THE **EXIT** PROJECT

THE ROAD SAFETY TRUST
Making Roads Safer

EXIT
POST COLLISION RESPONSE RESEARCH & TRANSLATION

THE EXIT PROJECT

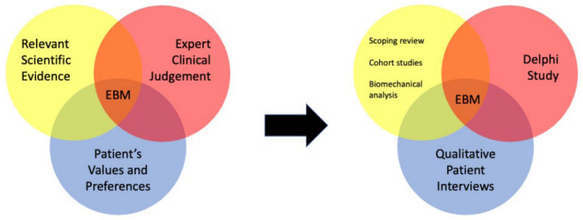
TABLE OF CONTENTS

EXECUTIVE SUMMARY

Road traffic collisions are a leading cause of death and injury. Following a road traffic collision many patients will remain trapped in their vehicle. Extrication is the process by which injured or potentially injured people are removed from their vehicle by the rescue services.

Rescue service training focuses on the absolute movement minimisation of potentially injured patients' spine and has developed extrication techniques which prioritise this approach. Unfortunately, these techniques take significant amounts of time (30 minutes plus) which delays access to potentially lifesaving treatments for injuries.

In this Road Safety Trust funded project, the EXIT team reconsider extrication, uses the lens of evidence-based medicine (EBM). The principles of EBM; consideration of the relevant scientific evidence, patient values and preferences and expert clinical judgement are used as a framework for this project.



Aims:

The primary aim of this work was to develop evidence-based guidance for the extrication of patients trapped in motor vehicles. This was achieved through:

- Describing the injury patterns, morbidity and mortality of patients involved in MVCs (trapped and not trapped).
- Analysing the movement associated with and the time taken to deliver across a variety of extrication methods.
- Determining the perceptions of patients who have undergone vehicle extrication and describe their experiences of extrication.
- Developing consensus-based guidelines for extrication.

Methods:

In order the achieve this aim, ten studies were planned and delivered:

Study 1 is a scoping review using systematic methodology to consider the literature in relation to extrication and related topics from medical, rescue and grey sources. Evidence gaps are highlighted and discussed.

Studies 2,3 and **4** are retrospective cohort studies based on the United Kingdom, national trauma registry. These studies consider the rate of spinal injuries and time-dependent injuries in trapped and not trapped patients. The effect of biological sex (study 3) and ageing (study 4) are analysed and reported separately. Multivariate logistical regression techniques are used to compare the groups and identify and report the excess mortality associated with entrapment.

The relevant scientific evidence section of the EBM framework is completed with four biomechanical studies. Each of these studies are powered using a minimally clinical important difference in cervical spine movement and utilise healthy volunteers across a range of ages and body mass indexes. Inertial motion units are used to capture movements at the cervical and lumbar spine across a range of extrication types.

Study 9 considers patient values and preferences. Semi-structured qualitative interviews are used to report the patient experience of extrication.

Finally in **study 10**, Delphi consensus techniques were used to consider statements related to extrication derived from studies 1-9. Stakeholder organisations nominated subject matter experts for participation. Following the Delphi process, stakeholders agreed a set of principles based on the consensus statements on which future guidance should be based.

Results

The scoping review demonstrated that the link between reported injuries and deaths associated with MVCs and the evolution of extrication techniques is tenuous.

Study 2 demonstrated that trapped patients have a higher mortality (8.9% vs 5.0%, $p < 0.001$) and more significantly injured (trapped injury severity score (ISS) 18 (interquartile range (IQR) 10–29) vs not trapped 13 (IQR 9–22). The rate of spinal injuries that are likely to influence extrication technique is extremely low (0.7%). In Study 3, female patients are more likely to be trapped than males (female patients (F) 15.8%, male patients (M) 9.4%; p<0.0001). Female patients have a higher incidence of spinal (F 359 (12.5%), M 485 (9.9%); p=0.001) and pelvic (F 420 (14.6%), M 475 (9.7%); p<0.0001) injuries. Male patients have a higher incidence of head (M 1318 (27.0%), F 578 (20.1%)), chest (M 2721 (55.8%), F 1438 (49.9%) and limb injuries M 1744 (35.8%), F 778 (27.0%) all p<0.0001. Study 4 demonstrated that older patients have an excess mortality associated with entrapment (adjusted odds ratio (OR) trapped 30.2 (19.8–46), not trapped 24.2 (20.1–29.2). Older trapped patients have increased but still low rates of spinal injury (80+, 6.6%, mean 6.8%, p=0.345). Injured older patients have a similar potential for self-extrication as younger people (80+, 44.4%, mean 41.4%).

In the biomechanical studies (studies 5-8) when volunteers self-extricated a collar was found to reduce movement at the cervical spine (collar 6.9mm, no-collar 28.3mm, $p < 0.001$). Self-extrication produced the smallest anterior-posterior movement at the cervical spine (2.6mm), with rapid extrication producing the largest (6.21mm). The differences between self-extrication and all other methods were significant ($p < 0.001$), small non-significant differences existed between roof removal, b-post rip and rapid removal.

Study 9 identified that the main theme across all participants in the patient interviews was the importance of communication; successful communication resulted in a sense of wellbeing and where communication failures occurred this led to distress. The data generated three key sub-themes; 'on-scene communication', 'physical needs' and 'emotional needs'. Specific practices were identified that were of use to patients during entrapment and extrication.

In study 10, consensus was reached on 91 statements (89 agree, 2 disagree) covering a broad range of domains related to: extrication terminology, extrication goals and approach, self-extrication, disentanglement, clinical care, immobilisation, patient-focused extrication, emergency services call and triage, and audit and research standards.

> ***"Successful communication resulted in a sense of wellbeing and where communication failures occurred this led to distress.***

Conclusions:

This project considers current extrication techniques through the 'lens' of EBM. By systematically applying EBM principles to this focused area of practice the current approach to extrication is successfully challenged and new, original evidence-based guidance for clinicians and rescuers is offered. The adoption of this fresh approach will reduce extrication times and may reduce morbidity and mortality.

The paradigm of absolute movement minimisation is without a justifiable evidence base; nonetheless it has been historically championed and adopted. Movement minimisation has remained unchallenged for at least four decades, during which time the excess death associated with entrapment has not been investigated nor the paradigm reconsidered.

This project adds new knowledge and understanding through retrospective cohort studies and biomechanical work to fill the gaps in the 'relevant scientific evidence' component of the EBM triad. These studies demonstrate the low rate of spinal cord injury, the presence of other time dependent injuries and the failure of current, promoted extrication methods to minimise movements.

The patient perspective is now understood, the importance of communication in this environment is reinforced and patient values and preferences are incorporated into new principles that will improve their experience of entrapment and extrication.

Expert clinical and rescuer judgement has facilitated the development of consensus statements. The synthesis of these statements in collaboration with national level stakeholders into new principles will have significant implications for clinicians, rescuers, and patients.
The impact following the adoption of the principles resulting from this project on extrication type, time and patient outcomes will be monitored through longitudinal analysis of national level data sets.

