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Sex-disaggregated analysis of the injury patterns, outcome data and trapped status of major trauma patients injured in motor vehicle collisions

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Sex-disaggregated analysis of the injury patterns, outcome data and trapped status of major trauma patients injured in motor vehicle collisions

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Abstract:

Objectives: To identify the differences between women and men in the probability of entrapment, frequency of injury, and outcomes following a Motor Vehicle Collision. Publishing sex-disaggregated data, understanding differential patterns and exploring the reasons for these will assist with ensuring equity of outcomes especially in respect to triaging, rescuing and treating all patients.

Design: We examined data from the Trauma Audit Research Network (TARN) registry to explore sex differences in entrapment, injuries and outcomes. We explored the relationship between age, sex and trapped status using multivariate logistical regression.

Setting: TARN is a UK based trauma registry covering England and Wales.

Participants: We examined data for 450,357 patients submitted to TARN during the study period (2012-2019) of which 70 027 met the inclusion criteria. There were 18,175 (26%) females and 51,852 (74%) males.

Primary and secondary outcome measures: We report difference in entrapment status, injury and outcome between females and males. For trapped patients we examined the effect of sex and age on death from any cause.

Results:

Females were more frequently trapped than males ($p<0.0001$). In trapped patients, males more frequently suffered head, face, thoracic and limb injuries (all $p<0.0001$). Females had more injuries to the pelvis ($p<0.0001$) and spine ($p<0.001$). Following adjustment for the interaction between age and sex, ISS, GCS and the Charlson comorbidity index, no difference in mortality was found between females and males.

Conclusions:

There are significant differences between females and males in the frequency at which patients are trapped and the injuries these patients sustain. This sex-disaggregated 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.

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Strengths and limitations of this study:

- We include data from 70,027 patients over a 8-year time period.
- The source dataset is of high quality; the Trauma Audit and Research Network (TARN).
- The dataset does not allow clear differentiation between patients that are 'medically trapped (e.g., due to pain) or 'physically trapped' (e.g. due to intrusion into the vehicle)
- We pre-specified to minimise bias but the inherent concerns of a retrospective cohort analysis remain.
- We only include patients who meet the threshold for inclusion to TARN and therefore miss MVCs where severe injury did not occur.

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Key words:

Extrication

Sex

Gender

Motor Vehicle Collision

Accidents, traffic

Spinal injuries

Pre-hospital care

Emergency Medical Services

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Background:

An introduction to sex and gender:

Sex refers to the biological attributes of humans and animals associated with physical and physiological characteristics such as reproductive anatomy, gene expression, chromosomes and hormone profiles. It is usually categorized as male or female, although there are other variations in sex characteristics [1].

Gender refers to the societal overlay of roles, behaviours and identities ascribed to individuals. It influences how people see themselves, how they are perceived by others; societal bias affects distribution of power and resources. Gender identity refers to individual's deeply felt internal and individual experience of gender. Gender identity is a spectrum and are not restricted to man and woman. An individual's gender identity may differ from their sex assigned at birth [1].

Research outcomes may depend on patient sex (such as medication trials, where sex hormones may affect efficacy), gender (e.g., in trials where actual or perceived behavioural differences may be important) or both. The TARN dataset includes sex as recorded on the hospital notes and may represent either sex assigned at birth or gender.

Historical epidemiological data describe major trauma secondary to injury in the UK as predominantly a disease of young men [2]. More recent analysis demonstrates that this paradigm no longer applies, with particular focus on the burden of trauma in the older population [3,4]. Despite increasing awareness of these changing demographics, trauma systems remain tuned to recognising and treating historical perceived norms [4,5].

Motor vehicle collisions (MVCs) are a significant cause of morbidity and mortality throughout the world accounting for 1.35 million deaths and between 20 and 50 million injuries worldwide per annum [5]. To our knowledge no studies have considered the differences in injury patterns, entrapment status and morbidity and mortality outcomes between females and males. Failure to collect and analyse sex-disaggregated data is a common concern in research; whilst most studies present baseline demographic data by sex, far fewer report outcome data by sex or conduct sex and gender-based analysis (SGBA) [1,6]. Failure to carry out SGBA can have serious consequences for patient outcome. As an example, females are 50% more likely to be misdiagnosed when experiencing a myocardial infarction due to persistent gender-blind research which overlooked

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different presentation of symptoms in women compared to men. Women's symptoms have been labelled 'atypical' despite being experienced by half of the population [7].

Following an MVC some occupants will be 'trapped' and be unable to exit the vehicle without assistance [8]. Those who are physically trapped will require the assistance of fire and rescue services to perform a mechanical intervention to the vehicle to create space for extrication [9]. Patients who are medically trapped due to pain or disability will require physical assistance, analgesia and the application of spinal precautions or reassurance that such precautions are not required. Patients who are trapped have worse outcomes than those who are not trapped [8].

We could find no previous sex-disaggregated data which report injury patterns for patients trapped following an MVC. This information would be useful for those triaging, rescuing or treating patients. There may be additional value of sex-disaggregated data to target public health interventions, road planning and the design of safety systems such as restraint devices and airbags.

The aims of this study were to define the probability of entrapment, frequency of injury, and outcomes by the sex of the casualty.

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Methods:

A retrospective review of the UK Trauma Audit and Research Network (TARN) database was carried out including patients injured between 1st January 2012 and 31st December 2019. TARN collects data from Major Trauma Centres and Trauma Units in the UK. Eligibility criteria for inclusion in the TARN database include trauma patients who are admitted to hospital for ≥72 hours, admitted to a critical care unit, who die in hospital or are transferred to another hospital for specialist care. Pre-hospital deaths and isolated closed fractures of the limbs and hip fractures in patients over the age of 65 are not included. TARN includes routine data on patient demographics, physiology, interventions, injuries and in some circumstances (including MVCs) the trapped status of the patient.

Inclusion criteria were patients aged 16 years or older, with mechanism coded as "Vehicle Incident/Collision", directly admitted to a TARN participating hospital in England and with complete documented outcomes. To ensure data quality, patients were excluded if they underwent secondary transfer from another hospital or when the trapped status was not documented on the database.

For patients that met the inclusion criteria, data fields including sex, age, trapped status, injury severity score (ISS), abbreviated injury scale (AIS) for each body region, any details of spinal injury and significant time dependent injuries as described in previous work were made available for analysis [8].

