland, Wales and Ireland, it is unknown if all services were represented as participants were not asked to provide work details to ensure anonymity. Further, approximately one-third of HEMS were not represented within

Table 2 Round 4 results: top 20 ranked questions

No.	Question	Mean ranking (SD)*
1	Which cardiac arrest patients should critical care teams be dispatched to, and how do we identify these patients during the emergency call?	4.56 (4.75)
2	How can dispatch of critical care teams to patients be improved? Can the use of digital health technology assist?	5.96 (5.24)
3	In patients with medical OHCA attended by prehospital critical care teams, which interventions beyond current ALS guidelines improve outcomes?	6.00 (4.97)
4	What strategy of volume resuscitation improves outcomes in injured patients with haemorrhagic shock?	7.13 (5.47)
5	In patients with ROSC following OHCA, does PHEA improve patient outcomes?	8.04 (5.41)
6	What clinical features and interventions are associated with survival to hospital discharge in patients in traumatic cardiac arrest?	8.52 (5.40)
7	In patients with severe traumatic brain injury, does prehospital administration of osmotic agents result in improved neurological outcome and survival, and if so, what is the optimal dose?	9.39 (5.72)
8	What strategy for volume resuscitation improves outcomes in patients with traumatic brain injury?	9.48 (4.88)
9	What is the benefit offered to patients with moderate to severe head injury by prehospital critical care teams?	9.61 (5.73)
10	Does prehospital reversal of anticoagulation improve outcomes in patients with traumatic brain injury?	9.96 (4.69)
11	Does transfer to a neurological centre for consideration of time critical thrombectomy improve outcome in patients with suspected stroke in the prehospital setting?	10.61 (5.39)
12	Which adult trauma patients with frailty benefit from triage to a Major Trauma Centre?	10.87 (4.62)
13	In trauma patients undergoing PHEA, does the time interval between the 999 call and PHEA delivery impact on patient focused outcomes?	11.09 (5.30)
14	Does prehospital administration of calcium in major traumatic haemorrhage improve patient outcomes, and if so, what is the optimal dose?	11.91 (4.66)
15	Is prehospital critical care clinician dispatch superior to standard ambulance service dispatch?	12.17 (6.31)
16	Is there any benefit to patients by using prehospital point of care testing?	12.22 (4.24)
17	How can we identify risks to well-being and protect the mental health of prehospital critical care providers?	12.74 (4.95)
18	In cases of prehospital death, what strategies can be used by prehospital practitioners to improve the experience for friends, family and bystanders?	12.83 (5.31)
19	Does the use of POCUS in prehospital critical care improve patient outcomes?	13.09 (4.88)
20	Which prehospital simulation strategies are optimal to improve patient, clinician and procedural outcomes?	16.83 (4.05)

*Values are expressed as the mean (SD) final ranking assigned during round 4 of the process, with a lower value indicating a higher priority.

OHCA, out-of-hospital cardiac arrest; PHEA, prehospital emergency anaesthetic; POCUS, point-of-care ultrasound; ROSC, return of spontaneous circulation.

the SME panel. There was also an imbalance in the clinical roles of participants across the four rounds, with considerably more prehospital critical care doctors participating than paramedics. Consensus was not reached in round 3, necessitating addition of a fourth round. This may have been partly due to similarly themed questions being put forward for scoring by the SME panel. Additionally, priorities may differ at a personal and service level based on local project involvement.

Nevertheless, our defined top research priorities should be regarded as important for the conception and design of future research studies, having undergone a selection process with involvement of many recognised experts in prehospital critical care in the UK. The results of this Delphi should inform development of future funding applications and encourage collaborative working with a view to addressing remaining evidence gaps.