Impact:

These principles have been adopted by national level stakeholders in the UK and are being incorporated into national clinical and operational guidance.

This project has significant implications for patients, clinicians, and rescue teams. Rescue times will be reduced, resource will be more effectively utilised (and therefore available for other patients) and patient experience will be improved.

- An understanding of patient injuries and the differences that occur with age and gender will have implications for car design and clinical and rescue responders.

- The biomechanical data will inform and lead to changes in established national and international extrication practice. Reduced extrication times will lead to decreased time to life-saving treatment.

- Understanding the patient experience will lead to a patient centred extrication experience and reduce the psychological impact of entrapment.

- The cohesive, coherent, evidence-based principles will provide a framework for clinical and rescue practitioners to work together to reduce the morbidity and mortality associated with motor vehicle collisions.

- This project contributes towards and is a significant step forward in achieving the Road Safety Trust's vision of zero deaths and serious injuries on UK roads.

> ***"This project has significant implications for patients, clinicians, and rescue teams. Rescue times will be reduced, resource will be more effectively utilised and patient experience will be improved.***

EVIDENCE BASED **GUIDANCE**

- Operational and clinical team members should work together to develop a bespoke patient centred extrication plan with the primary focus of minimising entrapment time

- Independent of actual or suspected injuries, patients should be handled gently. A focus on absolute movement minimisation is not justified

- When clinicians are not available, FRSs should where necessary assess patients, deliver clinical care and make and enact extrication plans (including self-extrication)[1]

- Self-extrication or minimally assisted extrication should be the standard 'first line' extrication for all patients who do not have contraindications, which are:
  - An inability to understand or follow instructions,
  - Injuries or baseline function that prevents standing on at least one leg, (specific injuries include: unstable pelvic fracture, impalement, bilateral leg fracture)

- All patients with evidence of injury should be considered time-dependent and their entrapment time should be minimised

- Incidents where a patient may require disentanglement are complex and associated with a high morbidity and mortality. A senior FRS and clinical response should attend such instances

- **Clinical care during entrapment:**
  - Can be delivered by FRS or clinical services
  - Should be limited to necessary critical interventions to expedite safe extrication
  - Rescuers should be aware that clinical observations may prolong entrapment time and as such should be kept to the minimum
  - FRS and clinical personnel should be aware of the physical and observable signs of patient deterioration and if identified should make this known to the responsible clinician

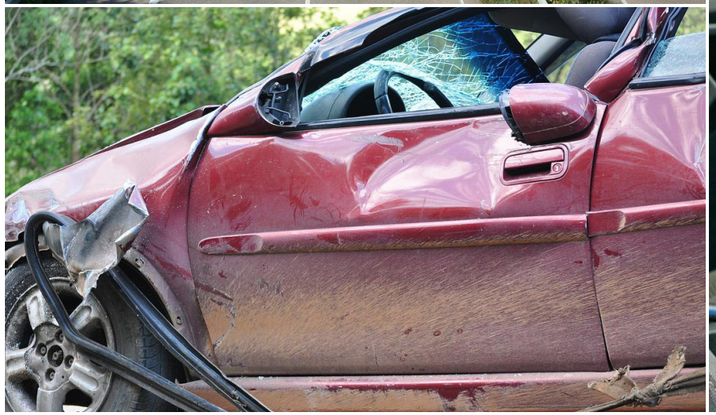
- Multi-professional datasets should be developed with patient and public engagement and should include entrapment status, entrapment time, injuries, extrication approach, clinical care

- **Immobilisation:**
  - Longboards are an extrication device and should not be used beyond the extrication phase
  - Kendrick Extrication Devices prolong extrication time and their use should be minimised
  - Pelvic slings should not be applied to patients until they have been extricated
  - Cervical collars should only be used following assessment and should be loosened or removed following extrication

- **Patient focused extrication:**
  - Build a connection with patients, explain actions, and use their name
  - Where appropriate, reassure patients as to the safety of their co-occupants and others involved in the incident (including animals)
  - Provide an 'extrication buddy'
  - Allow communication with family members or other close contacts
  - Rescue teams should not publish extrication related imagery to social media or other outlets
  - Minimise the ability of the public to view the accident, take photographs or record videos. Provide education to this effect

- **On initial call to Emergency Services**
  - Attempt to clarify entrapment status
  - Attempt to identify patients who require disentanglement (and dispatch an appropriate priority senior[2] response)
  - A standard multi-agency MVC trauma message should be developed to ensure the correct resources are deployed
  - Minimise the ability of the public to view the accident, take photographs or record videos. Provide education to this effect

- **Agreed nomenclature for categories of patient:**
  - Not injured
  - Minor injuries (evidence of energy transfer but no evidence of time-dependent injury)
  - Major injury (currently stable but should be assumed to be time-dependent)
  - Time critical injured (Time critical due to injury; use fastest route of extrication)
  - Time critical hazard (e.g. secondary to fire or other hazard)



WHAT IS THE **EXIT PROJECT?**

Tim Nutbeam and Rob Fenwick began the EXIT project in 2007 when they worked together with the West Midlands Care Team (a prehospital team providing critical care at the roadside). Their personal experience of road traffic collisions and their tragic consequences led to the formation of the EXIT project.

In 2017 Mike Dayson was seconded from Cleveland Fire Brigade to partner with the EXIT project to support the delivery of this work stream.

Working with firefighters, fire services, methodologists, experts in biomechanics, automotive engineers, medics, air ambulance teams, charities, public and statutory bodies and statisticians, the EXIT project has delivered and continues to deliver new findings that can be translated to a direct impact on patient outcomes.

INTRODUCTION: **WHY WAS THE EXIT PROJECT NEEDED?**

Motor vehicle collisions are a leading cause of death throughout the world: the World Health Organization (WHO) estimated that MVCs contribute to 1.3 million deaths and 20-50 million injuries globally per annum.

Following a collision some people will remain in their vehicles. Patients who remain in their vehicles and cannot leave without assistance are considered ‘trapped’. Patients can be trapped due to:

i) Their injuries preventing them leaving the vehicle (physical restriction and/or pain)

ii) The transfer of energy to the vehicle causing mechanical or structural changes preventing them getting out

iii) The patient, bystander or health care provider having concerns in relation to exacerbating a potential injury (particularly spinal) injury preventing movement

Many of these patients will undergo ‘extrication’, a process by which rescue services will facilitate their removal from a vehicle.