Simple descriptive analysis was used to define the characteristics of the female and male groups. Levene's test was used to assess equality of variances and a two-tailed t-test to compare means and Mann-Whitney test for comparing medians. Chi square test was used for categorical variables. *P* values of less than 0.01 were considered significant due to multiple analyses being performed. The relationship between age, sex, and trapped status was explored further using multivariate logistical regression. SPSS (IBM Corp v.23 Armonk, NY) and Stata (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX) were used for the analyses.

TARN data analyses are conducted using anonymised data which is governed by a code of practice approved by the Confidentiality Advisory Group who are appointed by the Health Research Authority. Additional individual ethical approval was not required for this analysis.

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Patient and public involvement:

TARN has patient and public involvement on the TARN Board which has oversight of the research portfolio in addition we sought the opinions of the advocacy group GENDRO on our analysis plan.

Results:

Between 2012 and 2019, there were 450 437 cases identified on the TARN database. Following exclusions, data for 70,027 patients with a known trapped status were analysed (Figure 1).

Figure 1: Strobe Diagram

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The characteristics of each group are summarized in Table 1. Twenty-six percent of patients were female. The average age (SD) across all eligible patients was 46.2 (20.1); females were older than males (52.4 (SD 22.0) vs 44.1 (SD 18.9), p=<0.0001). Females had less severe injury (p<0.0001). Mean (median for GCS) physiological variables were similar for females and males. Small differences in heart rate, respiratory rate and oxygen saturations demonstrated statistical but not clinically significant differences.

Of patients who survived to hospital, 3,868 (5.5%) died within 30 days of initial injury. Females had statistically worse survival although the difference was small (94.0% versus 94.6%, p=0.001). A higher proportion of females were trapped than males (p=<0.0001). Of the population of patients who were trapped, females had better outcomes (92.3% alive at 30 days compared to 90.0% of males, p=0.01).

Table 1: Demographics, outcomes and physiology

	All Trapped and Not Trapped				Only Trapped		
	Total	Female	Male	P value	Female	Male	P value
Number (%)	70027	18175 (26.0)	51852 (74.0)	<0.0001	2879 (15.8)	4875 (9.4)	<0.0001
Age (mean, SD)	46.2 (20.1)	52.4 (22.0)	44.1 (18.9)	<0.0001	50.1 (21.8)	42.9 (19.7)	<0.0001
ISS (Median, IQR)	13 (9-22)	13 (9-22)	13 (9-24)	<0.0001	17 (9-27)	19 (10-29)	<0.0001
Driver of vehicle	16600	5132 (30.9)	11468 (69.1)	<0.0001	1623 (31.9)	3471 (68.1)	<0.0001
Systolic Blood Pressure (mean, SD)	133.3 (28.0)	133.1 (30.2)	133.4 (27.2)	0.361	128.7 (30.7)	129.5 (30.9)	0.309
Heart Rate (mean, SD)	86.7 (22.2)	87.9 (21.9)	86.2 (22.3)	<0.001	91.2 (24.2)	92.1 (26.3)	0.185
Respiratory Rate (mean, SD)	20.3 (6.9)	20.3 (6.7)	20.3 (7.0)	0.833	21.3 (7.3)	21.5 (8.2)	0.207
Oxygen Saturation (mean, SD)	96.1 (7.9)	96.2 (7.3)	96.0 (8.0)	0.001	97.4 (5.9)	97.3 (5.9)	0.544
GCS ISS (Median, IQR)	15 (15-15)	15 (15-15)	15 (15-15)	n/a	15 (1415)	15 (14-15)	n/a
Alive at 30 days (n,%)	66159 (94.5)	17084 (94.0)	49075 (94.6)	0.001	2657 (92.3)	4396 (90.0)	0.01

Table 2 and 3 show that trapped females and males demonstrated significant differences in the incidence of thoracic and spinal injuries. Tension pneumothorax was more common in males and dens fractures were more common in females (both p<0.0001). Spinal cord injuries were also more common in females (p=0.038). In trapped patients, males were more likely to suffer from head, face, thoracic and limb injuries (all p<0.0001, Table 3), while females were more likely to have pelvic (p<0.0001) and spinal injuries (p<0.001). The incidence of abdominal injuries was similar in females and males.

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Table 2: Significant and spinal injuries by sex for trapped casualties

	Female	%	Male	%	P value
Pelvic ring fracture with blood loss >20%	23	0.8	48	1.0	0.394
Blood loss>20% (%)	114	4.0	161	3.3	0.139
Tension pneumothorax (%)	26	0.9	92	1.9	<0.0001
Multiple spinal fractures (%)	429	14.9	649	13.3	0.54
Dens fracture (%)	85	3.0	79	1.6	<0.0001
Spinal compression fracture grade 2/3 (%)	66	2.3	75	1.5	0.022
Unstable spinal fracture (%)	276	9.6	441	9.0	0.43
Spinal cord injury (%)	218	7.6	308	6.3	0.038

Table 3: Injury site by sex for trapped casualties

	Female	%	Male	%	P value
Head AIS 3+	578	20.1	1318	27.0	<0.0001
Face AIS 3+	6	0.2	46	0.9	<0.0001
Thoracic AIS 3+	1438	49.9	2721	55.8	<0.0001
Abdomen AIS 3+	355	12.3	595	12.2	0.87
Spine AIS3+	359	12.5	485	9.9	0.001
Pelvic AIS 3+	420	14.6	475	9.7	<0.0001
Limb AIS 3+	778	27.0	1744	35.8	<0.0001

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Figure 2 demonstrates the interaction between adjusted mortality, trapped status and age. This analysis adjusts for the interaction between age and sex, ISS, GCS and the Charlson comorbidity index. In this adjusted analysis, trapped male patients were more likely to die – but the 95% confidence intervals overlapped between the male and female groups for all age categories.

Figure 2: Adjusted mortality and age
(Error bars = 95% Confidence Intervals)

Figure 3 displays the interaction between probability of entrapment, sex and age. Females were more likely to be trapped in all the age groups considered – except in patients aged 80 and over.

Figure 3: Probability of entrapment and age
(Error bars = 95% Confidence Intervals)

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Discussion:

This is the largest analysis to date of sex-disaggregated data for trauma patients following an MVC and confirms significant differences in injury patterns and trapped status between females and males.