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Contributors LR: Responsible for overall study content and is the guarantor. Involved in protocol drafting, ethics applications, survey design, study rollout, result analysis, chairing SME meeting, manuscript drafting, manuscript approval. SMCl: involved in protocol drafting, ethics applications, survey design, study rollout, result analysis, chairing SME meeting, manuscript drafting, manuscript approval. KW: involved in study rollout, analysis of results, manuscript approval.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Allied Health, Nursing & Midwifery & Medicine School Research Ethics Panel at Anglia Ruskin University (Study ref AH-SREP-20-100). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. Most data relevant to the study are either included in the article or uploaded as a supplementary file. Other data if required are available on reasonable request.

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Supplementary file 1: Questions deemed out of scope of pre-hospital critical care and excluded following round 1

Do older frail patients benefit from community-based emergency care teams compared to usual care
Do Community Emergency medicine care services provide improved patient outcomes compared to standard care
Do community emergency medicine placements provide superior training in emergency medicine to in-hospital placements?
Does discharging patients in the community (Community Emergency Medicine) lead to improved patient and system outcomes? (Reduced hospital-associated harms / improved staff developed and retention / system efficiencies (reduced activity in ED and admissions) / economic benefit
Does a "one in, one out" policy in the Emergency Department improve overall waiting times?

Supplementary file 2: The 142 research questions excluded following rating in Round 2

Research question	Mean importance rating in Round 2
How have survival rates evolved in the last two decades and what are the factors that will improve survival rates in the next 20 years?	3.67
Do pre-hospital antibiotics for non-grossly contaminated penetrating trauma/large open wounds reduce subsequent wound infection?	3.67
How often do pre-hospital critical care services obtain follow up on their patients to confirm or deny their primary survey findings to improve learning and training?	3.67
Does 5% hypertonic saline have a role in non-traumatic intracranial haemorrhage with signs of raised ICP?	3.66
What key words are used by a layperson to describe a viable cardiac arrest who may benefit from a critical care team and a good neurological outcome is likely versus those likely to be fatal?	3.64
In patients with undifferentiated non-traumatic intracranial bleeding receiving pre-hospital PHEA what range of systolic blood pressures in transit is correlated with an improvement in patient focused outcomes (e.g. mortality/morbidity)?	3.64
Would a national 'code red' bypass system be beneficial to improve outcomes by taking unstable haemorrhaging patients straight to theatre?	3.64
Would outcomes in critically unwell children (including in ROSC following medical cardiac arrest) be better if taken to a tertiary centre and would the experience be better for patients and their families?	3.63
Can a rule based dispatch tool be used to identify patients that would benefit from critical care team interventions as accurately as a clinician?	3.62
For children should there be a national standard age per page?	3.61
In pre-hospital critical care research what is the correct outcome measure (s) to use? There is a belief from some that by the time of survival to discharge (weeks or months from the incident) that any treatment effect of pre-hospital care is so diluted that it results in negative trials.	3.61
Is there outcome evidence for direct-to-burns centres in the UK?	3.61
Can standard ambulance responding resources adequately identify patients that will benefit from specialist pre-hospital resources (including community emergency medicine, frailty teams and critical care teams)?	3.60
Current major trauma tools permit TU bypass for up to 45-60 minute journeys - but what is the more meaningful metric: transfer time only, or on scene time to arrival in hospital?	3.59
Do patients receiving pre-hospital anaesthesia suffer from awareness under anaesthesia?	3.58