Rescue service extraction techniques have evolved since the 1950's. This evolution has been facilitated by the production of faster, more powerful cutting and lifting equipment. However, throughout the last 70 years there has been no change in the fundamental tenet of extrication: that of absolute 'movement minimisation'; the adoption of strategies, techniques and approaches that conceptually lead to minimal spinal movement for the patient being extricated. Rescue service guidelines and firefighter manuals inform us that the purpose of movement minimisation is to minimise the frequency and severity of secondary spinal cord injury (see Box).

closer examination of the movement minimisation concept raises the following considerations:

- Movement minimisation takes time; the longer an extrication takes, the longer a patient will remain trapped and the timeline between injury and clinical intervention will get longer. This may result in excess death and injury.

- The utility of current extrication techniques to deliver movement minimisation is unknown, with recent analysis challenging the assumption that the rescue techniques achieve their central purpose.

- The origins of movement minimisation as a concept and the justification for its adoption as a central tenet of extrication practice are unclear. Importantly there is no evidence of appropriate consideration of available data and this data being used to inform the current approach.

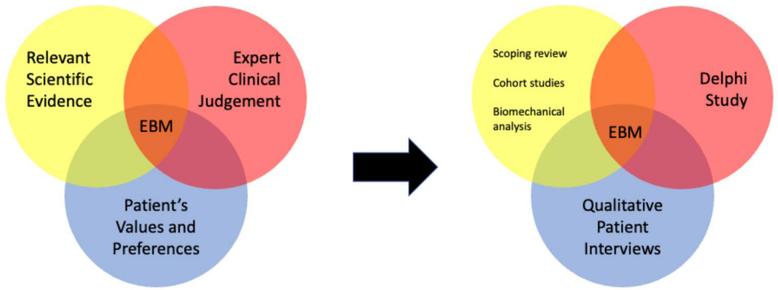
In summary, this project was needed because patients who are trapped following an accident may do worse than their not trapped counterparts; rescue services have been utilising extrication techniques which have not been established from a reputable evidence base, are following a central tenet which may be erroneous and the effectiveness of such techniques to achieve their desired aims were unclear.

What we did

This project utilised the principles of evidence-based medicine to explore the status quo of extrication, identify and fill evidence gaps and conclude with an evidence-based alternative to the current situation.

This research utilises the concept of Evidenced Based Medicine (EBM) as a framework for identifying research priorities and addressing knowledge gaps. This research and its relation to EBM can be summarised in the figure below.

EVIDENCE BASED MEDICINE AND STUDIES CONTRIBUTING TO THIS RESEARCH



> ***"The Fire and Rescue Service has killed more people than it has saved through the mishandling of the cervical spine***

This research consists of six sections. The sections are introduced below.

- **Section 1: Evidence Review:**

  A scoping review of the literature in relation to extrication.

- **Section 2: Retrospective Cohort Studies**

  Section 2 consists of three original published retrospective cohort studies which identifies, quantifies and reports differences in outcomes and injury patterns between trapped and not trapped patients.

- **Section 3: Biomechanical Studies**

  Section 3 consists of four original biomechanical studies. Each of the four biomechanical studies assess the utility of established extrication techniques to deliver movement minimisation. These used a range of healthy volunteers, and the full range of extrication techniques are considered and compared.

- **Section 4: Patient Values and Preferences**

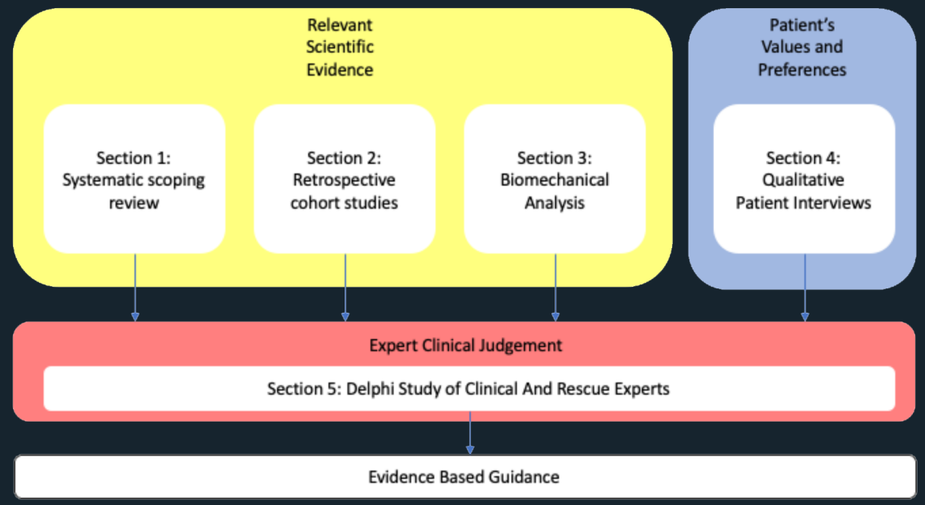
  This section considers the patient experience of extrication. This section ensures that patient values and preferences are considered within this EBM approach to the development of new extrication guidance.

- **Section 5: Expert Clinical Judgement**

  In this section, consensus finding techniques are utilised with a multidisciplinary group of prehospital clinical and rescue professionals to translate the available data to practical evidence-based guidance.

- **Section 6: Evidence based extrication and next steps**

  We make recommendations on an evidence-based approach to extrication of patients trapped following an MVC, and discuss some of the challenges to implementation and areas for further work identified and prioritised.



SECTION 1:
EVIDENCE REVIEW

What we did:

We conducted a systematic scoping review of the literature. This means that we looked at the literature in an organised and methodical way considering scientific articles, manuals, textbooks, scientific meeting notes and the "grey" unpublished literature across the disciplines of medicine, vehicle design, road safety, rescue and further afield.

We looked specifically for sources that helped with the following research questions:

- What is the (historical and scientific) context for current extrication approaches as delivered by rescue services?

- What injuries are sustained by patients who are trapped in their motor vehicles and how does this influence extrication practice?

- What are the needs of patients who are trapped following an MVC, how are these met and following extrication where is their care best delivered?

What we found:

We reviewed over 7,000 individual sources, discarded those that were irrelevant and summarised the findings by categories which were established from the evidence available.

These categories were: Extrication training and principles, Injuries, Immobilisation, Care during entrapment, Clinical response type, Vehicle deformity, intrusion, entrapment and extrication time, Extrication specific papers.

We found that despite there being a large number of sources to review there was little high-quality evidence to help with our research question. Considering the large number of patients whose clinical care, timeline to hospital and patient experience may have been adversely affected by their trapped status, there is little focused literature which allows an understanding of key areas of this area of practice which would enable development of evidence-based extrication guidance.

Areas where data is not available or not sufficient includes the difference in injury patterns between trapped and not trapped patients, the difference in outcome between trapped and not trapped patients, the efficacy of extrication techniques to minimise movement and their clinical or outcome implications.

There is not currently evidence that enables us to understand 'patient values and preferences'; we do not have data which supports an understanding of the patient experience of extrication and how this may be improved. Despite a large number of case reports and papers from single or small groups of experts there is no coherent, consensus 'expert clinical judgement' which bridges the rescuer-clinician divide in the current literature. The absence of multidisciplinary guidance based on the best available evidence demonstrates another important gap in relation to this important patient group.