The explanations for these differences are likely to include both reasons pertaining to biological sex (e.g. physical size, muscle mass, hormonal differences) and reasons pertaining to gender (such as driving behaviours, post-collision behaviours, and responses by emergency responders such as decisions related to extrication).

Age, ISS, physiology and outcomes:

Of patients in the analysis, females had a lower ISS and tended to be older than males. These differences were more apparent in those patients that were trapped. The recorded physiological observations are broadly similar between sexes.

However, there are gender-related differences that may contribute to the observed differences. Men drive more miles, faster, in a more risky manner and more frequently have accidents, resulting in the higher injury burden and mortality as seen in this analysis and elsewhere [10–13]. Women make up a higher proportion of older drivers [14]. Older females are more likely than men of equivalent age to be killed or seriously injured in collisions, after controlling for miles driven; whereas young men have the highest risk of serious injury or death per million miles driven [11].

Injuries in trapped casualties:

Trapped males were more likely to have severe injuries of the head, face, chest (including tension pneumothorax) and limbs, with females more likely to have injuries of the vertebrae, spinal cord and pelvis. No statistically significant differences were found between trapped females and males in relation to pelvic ring injuries with blood loss, multiple spinal fractures or abdominal injuries.

Differences in injuries may be accounted for by i) differences in car usage, kinematics, and mechanism of injury (MOI), ii) differences in effectiveness and availability of safety systems and iii) differences in biological propensity to certain injury types.

i) Difference in kinematics and resultant mechanism of injury. An analysis of the UK based STATS-19 MVC registry demonstrates that males are more likely to have MVCs whilst

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travelling forwards (64.2% vs 56.5%) whereas females are more likely to have collisions whilst manoeuvring (16.1% vs 11.9%) or turning (10.7% vs 8.4%). Similar findings are reported in the United States, with females more likely to be involved in a side impact MVC and males more likely to have a frontal impact [15]. Side impact MVCs result in a transfer of energy to the patient that is more likely to cause significant spinal injury [16]. Side impacts are also a common cause of lateral compression fractures of the pelvis [17,18] which may explain the finding of an increased prevalence of these injuries in females. It is rare for lateral compression fractures of the pelvis to be associated with significant bleeding which perhaps accounts for the higher rate of pelvic fractures in females but not a high rate of pelvic fractures with significant blood loss [19].

Males experience a higher rate of frontal collisions, which may account for the increased rate of head, face and chest injury found in this study ,through interactions and resultant energy transfer with the steering wheel and/or air bag [20,21]. The higher rate of male drivers and their interactions with the pedals and the “bracing” experienced by drivers pre-collision may explain the higher rate of limb injury seen in males in this study [22,23].

ii) Differences in availability and effectiveness of safety systems. Safety systems are less effective for passengers than drivers and are optimised to minimise energy transfer from frontal collisions [22,24,25].

iii) It has been previously demonstrated that women are more likely to be compliant with safety systems such as seat belts than men and as a result have less risk of multiple and severe injuries and their associated mortality [26,27]. However, the safety features incorporated in modern cars are less likely to be effective for women. Current mandatory crash testing uses a scaled-down 50th centile male mannequin to represent 5th percentile females and are not modelled to account for anthropometric differences between females and males [28–31]. This systemic bias, with cars developed, tested and safety-rated using primarily an anatomically correct, weighted and biomechanical matched male mannequin has led to the development of safety systems which are likely to be more effective for males than females. For example, whiplash protection systems are significantly more effective at preventing injury in men than women [29,32].

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Comparison of female and male dummies demonstrates higher biomechanical response in the female dummy in the neck region which may offer some explaination for the increased rate of spinal fractures in females found in our study [33].

Moreover, females are more likely to drive and be injured in smaller cars, with less efficient safety systems. Smaller cars are associated with a greater injury burden and may account for some of the sex-related differences seen in this study [34].

iii) Females are biologically prone to certain injury types.

The intersection of age, biological differences, female propensity to injury and medical conditions such as osteoporosis may further account for some of the differences in injuries seen in this analysis [35]. Females and males differ physically in ways which are pertinent to injury and entrapment in RTCs. They each have unique anthropometry for example: females have wider pelvic measurements and shorter torsos, even controlled for height difference [36]. As such, female pelvic geometry may be more prone to injury following a side impact [37]. A combination of these factors may explain the differences seen in injury patterns in this study; we found a greater proportion of pelvic fractures in females, and a higher rate of head and chest injury in males.

Sex hormones affect body composition. Testosterone contributes significantly greater skeletal muscle mass (8% greater, after correcting for BMI) in males, which does not start to fall until the fifth decade [38]. Female sex hormones are responsible for ligaments in females being more lax, which combined with females' cervical vertebrae being smaller than males of equivalent head size, may explain the greater rate of spinal cord injury in females [39,40]. Post-menopausal changes in bone composition mean that females have a 50% greater loss of bone in old age compared to males, again making them susceptible to fractures as a result of MVC [35].

Trapped status and death:

Females were more likely than men to be trapped (15.8 vs 9.4%, p<0.0001). The mean age of trapped females was significantly higher than trapped males; this may influence their own ability to self-extricate due to frailty or relative immobility[41]. An additional possible explanation may include different treatment by rescuers, for example, perhaps being less likely to recommend or facilitate self-extrication for older females. Females are more likely to sit closer to the steering wheel,

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meaning that less movement intrusion of the dashboard and steering wheel is required to cause entrapment [42]. Furthermore, this study found that females are more likely to have injuries of the pelvis and spine and these injuries may prevent self-extrication and increase the frequency of entrapment.

Post-collision behaviour and patient experience differences between females and males may contribute to the increased rate of entrapment in females, who are more likely to experience multi-region and widespread pain following a MVC, which may prevent them leaving the vehicle without assistance [43]. TARN does not record whether a patient was physically trapped by vehicle deformation or medically trapped (e.g. by pain) which prevents further analysis within this dataset.

Trapped females had a lower ISS than trapped males and were less likely to die (7.7% vs 10.0%). However, once the factors in our model were considered (age, sex, ISS, GCS and Charlson co-morbidity index) no difference in mortality was found between females and males (Figure 2).