Does the application of a pelvic binder in trauma patients improve outcomes and can we produce better evidence-based guidelines for their use?	3.57
Can pre-hospital thoracostomy incisions be safely used for in-hospital chest drains? Does the pre-hospital administration of antibiotics around the time of procedure affect this?	3.57
Are pre-hospital critical care teams meeting the analgesic requirements of paediatric patients?	3.57
What is the right dose and frequency of adrenaline in cardiac arrest to improve neurologically intact survivors?	3.57
Does careful pre-hospital control of point of care PaCO ₂ via invasive arterial access sensors improve outcomes (e.g. coagulopathy, multiorgan dysfunction, cardiac output, neurological recovery, 30-day mortality) in brain injured patients?	3.57
What is the experience of relatives involved in stopping resuscitation at scene for adults in medical cardiac arrest and how can this be improved?	3.57
What are the barriers to using integrated IT systems between the pre-hospital and in-hospital phase of care?	3.56
Is ketamine infusion an effective post RSI sedative agent? Is there an alternative better agent?	3.55
Can a routine formal debrief process following complex jobs reduce the risk of staff sickness?	3.55
What anatomical/physiological injury patterns represent the greatest proportion of pre-hospital deaths and how can these be best treated in future?	3.55
In patients with or without airway/ventilation compromise in the pre-hospital setting, is pre-hospital RSI detrimental compared to hospital RSI in terms of patient survival?	3.55
For pre-hospital practitioners what is currency and competency, and how can these be measured?	3.53
What endpoints should we use when titrating to physiological parameters (e.g. blood pressure targets in trauma, head injury, mixed disease) and is variability in recorded observations predictive of worse outcomes? Are point-of care blood measurements useful (e.g. lactate, calcium, other biomarkers)?	3.53
Does videolaryngoscopy improve the first pass success rate for intubation compared to direct laryngoscopy in patients undergoing pre-hospital emergency anaesthesia, including in special groups e.g. obese patients?	3.51
Is pre-hospital paediatric trauma care managed as effectively as the adult population or do we do less for children?	3.51
How do non-medical responders (Police, Fire, etc.) feel about witnessing pre-hospital critical care interventions (RSI, thoracostomy, thoracotomy, blood transfusion, amputation, hysterotomy)? Do these cause psychological distress, if so how can the impact of this be mitigated?	3.50

Is bolus IV levetiracetam effective as a second line antiepileptic in patients with benzodiazepine refractory status epilepticus in the pre-hospital setting? (Primary outcomes of seizure control, secondary outcomes of seizure recurrence and complications including need for airway support).	3.49
Does pre-hospital regional anaesthesia improve patient outcomes and patient experience (e.g. time to analgesia/pain scores)?	3.49
Can survivable outcomes for catastrophic haemorrhage be improved by CCP led/ delivered plasma?	3.47
Which triage system leads to better patient outcomes: injury-based tool or mechanism and clinical suspicion of injury?	3.47
What are the unmet needs of adult trauma patients in the pre-hospital setting in order to improve future patient experience?	3.47
In the absence of the availability of blood products in patients at risk from death from bleeding does permissive hypotension or a crystalloid based resuscitation strategy lead to decreased mortality?	3.46
What is the optimum size and composition of a pre-hospital critical care team, and how does this impact on patient outcomes?	3.46
Can use of body-worn cameras and review of footage during pre-hospital taskings improve team debriefing, personal and institutional learning?	3.45
In patients (major trauma and post cardiac arrest) receiving pre-hospital anaesthesia which physiological values (HR, BP, EtCO ₂ , SpO ₂) are associated with good functional outcome?	3.45
How do we improve recognition by critical care teams of traumatic haemorrhage pre-hospital?	3.44
What are the geographical gaps in pre-hospital critical care provision in England and Wales?	3.44
Is the use of Pentrox for acute traumatic pain safe in the under 16s?	3.43
Is there a role for defined pre-hospital care pathways to directly bring patients for ECMO?	3.42
What does 'good' look like, from the perspective of service users and relatives of those accessing pre-hospital critical care services?	3.42
Can a dedicated follow-up support clinician improve quality of life for major trauma patients compared to those who do not receive such care?	3.42
What are the risk factors associated with paediatric PHEA?	3.41