What this means:

There is a paucity of published evidence to support the current approach to extrication of entrapped patients following a collision. Focused studies identifying in detail the injures and their sequelae associated with entrapment, the biomechanics of current techniques and ensuring that the patient perspective is captured will enable the development of much needed evidence based multidisciplinary guidance.

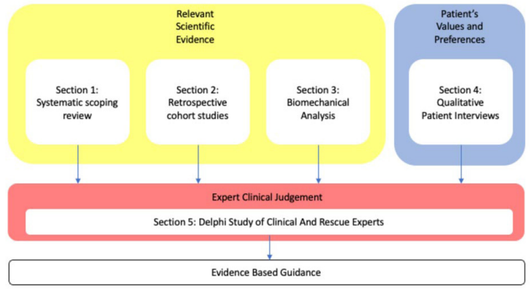
In summary:

We looked for the evidence to support current extrication techniques and couldn't find any! The next sections of the EXIT project look to "fill in the gaps" by the generation of new high-quality evidence.

Box: **What does p <0.001 mean**

When performing a scientific comparison between groups we often use a "p-value" or probability of the result occurring by chance . The lower the p value the more likely the result is "statistically significant" (i.e. due to the intervention and not due to random chance). A p value of <0.001 is considered highly significant and indicates that the findings would only have occurred by chance alone fewer than one time in 1,000.

SECTION 2:
RETROSPECTIVE COHORT STUDIES



In this section we present three papers which consider the injures and outcomes of patients injured in motor vehicle collisions. We pay particular attention to the difference between trapped and non-trapped patients and go on to consider the effect of patient sex and age on injuries, outcomes and trapped status.

In each of these papers we rely on data from the Trauma Audit and Research Network (TARN). This national level database (the largest trauma database in Europe) collects, analyses and reports high quality data for injured patients in England and Wales.

Paper: A comparison of the demographics, injury patterns and outcome data for patients injured in motor vehicle collisions who are trapped compared to those patients who are not trapped

Reference: Nutbeam T, Fenwick R, Smith JE, Bouamra O, Wallis L, Stassen W. A comparison of the demographics, injury patterns and outcome data for patients injured in motor vehicle collisions who are trapped compared to those patients who are not trapped. Scand J Trauma Resusc Emerg Medicine 29, 17 (2021).

https://sjtrem.biomedcentral.com/articles/10.1186/s13049-020-00818-6

What we did:

We considered the outcomes of 426,135 patients injured in England between 2012 and 2018. We focused on 63,625 patients injured in motor vehicle collisions and analysed the injuries and outcomes of the patients who were trapped and those that weren't.

What we found:

We identified 6983 trapped and 56,642 not trapped patients. Trapped patients had more injuries and a higher mortality (8.9% vs 5.0%, $p < 0.001$). Trapped patients had more deranged physiology with lower blood pressures, lower oxygen saturations and lower conscious level (all $p < 0.001$). Trapped patients had more significant injuries of the head chest, abdomen and spine (all $p < 0.001$) and an increased rate of pelvic injures with significant blood loss, blood loss from other areas or tension pneumothorax (all $p < 0.001$).

Importantly, spinal cord injuries were rare (0.71% of all extrications) and frequently (in patients with a spinal cord injury) there was another severe and potentially time dependent injury/ injuries.

What this means:

Trapped patients are more likely to die than those who are not trapped. The frequency of spinal cord injuries is low, accounting for < 0.7% of all patients extricated. Patients who are trapped are more likely to have time-critical injuries requiring intervention. Extrication takes time and when considering the frequency, type and severity of injuries reported here, the benefit of movement minimisation (the current extrication technique) may be outweighed by the additional time taken. Improved extrication strategies should be developed which are evidence-based and allow for the rapid management of other life-threatening injuries.

In summary:

Trapped people are more injured and more likely to die. Prolonged extrication techniques based on movement minimisation are perhaps not justified given the low rate of spinal cord injury and the high rate of other injuries.

Paper: Sex-disaggregated analysis of the injury patterns, outcome data and trapped status of major trauma patients injured in motor vehicle collisions: a prespecified analysis of the UK trauma registry (TARN).

Reference: Nutbeam T, Weekes L, Heidari S, Fenwick R, Bouamra O, Smith JE, Stassen W et al. Sex-disaggregated analysis of the injury patterns, outcome data and trapped status of major trauma patients injured in motor vehicle collisions: a prespecified analysis of the UK trauma registry (TARN). BMJ Open 2022;0:e061076. doi:10.1136/ bmjopen-2022-061076

https://bmjopen.bmj.com/content/12/5/e061076

What we did:

We considered the outcomes of 450,357 patients injured in England between 2012 and 2019. We focused on 70,027 patients injured in motor vehicle collisions. We analysed the injuries and outcomes of males and females by trapped status and reported these.

What we found:

Female patients were more frequently trapped than male patients. Female patients were trapped 15.8% of the time compared to male patients being trapped 9.4% of the time. Trapped male patients more frequently suffered head, face, chest and limb injuries. Female patients had more injuries to the pelvis and spine.

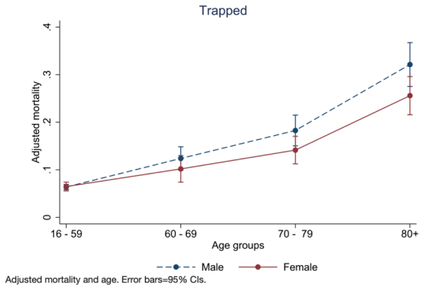


Figure 2 Adjusted mortality and age. Error bars=95% CIs.

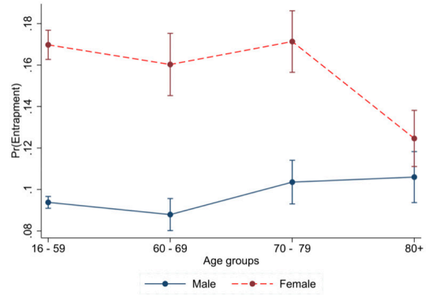


Figure 3 Probability of entrapment and age. Error bars=95% CIs.

What this means:

There are significant differences between female and male patients in the frequency at which patients are trapped and the injuries these patients sustain. This data may help vehicle manufacturers, road safety organisations and emergency services to tailor responses with the aim of equitable outcomes by targeting equal performance of safety measures and reducing excessive risk to one sex or gender.

In summary:

Males and females have different injuries. Women are much more likely to be trapped. Extrication techniques are like to be equally applicable to male and female patients.

Paper: Do entrapment, injuries, outcomes and potential for self-extrication vary with age?

Reference: Nutbeam T, Kehoe A, Fenwick R, Smith JE, Bouamra O, Wallis L, Stassen W. Do entrapment, injuries, outcomes and potential for self-extrication vary with age? A pre-specified analysis of the UK trauma registry (TARN). Scand J Trauma Resusc Emerg Medicine 30, 14 (2022).