Clinical and operational implications:

This study shows that men and women experience different rates of entrapment and different injury patterns when involved in MVCs. This may have implications for the design of car safety systems, so as to protect men and women equally. Likewise, for prehospital clinicians, this work highlights the differences seen in clinical practice when attending MVCs.

This study was unable to distinguish entrapment due to medical causes (e.g. pain or relative immobility) from physical entrapment due to vehicle deformity, which implies a greater energy transfer collision. The higher rate of female entrapment seen may in part be explained by this cohort being older and having greater co-morbidity. Current UK extrication dogma still prioritises 'spinal precaution' methods of extrication that involve the patient being passive in the process. A greater focus on self-extrication as a safe alternative to rescue service assisted extrication may in future reduce the number of medically trapped patients.

Limitations:

Not all patients trapped in a MVC were included in this study due to the TARN inclusion criteria. Of note, pre-hospital deaths from the most severe MVCs are not included, nor were patients who received minor injuries but physically trapped by mechanical deformation of the vehicle. This analysis did not discriminate between the type of vehicle (e.g. car or bus/coach or light/heavy goods vehicle) and includes all occupants of vehicles involved in a motor vehicle collision which is a

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heterogenous group. The “trapped” status recorded on TARN has poor data completeness, the definition is open to interpretation and cannot distinguish between type and mode of entrapment. These limitations may hinder our interpretation of trapped status.

Conclusions:

More males are more severely injured and die as a result of MVC than females. Females under 80 are more frequently trapped than males. Females are more likely to have spinal and pelvic injuries and males are more likely to have head, face, thoracic and limb injuries. Differences in driving behaviours, kinematics, collision type, position in vehicle, the efficacy of safety systems, biological vulnerability to certain injury types and post-injury behaviour may all have influence on these patterns.

Sex-disaggregated data on mortality, entrapment and injury patterns in motor-vehicle collisions may help to inform vehicle manufacturers, emergency services personnel and road-safety organisations 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. Future work should include appropriate sex and gender-based analysis designed to shed light on the biological and sociocultural factors that creates differential experience and outcome for women and men.

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Declarations

Ethics approval and consent to participate

TARN data analyses are conducted using anonymised data which is governed by a code of practice approved by the Confidentiality Advisory Group who are appointed by the Health Research Authority. Additional individual ethical approval was not required for this analysis.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

TN, LW, SH, RF, JS and WS contributed to the conception and study design, analysis and interpretation of data, drafting and revising the manuscript. OB contributed to the analysis and interpretation of the data and critically revised the manuscript. All authors read and approved the final manuscript.

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Authors' information (optional)

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Figures and tables legend:

Figure 1: Strobe Diagram

Figure 2: Adjusted mortality and age
(Error bars = 95% Confidence Intervals)

Figure 3: Probability of entrapment and age
(Error bars = 95% Confidence Intervals)

Table 1: Demographics, outcomes and physiology
Table 2: Significant and spinal injuries by sex for trapped casualties
Table 3: Injury site by sex for trapped casualties

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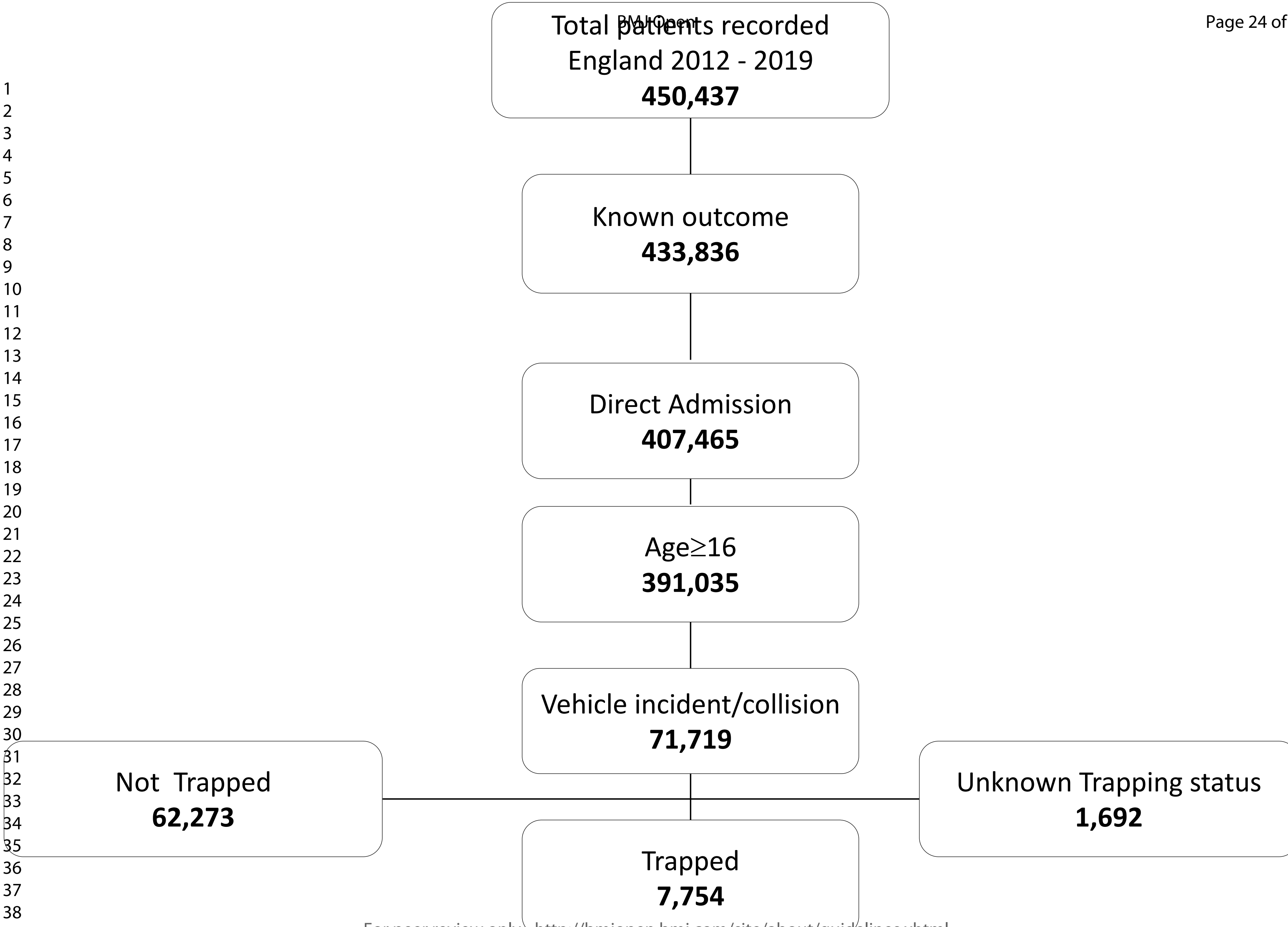
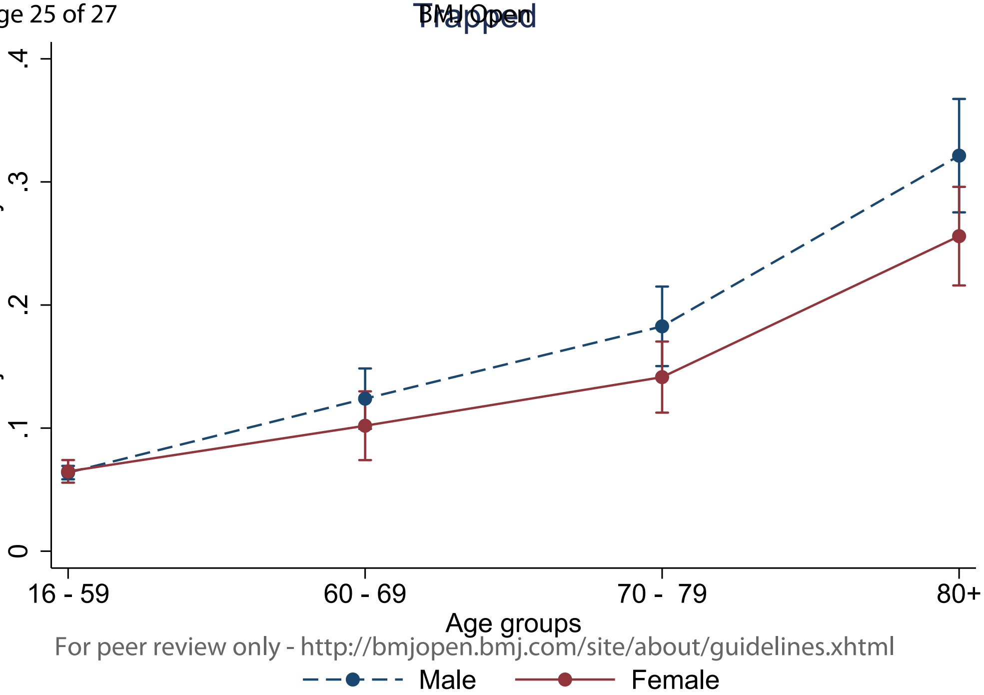