What is the optimum C-spine immobilisation strategy for patients suffering major trauma? Do rigid collars worsen outcomes and is a more pragmatic strategy a safe option?	3.40
What is the optimal dose and route of TXA administration in bleeding patients and are there any side effects to administration (e.g. hypotension which could be confused with bleeding)?	3.40
Can the integration of critical care teams with ambulance crews, including shared basing and cross training, improve time to time-critical intervention?	3.40
Does pre-hospital partial zone 1 REBOA improve coronary perfusion and clinical outcomes in patients with severe haemorrhagic shock, irrespective of the origin of bleeding (i.e. arterial, venous, parenchymal, bony)?	3.39
Can intra-nasal ketamine confer a significant improvement in analgesic relief for patients with severe pain, compared to standard care?	3.37
Does time from 999 to arrival of critical care team with patient impact on patient-focused outcomes (e.g. mortality/morbidity)? If yes, is there an optimal time for critical care arrival and how can this be factored into mission planning (e.g. air vs road)?	3.37
Is the mental welfare of pre-hospital critical care providers more or less negatively affected than standard ambulance crews?	3.35
Deployment of critical care teams: when should a team mobilise by air versus road? (Considerations: patient outcomes, cost, night versus day flying).	3.35
What are the long-term sequelae of pre-hospital administered analgesia and sedation regimes in terms of: 1. long term pain outcomes; 2. long term psychological sequelae (including PTSD and associated conditions); 3. other patient-reported outcome measures?	3.34
What is the incidence of dysphoria associated with pre-hospital ketamine use and does routine co-administration of midazolam prevent it?	3.32
Does large bore central venous access for major haemorrhage patients improve outcomes in non-urban pre-hospital critical care services?	3.31
Can a national training programme for critical care paramedics within HEMS improve the standardisation and quality of care?	3.31
Can non-clinical dispatchers effectively improve time to PHEA in a well governed pre-hospital care team using existing triage tools and coding?	3.30
How are HEMS teams perceived by the ambulance services and what factors could be improved to ensure the patient pathway is improved?	3.30
Is REBOA superior to thoracotomy with aortic compression in blunt traumatic cardiac arrest?	3.29
Scene times, ambient temperatures and weather, exposure and warming devices - why are we still delivering cold patients to hospitals?	3.28

What do sub-specialty trained PHEM doctors do next? Do they stay in PHEM? What does a PHEM career look like? Does the training scheme work?	3.28
EtCO ₂ as a surrogate of PaCO ₂ for targeting physiological parameters: What is the correlation between PaCO ₂ and pre-hospital EtCO ₂ ? What calibrations of EtCO ₂ measurement are used across the country?	3.27
Do the patient triage destinations assigned by pre-hospital medical teams improve patient outcome in non-life threatening patients?	3.27
Do pre-hospital critical care services over-triage patients to major trauma centres?	3.27
Does administering pre-hospital antibiotics improve patient outcomes significantly?	3.26
Can frailty be assessed in older patients with trauma in the pre-hospital setting, and does it impact their outcome?	3.25
Does a critical care team deployment alter the decision of egress of patients to the nearest ED for patients of gunshot or stabbings by the ambulance crew or does it lead to a delay to definitive care when not in TCA?	3.25
Does routine core body temperature measurement in adult trauma patients undergoing endotracheal intubation, result in better avoidance of hypothermia in the pre-hospital setting?	3.23
Should we be using specific drug therapies in cardiac arrest management (e.g. naloxone in opiate induced arrest/calcium chloride in those with suspected hyperkalaemia - dialysis/renal patients)?	3.22
What are the pharmaceutical options for intranasal paediatric analgesia for non-physicians, bearing in mind the medicolegal framework surrounding controlled drugs?	3.22
What coping support mechanisms are in place locally, regionally and nationally to promote well-being in the team?	3.22
In the management of the adult pre-hospital medical cardiac arrest what is the optimal ventilation strategy (pressures/volumes/ PEEP)?	3.21
What is the best fluid warmer for pre-hospital teams?	3.21
Is it important to have a nationally-led major incident working group to develop nationally agreed responses to major/catastrophic incidents? Do we need a subgroup within AAUK to work alongside NARU?	3.20
What are the educational benefits of hospital placements (such as ITU, ED and Theatres) on the performance and development of Specialist Paramedics in Critical Care? What are the learning objectives for these placement activities and how can they be measured and evidenced?	3.20
Are on-line platforms suitable for post-incident debrief and shared learning events after critical incidents?	3.19
Do pre-hospital intravenous and intra-arterial lines increase the risk of line-associated sepsis?	3.19