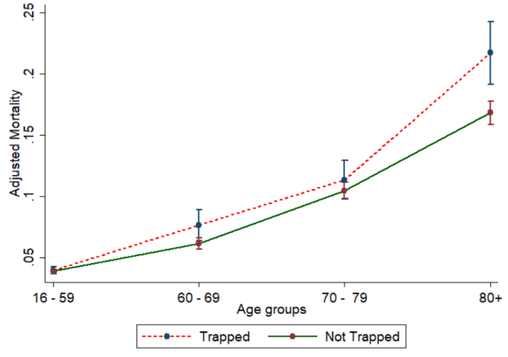
https://sjtrem.biomedcentral.com/articles/10.1186/s13049-020-00818-6

What we did:

We analysed the injures and outcomes of 70,027 patients injured in motor vehicle collisions. We compared the age groups: 16-59, 60-69, 70-79 and 80+ years. We used statistical techniques to examine any interaction between age, trapped status and death. We used expert consensus to define which injuries and physiology would prevent self-extrication and report the frequency of these factors by age category.

What we found:

Older patients were more likely to be trapped and to die following a motor vehicle collision. Head, abdominal and limb injuries were more common in the young with chest and spinal injuries being more common in older patients. No significant differences were found between the age groups in relation to ability to self-extricate.



What this means:

Patients over the age of 80 are more likely to die when trapped following a motor vehicle collision. Older patients are more likely to have chest and spinal injuries than younger patients - however, the overall rate of spinal injuries remains low across all age groups. Older patients are no more likely to have injuries that would hinder self-extrication than younger patients.

Self-extrication should be considered the primary route of egress for patients of all ages apart from where it is clearly impracticable or unachievable. For those patients who cannot self-extricate a minimally invasive extrication approach should be employed to minimise entrapment time.

In summary:

Older people are more likely to die. Differences in injuries are not likely to affect extrication strategy. Self-extrication should be considered and is likely to be viable in a vast majority of cases.

What we have learnt from Section 2:

- Trapped patients have more injuries and are more likely to die

- The rate of spinal cord injuries (around which extrication techniques are based) is low (0.7%).

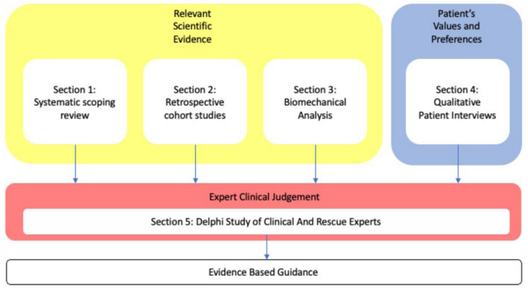
- Female patients are more likely to be trapped than males. Female patients have a higher incidence of spinal and pelvic injuries. Male patients have a higher incidence of face head, chest and abdominal injuries.

- Older people have an excess mortality associated with entrapment.

- Older trapped people have increased but still low rates of spinal injury.

- Older people have a similar potential for self-extrication as younger people.

SECTION 3:
BIOMECHANICAL ANALYSIS



In this section we use biomechanical techniques to study established extrication techniques which are currently used in rescue practice. By understanding the movements (particularly) at the spine associated with these techniques we can consider if they are achieving their intended objectives of movement mitigation.

Each of the four studies have similar methodology; applied to a particular area of extrication practice.

The common features of all the studies are that:

- Inertial motion units (IMUs) are used to capture movement data from people who either removed themselves from vehicles or were extricated using existing methods. Each IMU contains three orthogonal linear accelerometers, three orthogonal rate gyroscopes and three orthogonal magnetometers. By attaching inertial measurement unit (IMU) sensors to each of the major segments of the body movements can be recorded and reported. In these studies, we focused on movements at the cervical and lumbar spine. The anatomy of the thoracic spine means that it is essentially "fixed"; pilot work demonstrated that recording data from this area did not add value to the study.

- Healthy volunteers were recruited to participate. These volunteers all gave their time freely, went through a formal consent process prior to participation, did not have existing spinal problems and did not have existing knowledge of extrication.

- All of the studies are "powered". This is a scientific term to indicate that the primary outcome (movement) and its variation were derived from prior/pilot work and then the appropriate number of extrications were calculated from this and performed to ensure that there were sufficient cases to ensure scientific rigour in identifying any differences between the techniques.

- We attempted to replicate "real life" extrications as much as we could. We used a variety of rescuers, volunteers and, where required, vehicles to make the results as pragmatic as possible.

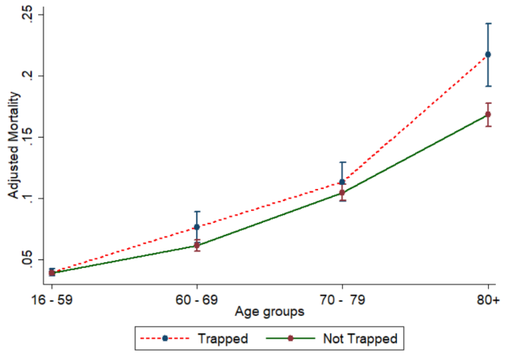
Biomechanical study 1: Nutbeam, T. Fenwick R, May B, Stassen W, Smith JE, Wallis L, Dayson M, Shippen J. The role of cervical collars and verbal instructions in minimising spinal movement during self-extrication following a motor vehicle collision - a biomechanical study using healthy volunteers. Scand J Trauma Resusc Emerg Medicine 29, 108 (2021).

https://sjtrem.biomedcentral.com/articles/10.1186/s13049-021-00919-w

Extrication studied: Self-extrication.

Self-extrication is the process by which a patient is instructed to leave their vehicle and completes this with minimal or no assistance from the rescue services

This study considers the roles of cervical spine collars and instructions and their effect on spinal movement during self-extrication. Four groups are compared: i) No instructions and no cervical collar, ii) No instructions, with cervical collar, iii) With instructions and no collar, and iv) With instructions and with collar.



Findings

What we learnt:

Self-extrication with no instructions but with a collar resulted in the smallest spinal movement of the four self-extrication approaches used.

Biomechanical study 2: Nutbeam, T. Fenwick R, May B, Stassen W, Smith JE, Shippen J. Maximum movement and cumulative movement (travel) to inform our understanding of secondary spinal cord injury and its application to collar use in self-extrication. Scand J Trauma Resusc Emerg Medicine 30, 4 (2022).

https://sjtrem.biomedcentral.com/articles/10.1186/s13049-022-00992-9

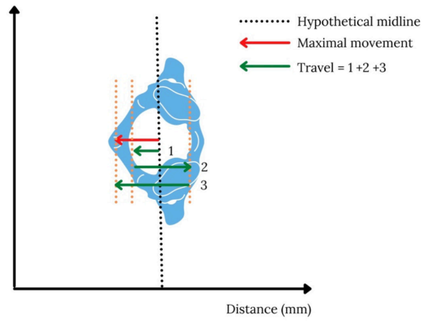
Extrication studied: Self-extrication and collar application
In this study total movement as well as maximal movements are considered.