Total patients recorded
England 2012 - 2019
450,437
Known outcome
433,836
Direct Admission
407,465
Age≥16
391,035
Vehicle incident/collision
71,719
Not Trapped
62,273
Unknown Trapping status
1,692
Trapped
7,754



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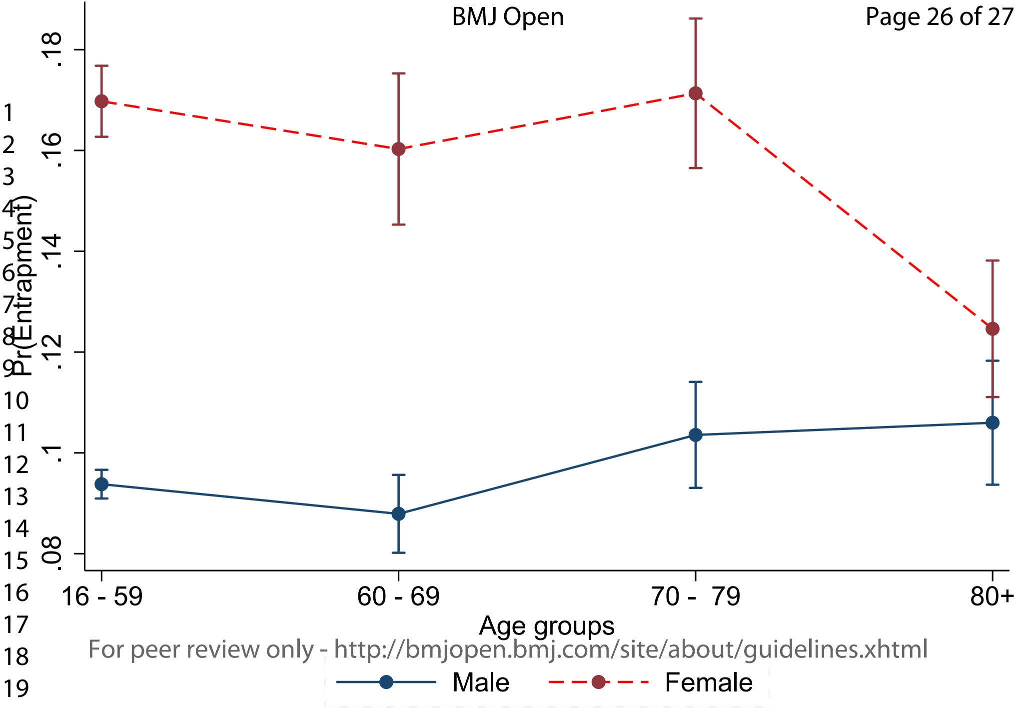

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	8/9
Outcome data	15*	Report numbers of outcome events or summary measures over time	9/10

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9/10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11/12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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

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

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Abstract

Objectives: To identify the differences between women and men in the probability of entrapment, frequency of injury, and outcomes following a motor vehicle collision. Publishing sex-disaggregated data, understanding differential patterns and exploring the reasons for these will assist with ensuring equity of outcomes especially in respect to triage, rescue and treatment of all patients.

Design: We examined data from the Trauma Audit Research Network (TARN) registry to explore sex differences in entrapment, injuries and outcomes. We explored the relationship between age, sex and trapped status using multivariate logistical regression.

Setting: TARN is a UK-based trauma registry covering England and Wales.

Participants: We examined data for 450,357 patients submitted to TARN during the study period (2012-2019) of which 70 027 met the inclusion criteria. There were 18,175 (26%) female and 51,852 (74%) male patients.