Is midazolam superior to diazepam for all cause seizure termination?	3.18
What are the benefits of, employment, recruitment and retention of Critical Care Paramedics in a pre-hospital service?	3.15
Is intranasal fentanyl superior to intranasal diamorphine for the treatment of moderate to severe pain in paediatric patients?	3.15
Is the 'hateful eight' validated for the identification of haemorrhagic shock pre-hospital, and which parameters are most reliable?	3.14
Is intravenous fentanyl superior to intravenous morphine in the management of moderate to severe pain in the PH setting?	3.13
What factors predict subsequent diagnosis of a causative coronary artery lesion disease in shockable OOHCA? (i.e. risk factors, history, ECG changes in ROSC to guide triage decisions to PPCI or elsewhere)	3.12
In a matched cohort of [trauma or medical] patients where a pre-hospital critical care team [all teams with same capabilities] arrives at a patient does the length of scene time (arrival to mobile in vehicle) impact on patient focused outcomes (e.g. mortality) and is there a group of patients in whom scene time is not related to patient focused outcomes (e.g. mortality)?	3.11
How is it most appropriate for consent to participate in clinical trials to be communicated and gained from patients receiving emergency care?	3.11
For patients in cardiac arrest secondary to hypothermia and/or drowning does an integrated patient care pathway from pre-hospital to ICU reduce 30-day mortality and improve functional outcomes?	3.08
In PHEA, how does the haemodynamic response compare with Ketamine/Fentanyl/Rocuronium induction vs Midazolam/Fentanyl/Rocuronium in the severe polytrauma patient?	3.08
Can critical care interventions such as drug assisted intubation, thoracostomy and blood product administration be safely performed by autonomous non-physicians? What level of education and experience would be required to allow this to safely happen and how would these interventions be governed?	3.08
Is it possible to quantify and assess a pre-hospital care physician's non-technical skills?	3.08
Can paramedics treat more cardiac arrests at scene and terminate earlier without detriment to that patient whilst benefiting other patients by freeing resources?	3.07
How accurate is pad placement for defibrillation in cardiac arrest?	3.07
When used at analgesic & sedative doses, does ketamine as an infusion provide less side effects than as a bolus?	3.07
Does assistant + CCP led interventions improve quality & timing of interventions on scene (compared to solo CCP RRVs)?	3.05

What is the current scope of practice and future direction of advanced paramedic practice in pre-hospital critical care teams?	3.05
Which pre-hospital services patients would benefit from paramedic delivered pre-hospital critical care?	3.04
Does the pre-hospital administration of dobutamine, levosimendin or adrenaline improve clinical outcomes (haemodynamics, cardiac output, multiorgan dysfunction, 30-day mortality) in patients with cardiogenic failure secondary to traumatic brain injury?	3.03
What adjuncts are available to optimise metabolic resuscitation in the pre-hospital phase for exsanguinating or high ISS patients? (e.g. ragadenoson/high-dose insulin/steroids etc)	3.03
Does the use of metaraminol at induction of PHEA reduce the incidence of hypotension?	3.03
Can a structured training program in "Non-Technical Skills" be demonstrated to reduce on scene times?	3.01
Can artificial intelligence be used to establish individualised blood pressure treatment goals in the pre-hospital setting for patients with TBI?	3.00
Is handover to an ED trauma team safer than retention of the patient into the hospital phase and then transition to imaging and/or theatre led by the pre-hospital care team?	3.00
Do personality types make an impact on team dynamics and the effectiveness of the pre-hospital care team?	2.99
How effective is the Lucas device compared to manual chest compressions in pre-hospital cardiac arrest management?	2.97
What is the incidence of unrecognised oesophageal intubation by Paramedics, Critical Care Paramedics, and Doctor/Paramedic HEMS team?	2.97
Does USS guided RUSH examination improve targeted reversible cause assessment in CCP led cardiac arrest management?	2.97
What does CCP-led service provision look like across the country? What lessons can be learnt to develop similar service provision to benefit local and regional differences in geography and demographics?	2.97
How can pre-hospital care be best tailored to meet the needs of local patient groups?	2.97
How should the cold chain for blood products be best managed?	2.96
What is the environmental impact of pre-hospital critical care - can it be reduced?	2.96