Representation of maximal movements which are captured and reported in current biomechanical models of spinal movement vs non-maximal movememts that are not

A

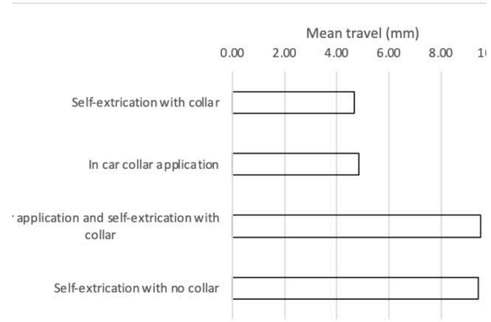
new metric to describe these movements "travel" is presented:

Maximal movement and travel



Findings

AP travel at cervical spine (MM)



What we learnt:

Total movement is similar across self-extricating healthy volunteers with and without a collar.

Biomechanical study 3: Nutbeam, T. Fenwick R, May B, Stassen W, Smith JE, Bowdler J, Wallis L, Shippen J. Assessing spinal movement during four extrication methods: a biomechanical study using healthy volunteers. Scand J Trauma Resusc Emerg Medicine 30, 7 (2022).

https://sjtrem.biomedcentral.com/articles/10.1186/s13049-022-00996-5

Extrication studied:

Roof removal

The most commonly delivered extrication type in the UK. The A, B and C posts and the roof removed facilitating a vertical extrication technique.
Technique: The participant was provided with manual neck stabilisation throughout, the back support of the driver's seat was reclined mechanically and the Long Spinal Board inserted to the seat base. The participant was then slid up the board until they were horizontally situated (securely) on the spinal board.

B-post rip

The B-post, driver's and driver's side rear door are removed to facilitate patient access and horizontal extrication.
Technique: The participant was provided with manual neck stabilisation throughout. The back support of the driver's seat was reclined mechanically. The spinal board was inserted at an oblique angle (pointed towards front centre console) and inserted to the seat base. Participant was then slid up the spinal board until fully on the board at which point the spinal board is rotated 45 degrees and placed horizontally onto the floor, next to the vehicle.

Rapid

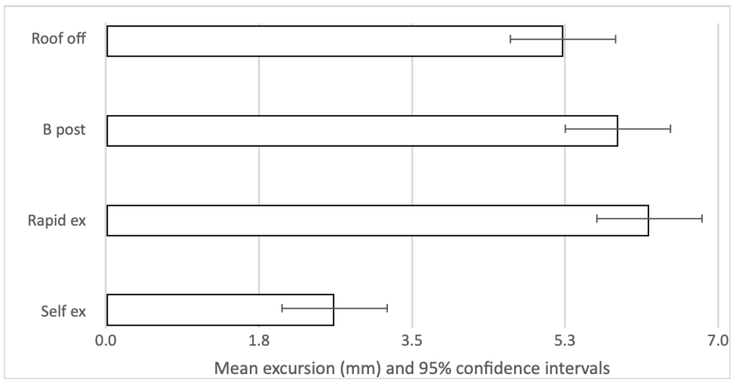
The driver's door is opened and the casualty assisted with a lateral extrication technique.
Technique: The driver's door is opened. The participant was provided with manual neck stabilisation throughout. The spinal board was inserted under the right thigh and hip, through an open door on the driver's side. Hereafter, the participant was then lifted up the spinal board in a lateral position until the feet are released from under the steering column, allowing rotation onto back and then finally, slid into position further up the spinal board.

Self-extrication

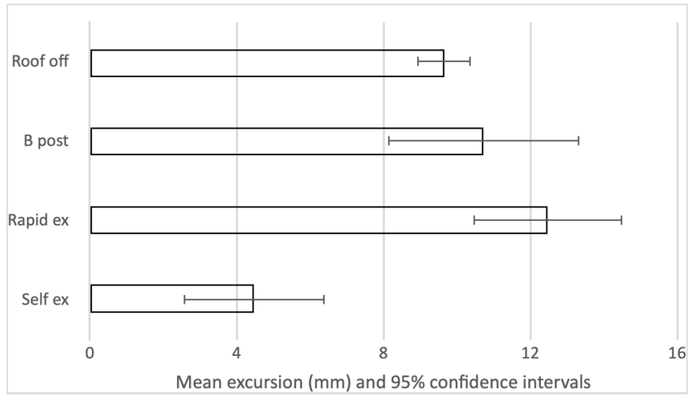
The casualty leaves the vehicle without assistance.
Technique: The participant is asked to get out of the vehicle and take one step away. The fire crew offered no instructions on how the participant should exit the vehicle.

What we found:

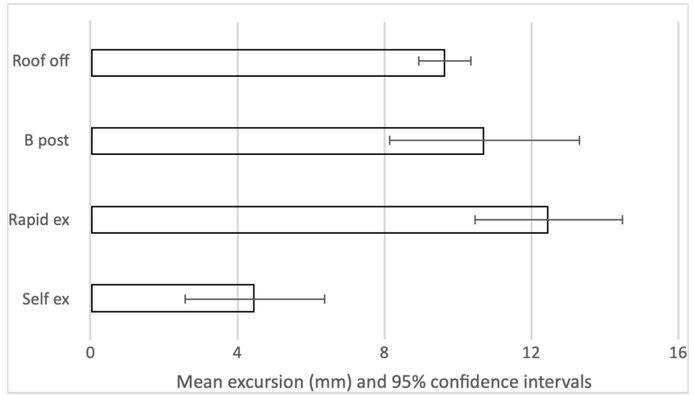
Mean excursion and confidence intervals for anterior-posterior movement at the cervical spine



Mean excusion and confidence intervals for anterior-posterior movement at the lumbar spine

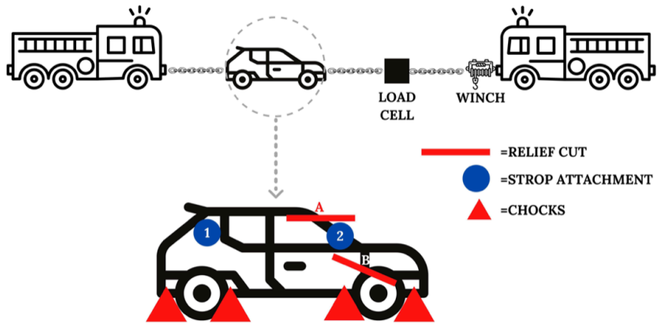


Time taken and confidence intervals (s)
Note – times above do not include "cutting" time.