Primary and secondary outcome measures: We report difference in entrapment status, injury and outcome between female and male patients. For trapped patients we examined the effect of sex and age on death from any cause.

Results: Female patients were more frequently trapped than male patients (female [F] 15.8%, male [M] 9.4%;, p<0.0001). Trapped male patients more frequently suffered head (M 1318 [27.0%], F 578 [20.1%]), face, (M 46 [0.9%], F 6 [0.2%]), thoracic (M 2721 [55.8%], F 1438 [49.9%]), and limb injuries (M 1744 [35.8%], F 778 [27.0%]; all p<0.0001). Female patients had more injuries to the pelvis (F 420 [14.6%], M 475 [9.7%]; p<0.0001) and spine (F 359 [12.5%], M 485 [9.9%]; p=0.001). Following adjustment for the interaction between age and sex, ISS, GCS and the Charlson Comorbidity Index, no difference in mortality was found between female and male patients.

Conclusions: There are significant differences between female and male patients in the frequency at which patients are trapped and the injuries these patients sustain. This sex-disaggregated 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.

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Keywords: Extrication; Sex; Gender; Motor Vehicle Collision; Accidents, traffic; Spinal injuries; Pre-hospital care; Emergency Medical Services

Strengths and limitations of this study

- We include data from 70,027 patients over an 8-year time period.
- The source dataset, the Trauma Audit and Research Network (TARN), is of high quality.
- The dataset does not allow clear differentiation between patients that are 'medically trapped' (e.g., due to pain) or 'physically trapped' (e.g. due to intrusion into the vehicle).
- We pre-specified outcome measures to minimise bias but the inherent concerns of a retrospective cohort analysis remain.
- Our analysis only includes patients who met the threshold for inclusion in TARN; therefore, motor vehicle collisions where severe injury did not occur were not included.

Introduction

Sex refers to the biological attributes of humans and animals associated with physical and physiological characteristics such as reproductive anatomy, gene expression, chromosomes and hormone profiles. It is usually categorized as male or female, although there are other variations in sex characteristics [1].

Gender refers to the societal overlay of roles, behaviours and identities ascribed to individuals. It influences how people see themselves, how they are perceived by others; societal bias affects distribution of power and resources. Gender identity refers to individual's deeply felt internal and individual experience of gender. Gender identity is a spectrum and are not restricted to man and woman. An individual's gender identity may differ from their sex assigned at birth [1].

Research outcomes may depend on patient sex (such as medication trials, where sex hormones may affect efficacy), gender (e.g., in trials where actual or perceived behavioural differences may be

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important) or both. The Trauma Audit and Research Network (TARN) dataset includes sex as recorded on the hospital notes and may represent either sex assigned at birth or gender.

Historical epidemiological data describes major trauma secondary to injury in the UK as predominantly a disease of young men [2]. More recent analysis demonstrates that this paradigm no longer applies, with particular focus on the burden of trauma in the older population [3,4]. Despite increasing awareness of these changing demographics, trauma systems remain tuned to recognising and treating historical perceived norms [4,5].

Motor vehicle collisions (MVCs) are a significant cause of morbidity and mortality throughout the world accounting for 1.35 million deaths and between 20 and 50 million injuries worldwide per annum [5]. To our knowledge no studies have considered the differences in injury patterns, entrapment status and morbidity and mortality outcomes between female and male patients. Failure to collect and analyse sex-disaggregated data is a common concern in research; whilst most studies present baseline demographic data by sex, far fewer report outcome data by sex or conduct sex and gender-based analysis (SGBA) [1,6]. Failure to carry out SGBA can have serious consequences for patient outcome. As an example, female patients are 50% more likely to be misdiagnosed when experiencing a myocardial infarction due to persistent gender-blind research which overlooked different presentation of symptoms in women compared to men. Women's symptoms have been labelled 'atypical' despite being experienced by half of the population [7].

Following an MVC some occupants will be trapped and be unable to exit the vehicle without assistance [8]. Those who are physically trapped will require the assistance of fire and rescue services to perform a mechanical intervention to the vehicle to create space for extrication [9]. Patients who are medically trapped due to pain or disability will require physical assistance, analgesia and the application of spinal precautions or reassurance that such precautions are not required. Patients who are trapped have worse outcomes than those who are not trapped [8].

We could find no previous sex-disaggregated data which report injury patterns for patients trapped following an MVC. This information would be useful for those triaging, rescuing or treating patients. There may be additional value of sex-disaggregated data to target public health interventions and the design of safety systems such as restraint devices and airbags.

The aims of this study were to define the probability of entrapment, frequency of injury, and outcomes by the sex of the casualty.

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Methods

A retrospective review of the UK Trauma Audit and Research Network (TARN) database was carried out including patients injured between 1st January 2012 and 31st December 2019. TARN collects data from Major Trauma Centres and Trauma Units in the UK. Eligibility criteria for inclusion in the TARN database include trauma patients who are admitted to hospital for ≥72 hours, or are admitted to a critical care unit, or die in hospital or are transferred to another hospital for specialist care. Pre-hospital deaths, isolated closed fractures of the limbs and hip fractures in patients over the age of 65 are not included. TARN includes routine data on patient demographics, physiology, interventions, injuries and in some circumstances (including MVCs) the trapped status of the patient.

Inclusion criteria were patients aged 16 years or older, with mechanism coded as "Vehicle Incident/Collision", directly admitted to a TARN participating hospital in England and with complete documented outcomes. To ensure data quality, patients were excluded if they underwent secondary transfer from another hospital or when the trapped status was not documented on the database.

For patients that met the inclusion criteria, data fields including sex, age, trapped status, injury severity score (ISS), abbreviated injury scale (AIS) for each body region, any details of spinal injury and significant time dependent injuries as described in previous work were made available for analysis [8].

Simple descriptive analysis was used to define the characteristics of the female and male groups. Levene's test was used to assess equality of variances and a two-tailed t-test to compare means and Mann-Whitney test for comparing medians. Chi square test was used for categorical variables. *P* values of less than 0.01 were considered significant due to multiple analyses being performed. The relationship between age, sex, and trapped status was explored further using multivariate logistical regression. SPSS (IBM Corp v.23 Armonk, NY) and Stata (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX) were used for the analyses. Additional analyses which were not pre-specified: injuries of patients who were excluded for incomplete entrapment data, injuries sustained by year over time, and a passenger / driver analysis. Analyses which are not prespecified are included in the supplemental file.