Does the base specialty of a PHEM doctor affect their first pass intubation success and other outcomes in the PHEM environment?	2.92
What are the barriers to paramedic progression in pre-hospital care?	2.91
Penthrox use: what is the national availability, what are the barriers to its use and is it safe to use during patient transfer via land and air?	2.91
Does remote access to on-scene monitoring (including video streaming) for the receiving ED team help to improve clinical outcomes?	2.88
Do pre-hospital care teams have a responsibility to provide immediate psychological support to bystanders at incidents and how would/could they do this to minimise harm?	2.86
Pre-hospital critical care is not equitably administered to females or older patients (compared to younger males). Why does this bias exist (when identifiable) and how may it be overcome? Which other at risk groups do not receive equitable care?	2.85
Would a pre-hospital lactate reading in the context of a traumatically injured patient assist in the decision to activate major haemorrhage protocols?	2.84
Should critical care paramedics working in the UK, be recognised as a speciality profession by the HCPC and have specific annotation to their registration?	2.82
Should pre-hospital clinicians use ultrasound FAST scans to triage?	2.82
Does the routine administration of antiemetics impact rate of air sickness in concussed/head-injured patients?	2.78
Is pre-hospital plasmin-TEG feasible in the pre-hospital arena to identify patients requiring massive transfusion in trauma?	2.77
What role do Air Ambulances have in the development of advanced practice roles for paramedics?	2.77
Should Penthrox become the drug of choice for simple painful procedures, replacing ketamine, and is Entonox then obsolete?	2.77
What is the most commonly used leadership model in the pre-hospital setting?	2.75
Are out of hospital cardiac arrest patients becoming too cold by inadvertent exposure whilst providing advanced life support?	2.75
Is hyperangulated videolaryngoscopy better than direct videolaryngoscopy or standard videolaryngoscopy in the pre-hospital environment?	2.75

In trained level 8 teams, how often does 'can't intubate can't oxygenate' (CICO) occur? How often is Plan D used (i.e. surgical airway)?	2.73
Is USS needed for safe subclavian access in the pre-hospital environment?	2.69
Does the perception of risk alter the appetite for employers to enable to full clinical potential of critical care paramedics?	2.67
How do first pass intubation rates on the floor vs on the stretcher compare?	2.67
What differences exist in education, training pathways, skills and knowledge between established overseas critical care paramedic and doctor-paramedic pre-hospital critical care teams (for example MICA in Victoria, Australia) and their UK counterparts?	2.67
For pre-hospital clinicians does the use of personal issue aviation helmets with additional hearing protection reduce the hearing loss associated with pre-hospital flights compared to "pooled" helmets?	2.65
In adults which upper limb splintage gives the best analgesic effect and long term outcome?	2.64
Does FASTER outperform FAST for the identification of acute stroke in the pre-hospital setting?	2.60
Is there a role for active cooling in any critical care scenario except for heat stroke and malignant serotonin syndrome?	2.59
Are external abdominal tourniquets useful in exsanguinating abdominal/pelvic haemorrhage?	2.47
What is pre-hospital critical care, what is enhanced care, is there a difference and does it matter?	2.45
Is it safe to wake up and discharge patients at scene after pre-hospital sedation?	2.40
Which position is better for out of hospital obstetric patients: Left or right lateral tilt?	2.24
Does conveying relatives to hospital with critically ill patients increase the chances of the ambulance crew getting COVID? Qualitative study of experience of patient and relative when relative is conveyed versus not.	1.93