What we learnt:

Self-extrication is associated with the smallest patient spinal movement and the fastest time to complete extrication. Rapid, B-post rip and roof off extrication types are all associated with similar movements and time to extrication in preprepared vehicles. In patients who can self-extricate, this should be the preferred extrication method. In patients who can't self-extricate, following disentanglement the most rapid method of extrication should be delivered.



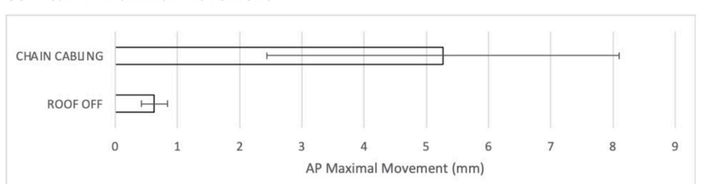
Biomechanical study 4: Nutbeam, T. Fenwick R, May B, Stassen W, Smith JE, Bowdler J, Wallis L, Shippen J. Comparison of 'chain cabling' and 'roof off' extrication types, a biomechanical study in healthy volunteers. Under peer review; Injury

Extrication studied: Chain cabling v's roof off

Chain cabling involves attaching anchored chains or strops to the front and rear posts of the damaged vehicle and using a winch to apply traction to the vehicle, therefore reversing the forces and vehicle distortion associated with a frontal collision.

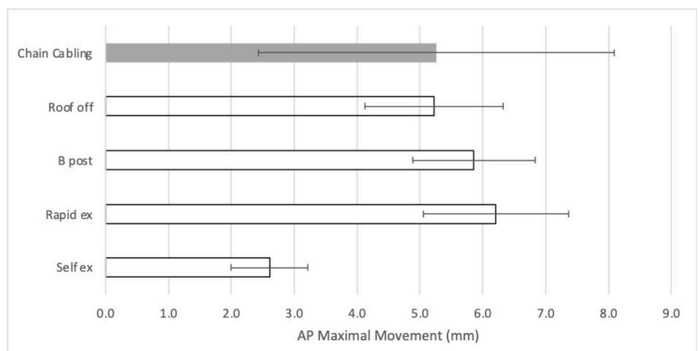
What we found:

Cervical AP Maximal movement



** Error bars indicate 95% confidence intervals*

Chain cabling extrication compared to other extrication types



Error bars indicate 95% Confidence Intervals

What we learnt:

The movement associated with chain cabling extrication was similar to that previously collected for other extrication types.

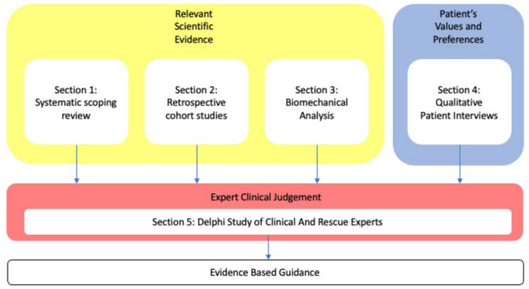
Section 3: Summary

- Self-extrication is associated with smaller movements at the cervical and lumbar spine than other extrication types.

- Extrication types that are not self-extrication appear to be similar in movement generation at the cervical and lumbar spine.

- There is a disconnect between the extrication techniques that are considered to reduce movement and their performance in this regard.

SECTION 4:
PATIENTS VALUES AND PREFERENCES



Section 4 relates to the "patient values and preferences" section of the EBM framework. This section presents a single paper which focuses on the patient experience of extrication. Patient values and preferences are a core element of Evidence Based Medicine. In this section an expert qualitative interviewer interviews patients with and without spinal cord injury who have been extricated.

Paper: Nutbeam T, Brandling J, Wallis L, Stassen W. Understanding people's experiences of extrication whilst being trapped in motor vehicles: a qualitative interview study.

What we did:

We recruited patients via the Devon Air Ambulance and the spinal injury charity Aspire. All of the patients had been extricated following a motor vehicle collision. The patients who were recruited by Aspire had spinal cord injuries.

An expert qualitative interviewer and psychotherapist interviewed each of the participants.

Themes from the interviews were collated and patient priorities identified.

What we found:

Extrication experience was improved by positive communication, companionship, explanations and planned post-incident follow-up. Extrication experience was negatively affected by failures in communication, loss of autonomy, unmanaged pain, delayed communication with remote family and onlooker use of social media.

What this means:

Recommendations are made which will support a positive patient centred extrication experience.

In summary:

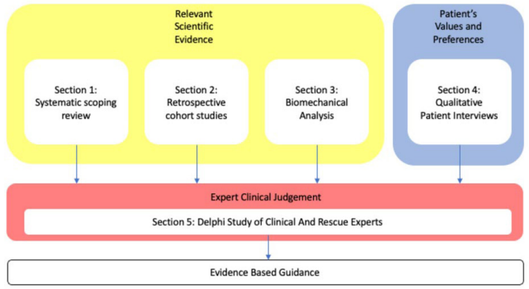
The trapped patient experience can be improved through positive communication, companionship, explanation and post-incident follow up. Steps should be taken to manage pain, avoid onlooker photographs / filming and support communication with family members.

> ***"Extrication experience was improved by positive communication, companionship, explanations and planned post-incident follow-up***

SUGGESTED BEHAVIOURS
FOR RESCUE TEAMS PERFORMING AN EXTRICATION

- Communication and companionship for entrapped patients should be designated to a specific staff member who if safe to do so and not an impediment for extrication should join the patient in the car
- An 'extrication buddy' should be assigned to explain the procedure, ensure companionship and provide reassurance to the patient whilst entrapped
- Communication with the patient should be clear and use accessible lay language
- Patients should be reassured that their co-occupants are safe (including animals)
- If conscious, patients should be allowed to communicate with their family members
- Where possible the ability of the public to photograph the vehicle and the patient should be minimised
- Attempts should be made to minimize onlooker photographer and post-accident photos on social media and news channels
- Rescuers and their affiliated organizations should not post extrication related photos on their social media channels or websites
- Where possible planned follow up should be offered to patients

SECTION 5:
EXPERT CLINICAL JUDGEMENT



The final piece of the EBM triad is that of "expert clinical judgement".

Here we use a group of experts nominated by key stakeholders to review all of the evidence available (old and new) and use this information to develop new guidance on extrication.

This work was supported by the following stakeholders:

Paper: Nutbeam T, Fenwick R, Smith JE, Dayson M, Carlin B, Wilson M, Wallis L, Stassen W. A Delphi Study of Rescue and Clinical Subject Matter Experts on the Extrication of Patients Following a Motor Vehicle Collision Scand J Trauma Resusc Emerg Med 30, 41 (2022). https://doi.org/10.1186/s13049-022-01029-x

Link: https://sjtrem.biomedcentral.com/articles/10.1186/s13049-022-01029-x

What we did:

This is a Delphi study of experts nominated by key stakeholders in clinical and operational extrication practice. A Delphi study iterative multi-stage consensus research technique where the experts interact anonymously from each other; developing and subsequently approving or rejecting statements reflecting different aspects of extrication practice. In this study 60 experts were nominated by the National Fire Chiefs Council (NFCC), the United Kingdom Rescue Organisation (UKRO), the National HEMS Research & Audit Forum (NHRAF), the College of Paramedics (CoP), the Pre-Hospital Trainee Operated Research Network (PHOTON) and the Faculty of Prehospital Care (FPHC).