TARN data analyses are conducted using anonymised data which is governed by a code of practice approved by the Confidentiality Advisory Group who are appointed by the Health Research Authority. Additional individual ethical approval was not required for this analysis.

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Patient and public involvement

TARN has patient and public involvement on the TARN Board which has oversight of the research portfolio. For this specific analysis we sought the opinions of the advocacy group GENDRO.

Results

Between 2012 and 2019, there were 450 437 cases identified in total on the TARN database. Following exclusions, data for 71,719 patients from a MVC were identified of which 70,027 patients had a known trapped status were analysed (Figure 1).

The characteristics of each group are summarized in Table 1. Twenty-six percent of patients were female. The average age (SD) across all eligible patients was 46.2 (20.1); female patients were older than male patients (52.4 (SD 22.0) vs 44.1 (SD 18.9), p=<0.0001). Female patients had less severe injury (p<0.0001). Mean (median for GCS) physiological variables were similar for female and male patients. Small differences in heart rate, respiratory rate and oxygen saturations demonstrated statistical but not clinically significant differences.

Of patients who survived to hospital, 3,868 (5.5%) died within 30 days of initial injury. Female patients had statistically worse survival although the difference was small (94.0% versus 94.6%, p=0.001). A higher proportion of female patients were trapped than male patients (p=<0.0001). Of the population of patients who were trapped, female patients had better outcomes (92.3% alive at 30 days compared to 90.0% of males, p=0.01).

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Table 1: Demographics, outcomes and physiology

	All Trapped and Not Trapped							Only Trapped				
	Total		Female		Male		P value	Female		Male		P value
Number (%)	70027		18175	(26.0)	51852	(74.0)	<0.0001	2879	(37.1)	4875	(62.9)	<0.0001
Age (mean, SD)	46.2	(20.1)	52.4	(22.0)	44.1	(18.9)	<0.0001	50.1	(21.8)	42.9	(19.7)	<0.0001
ISS (Median, IQR)	13	(9-22)	13	(9-22)	13	(9-24)	<0.0001	17	(9-27)	19	(10-29)	<0.0001
Driver of vehicle (%)	16600		5132	(30.9)	11468	(69.1)	<0.0001	1623	(31.9)	3471	(68.1)	<0.0001
Systolic Blood Pressure (mean, SD)	133.3	(28.0)	133.1	(30.2)	133.4	(27.2)	0.361	128.7	(30.7)	129.5	(30.9)	0.309
Heart Rate (mean, SD)	86.7	(22.2)	87.9	(21.9)	86.2	(22.3)	<0.001	91.2	(24.2)	92.1	(26.3)	0.185
Respiratory Rate (mean, SD)	20.3	(6.9)	20.3	(6.7)	20.3	(7.0)	0.833	21.3	(7.3)	21.5	(8.2)	0.207
Oxygen Saturation (mean, SD)	96.1	(7.9)	96.2	(7.3)	96.0	(8.0)	0.001	97.4	(5.9)	97.3	(5.9)	0.544
GCS ISS (Median, IQR)	15	(15-15)	15	(15-15)	15	(15-15)	n/a	15	(1415)	15	(14-15)	n/a
Alive at 30 days (n,%)	66159	(94.5)	17084	(94.0)	49075	(94.6)	0.001	2657	(92.3)	4396	(90.0)	0.01

Table 2 and 3 show that trapped female and male patients demonstrated significant differences in the incidence of thoracic and spinal injuries. Tension pneumothorax was more common in male patients and dens fractures were more common in female patients (both p<0.0001). Spinal cord injuries were also more common in female patients (p=0.038). When trapped, male patients were more likely to suffer from head, face, thoracic and limb injuries (all p<0.0001, Table 3), while female patients were more likely to have pelvic (p<0.0001) and spinal injuries (p<0.001). The incidence of abdominal injuries was similar in female and male patients.

Table 2: Significant injuries by sex for trapped casualties

	Female	%	Male	%	P value
Pelvic ring fracture with blood loss >20%	23	0.8	48	1.0	0.394
Blood loss>20% (%)	114	4.0	161	3.3	0.139
Tension pneumothorax (%)	26	0.9	92	1.9	<0.0001
Multiple spinal fractures (%)	429	14.9	649	13.3	0.54
Dens fracture (%)	85	3.0	79	1.6	<0.0001
Spinal compression fracture grade 2/3 (%)	66	2.3	75	1.5	0.022
Unstable spinal fracture (%)	276	9.6	441	9.0	0.43
Spinal cord injury (%)	218	7.6	308	6.3	0.038

Injuries are not mutually exclusive; patients may have more than one qualifying injury

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Table 3: Injury site by sex for trapped casualties

	Female	%	Male	%	P value
Head AIS 3+	578	20.1	1318	27.0	<0.0001
Face AIS 3+	6	0.2	46	0.9	<0.0001
Thoracic AIS 3+	1438	49.9	2721	55.8	<0.0001
Abdomen AIS 3+	355	12.3	595	12.2	0.87
Spine AIS3+	359	12.5	485	9.9	0.001
Pelvic AIS 3+	420	14.6	475	9.7	<0.0001
Limb AIS 3+	778	27.0	1744	35.8	<0.0001

Injuries are not mutually exclusive; patients may have more than one qualifying injury

Figure 2 demonstrates the interaction between adjusted mortality, trapped status and age. This analysis adjusts for the interaction between age and sex, ISS, GCS and the Charlson Comorbidity Index. In this adjusted analysis, trapped male patients were more likely to die but the 95% confidence intervals overlapped between the male and female groups for all age categories.

Figure 3 displays the interaction between probability of entrapment, sex and age. Female patients were more likely to be trapped in all the age groups considered except in patients aged 80 and over.

Discussion

This is the largest analysis to date of sex-disaggregated data for trauma patients following an MVC and confirms significant differences in injury patterns and trapped status between female and male patients.

The explanations for these differences are likely to include both reasons pertaining to biological sex e.g. physical size, muscle mass, hormonal differences and reasons pertaining to gender such as driving behaviours, post-collision behaviours, and responses by emergency responders such as decisions related to extrication.