Supplementary file 3: Questions scored in round 3 with their mean score

	Mean score
Medical cardiac arrest	
To which out of hospital cardiac arrest patients should critical care teams be dispatched?	7.3
Which out of hospital cardiac arrest patients do not benefit from transfer to a PCI centre?	4.4
How do we identify out of hospital cardiac arrest patients to whom critical care team should be dispatched from information received during the call?	6.8
In patients with medical out of hospital cardiac arrest attended by pre-hospital critical care teams, which interventions beyond ALS improve outcomes?	7.7
Trauma including TCA	
What is the role of thoracotomy in blunt trauma and in exsanguinating cardiac arrest?	5.9
What is the morbidity from pre-hospital thoracostomy in adult patients?	5.8
Which patients with penetrating trauma benefit from advanced on-scene care?	5.7
What clinical features and interventions are associated with survival to hospital discharge in patients with traumatic cardiac arrest?	6.3

Supplementary file 3: Questions scored in round 3 with their mean score

PHEA/airway/sedation/analgesia	
In patients with ROSC following OOHCA, does PHEA improve patient outcomes?	6.7
In trauma patients undergoing pre-hospital RSI, is there an impact on patient focussed outcome (e.g. mortality) correlated with 999 call time to time of RSI delivery?	6.2
Which is the best PHEA drug dosing regime to optimise first pass success and avoid drug-induced complications (e.g. hypotension) in post ROSC, head injury and polytrauma patients?	3.9
Neurological emergencies	
What is the benefit offered to head injured patients by critical care teams?	6.6
In patients with severe traumatic brain injury, does pre-hospital administration of osmotic agents result in improved survival or neurological outcome, and what is the optimal dose?	6.8
Does pre-hospital administration of FFP or whole blood improve short and longer-term outcomes?	5.5
Does pre-hospital reversal of anticoagulation improve outcomes in patients with traumatic brain injury?	6.4
Does invasive arterial blood pressure measurement improve patient care and outcomes without adversely affecting scene times?	4.9
Is PHEA superior to sedation in the management of agitated mild-moderate TBI?	4.2
Major haemorrhage/blood products	

Supplementary file 3: Questions scored in round 3 with their mean score

What is the optimal dose of calcium in major traumatic haemorrhage and does pre-hospital administration improve patient outcomes?	6.1
REBOA: does it improve survival in major trauma patients with major internal haemorrhage, and is it feasible in less heavily urbanised settings?	4.5
What method of volume resuscitation improves outcomes in injured patients with haemorrhagic shock?	7.5
What method of volume resuscitation improves outcomes in patients with traumatic brain injury?	7.3
Triage	
Which patients with frailty should be triaged to a major trauma centre?	6.1
Would the use of digital health technology improve dispatch of enhanced care teams to critically unwell patients?	7.3
Does transfer to a neurological centre for consideration of time critical thrombectomy improve outcome in patients suffering a suspected stroke in the pre-hospital setting?	6.5
Dispatch	
Is pre-hospital critical care clinician dispatch superior to standard ambulance service dispatch?	6.1
How can critical care dispatch be improved to quickly and accurately dispatch critical care teams to patients?	6.9
Impact/benefit of pre-hospital critical care teams	
What other benefits do pre-hospital critical care teams bring, other than medical outcomes?	5.5

Supplementary file 3: Questions scored in round 3 with their mean score

Is physician led pre-hospital care cost effective?	3.8
Well-being and mental health	
How can we identify risks to well-being and protect the mental health of pre-hospital critical care providers?	7.3
What is the effect of stress on performance of pre-hospital clinicians exposed to a recurring case load of critically injured patients?	4.7
Other	
What is the role of POCUS in pre-hospital critical care in improving patient outcomes?	6.1
Is there any benefit to patients by using pre-hospital point of care testing	6.5
In cases of pre-hospital death, what strategies can be employed by pre-hospital practitioners to improve the experience for friends and family who receive bad news in the acute setting?	6.0
What pre-hospital simulation strategy is optimal to improve patient, clinician and procedural outcomes?	6.0

Questions scored from 1 to 9 with 1 indicating should not be studied, and 9 indicating the question is of highest priority. Questions scoring 6.0 or greater i.e. of slightly high priority or more were brought forward to the ranking stage.