What we found:

Consensus was reached on 91 statements covering a broad range of domains related to: extrication terminology, extrication goals and approach, self-extrication, disentanglement, clinical care, immobilisation, patient-focused extrication, emergency services call and triage, and audit and research standards.

These statements were summarised into a consensus document which was adopted by all stakeholder groups.

What this means:

We have new evidence-based guidance for the extrication of patients following a motor vehicle collision:

EVIDENCE BASED GUIDANCE
PRINCIPLES

- Operational and clinical team members should work together to develop a bespoke patient centred extrication plan with the primary focus of minimising entrapment time.
- Independent of actual or suspected injuries patients should be handled gently. A focus on absolute movement minimisation is not justified.
- When clinicians are not available, FRSs should where necessary assess patients, deliver clinical care and make and enact extrication plans (including self-extrication)[1]
- Self-extrication or minimally assisted extrication should be the standard 'first line' extrication for all patients who do not have contraindications, which are:
  - An inability to understand or follow instructions,
  - Injuries or baseline function that prevents standing on at least one leg, (specific injuries include: unstable pelvic fracture, impalement, bilateral leg fracture)
- All patients with evidence of injury should be considered time-dependent and their entrapment time should be minimised
- Incidents where a patient may require disentanglement are complex and associated with a high morbidity and mortality. A senior FRS and clinical response should attend such instances
- **Clinical care during entrapment:**
  - Can be delivered by FRS or clinical services
  - Should be limited to necessary critical interventions to expedite safe extrication
  - Rescuers should be aware that clinical observations may prolong entrapment time and as such should be kept to the minimum
  - FRS and clinical personnel should be aware of the physical and observable signs of patient deterioration and if identified should make this known to the responsible clinician
- Multi-professional datasets should be developed with patient and public engagement and should include entrapment status, entrapment time, injuries, extrication approach, clinical care
- **Immobilisation:**
  - Longboards are an extrication device and should not be used beyond the extrication phase
  - Kendrick Extrication Devices prolong extrication time and their use should be minimised
  - Pelvic slings should not be applied to patients until they have been extricated
  - Cervical collars should only be used following assessment and should be loosened or removed following extrication
- **Patient focused extrication:**
  - Build a connection with patients, explain actions, and use their name
  - Where appropriate, reassure patients as to the safety of their co-occupants and others involved in the incident (including animals)
  - Provide an 'extrication buddy'
  - Allow communication with family members or other close contacts
  - Rescue teams should not publish extrication related imagery to social media or other outlets
  - Minimise the ability of the public to view the accident, take photographs or record videos. Provide education to this effect
- **On initial call to Emergency Services**
  - Attempt to clarify entrapment status
  - Attempt to identify patients who require disentanglement (and dispatch an appropriate priority senior[2] response)
  - A standard multi-agency MVC trauma message should be developed to ensure the correct resources are deployed
- Multi-professional datasets should be developed with patient and public engagement and should include entrapment status, entrapment time, injuries, extrication approach, clinical care

Terms:
FRS = Fire and Rescue Services
Disentanglement = requires the use of cutting tools to free patient

Agreed nomenclature for categories of patient:
- Not injured
- Minor injuries (evidence of energy transfer but no evidence of time-dependent injury)
- Major injury (currently stable but should be assumed to be time-dependent)
- Time critical injured (Time critical due to injury; use fastest route of extrication)
- Time critical hazard (e.g. secondary to fire or other hazard)

CONCLUSIONS AND NEXT STEPS

The principles of EBM have been used to provide new evidence based guidance for the extrication of patients who are trapped following a motor vehicle collision.

In Section 1 a scoping review of the literature identifies that current extrication practices and paradigms are not grounded in evidence and that references to a high rate of spinal injuries caused by rescuer handling are ‘zombie’ statistics without an identifiable origin. Section 1 highlights unknowns including: the rate of spinal injuries and time dependent injuries in the trapped population, the excess morbidity and mortality associated with entrapment across a range of patient groups, the spinal movements associated with current extrication techniques and an understanding of the patient experience of extrication.

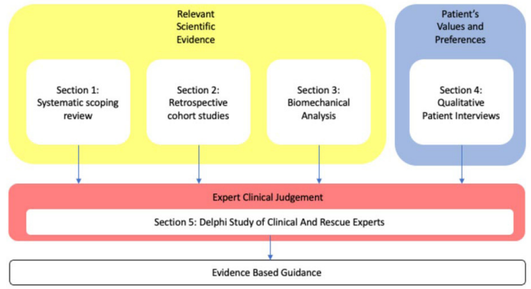
In Section 2, three retrospective cohort studies found that trapped patients have more injuries and are more likely to die; the rate of spinal injuries that are likely to influence extrication technique is extremely low; there are differences in the entrapment rates and injury patterns between female and male patients; older people have an excess mortality associated with entrapment and have a similar potential for self-extrication as younger people.

In Section 3, four original papers report the movements associated with current extrication techniques. These papers identify that self-extrication is associated with smaller movements at the cervical and lumbar spine than other extrication types and that extrication types that are not self-extrication appear to be similar in movement generation at the cervical and lumbar spine

Section 4 focuses on patient values and preferences. A single study reports a series of qualitative patient interviews. The experience of entrapped patients was improved by positive communication, companionship, explanations and planned post-incident follow-up. The experience of entrapped patients was made worse by communication failures, loss of autonomy, unmanaged pain, poor communication with remote family and the negative effects of onlooker use of social media.

In Section 5, a Delphi consensus study, used subject matter experts to formulate extrication guidance based on the evidence made available in Sections 1-4. The synthesis of these statements in collaboration with national level stakeholders into new principles will have significant implications for clinicians, rescuers, and patients.

This guidance has been adopted by a broad range of national level clinical and rescue stakeholders and is actively being incorporated into operational and clinical practice.



We have demonstrated that the historic paradigm of ‘movement minimisation’ in the development and application of extrication techniques is not grounded in evidence and that such an approach may contribute to the excess death associated with entrapment.

An evidence-based approach to extrication is proposed; this approach is validated through its adoption by national level stakeholders in the UK. Such an approach will reduce extrication times and may reduce morbidity and mortality.

The impact following the adoption of the principles resulting from this work on extrication type, time and patient outcomes will be monitored through longitudinal analysis of national level data sets.

Glossary of terms ?

Acknowledgements

THE EXIT PROJECT

Website
https://theexitprojectcouk.wordpress.com