Female patients in this analysis had a lower ISS and tended to be older than male patients. These differences were more apparent in those patients that were trapped. The recorded physiological observations are broadly similar between sexes.

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There are gender-related differences that may contribute to the observed differences. Men drive more miles, faster, in a riskier manner and more frequently have accidents, resulting in the higher injury burden and mortality as seen in this analysis and elsewhere [10–13]. Women make up a higher proportion of older drivers [14]. Older women are more likely than men of equivalent age to be killed or seriously injured in collisions, after controlling for miles driven; whereas young men have the highest risk of serious injury or death per million miles driven [11].

Trapped male patients were more likely to have severe injuries of the head, face, chest (including tension pneumothorax) and limbs, with female patients more likely to have injuries of the vertebrae, spinal cord and pelvis. No statistically significant differences were found between trapped female and male patients in relation to pelvic ring injuries with blood loss, multiple spinal fractures or abdominal injuries.

Differences in injuries may be accounted for by i) differences in car usage, kinematics, and mechanism of injury (MOI), ii) differences in effectiveness and availability of safety systems and iii) differences in biological propensity to certain injury types.

Difference in kinematics and resultant mechanism of injury. An analysis of the UK-based STATS-19 MVC registry demonstrates that male drivers are more likely to have MVCs whilst travelling forwards (64.2% vs 56.5%) whereas female drivers are more likely to have collisions whilst manoeuvring (16.1% vs 11.9%) or turning (10.7% vs 8.4%). Similar findings are reported in the United States, with female patients more likely to be involved in a side impact MVC and male patients more likely to have a frontal impact [15]. Side impact MVCs result in a transfer of energy to the patient that is more likely to cause significant spinal injury [16]. Side impacts are also a common cause of lateral compression fractures of the pelvis [17,18] which may explain the finding of an increased prevalence of these injuries in female patients. It is rare for lateral compression fractures of the pelvis to be associated with significant bleeding which perhaps accounts for the higher rate of pelvic fractures in female patients but not a high rate of pelvic fractures with significant blood loss [19].

Male patients experience a higher rate of frontal collisions, which may account for the increased rate of head, face and chest injury found in this study, through interactions and resultant energy transfer with the steering wheel and/or air bag [20,21]. The higher rate of male drivers and their interactions with the pedals and the “bracing” experienced by drivers pre-collision may explain the higher rate of limb injury seen in male patients in this study [22,23].

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Differences in availability and effectiveness of safety systems. Safety systems are less effective for passengers than drivers and are optimised to minimise energy transfer from frontal collisions [22,24,25].

It has been previously demonstrated that women are more likely to be compliant with safety systems such as seat belts than men and as a result have less risk of multiple and severe injuries and their associated mortality [26,27]. However, the safety features incorporated in modern cars are less likely to be effective for women. Current mandatory crash testing uses a scaled-down 50th centile male mannequin to represent 5th percentile females and are not modelled to account for anthropometric differences between females and males [28–31]. This systemic bias, with cars developed, tested and safety-rated using primarily an anatomically correct, weighted and biomechanically-matched male mannequin has led to the development of safety systems which are likely to be more effective for males than females. For example, whiplash protection systems are significantly more effective at preventing injury in men than women [29,32]. Comparison of female and male dummies demonstrates higher biomechanical response in the female dummy in the neck region which may offer some explanation for the increased rate of spinal fractures in female patients found in our study [33].

Moreover, female patients are more likely to drive and be injured in smaller cars, with less efficient safety systems. Smaller cars are associated with a greater injury burden and may account for some of the sex-related differences seen in this study [34].

Female patients are biologically prone to certain injury types. The intersection of age, biological differences, female propensity to injury and medical conditions such as osteoporosis may further account for some of the differences in injuries seen in this analysis [35]. Females and males differ physically in ways which are pertinent to injury and entrapment in RTCs. They each have unique anthropometry for example: females have wider pelvic measurements and shorter torsos, even controlled for height difference [36]. As such, female pelvic geometry may be more prone to injury following a side impact [37]. A combination of these factors may explain the differences seen in injury patterns in this study; we found a greater proportion of pelvic fractures in females, and a higher rate of head and chest injury in male patients.

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Sex hormones affect body composition. Testosterone contributes significantly greater skeletal muscle mass (8% greater, after correcting for BMI) in males, which does not start to fall until the fifth decade [38]. Female sex hormones are responsible for ligaments in females being more lax, which combined with females' cervical vertebrae being smaller than males of equivalent head size, may explain the greater rate of spinal cord injury in females [39,40]. Post-menopausal changes in bone composition mean that females have a 50% greater loss of bone in old age compared to males, again making them susceptible to fractures as a result of MVC [35].

Female patients were more likely than male patients to be trapped (15.8 vs 9.4%, p<0.0001). The mean age of trapped female patients was significantly higher than trapped male patients; this may influence their own ability to self-extricate due to frailty or relative immobility[41]. An additional possible explanation may include different treatment by rescuers, for example, perhaps being less likely to recommend or facilitate self-extrication for older females. Females are more likely to sit closer to the steering wheel, meaning that less movement intrusion of the dashboard and steering wheel is required to cause entrapment [42]. Furthermore, this study found that female patients are more likely to have injuries of the pelvis and spine and these injuries may prevent self-extrication and increase the frequency of entrapment.

Post-collision behaviour and patient experience differences between female and male patients may contribute to the increased rate of entrapment in females, who are more likely to experience multi-region and widespread pain following a MVC, which may prevent them leaving the vehicle without assistance [43]. TARN does not record whether a patient was physically trapped by vehicle deformation or medically trapped (e.g. by pain) which prevents further analysis within this dataset.

Trapped female patients had a lower ISS than trapped male patients and were less likely to die (7.7% vs 10.0%). However, once the factors in our model were considered (age, sex, ISS, GCS and Charlson Comorbidity Index) no difference in mortality was found between female and male patients (Figure 2).

This study shows that men and women experience different rates of entrapment and different injury patterns when involved in MVCs. This may have implications for the design of car safety systems, so as to protect men and women equally. Likewise, for prehospital clinicians, this work highlights the differences seen in clinical practice when attending MVCs.

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The higher rate of female entrapment seen may in part be explained by this cohort being older and having greater co-morbidity. Current UK extrication dogma still prioritises 'spinal precaution' methods of extrication that involve the patient being passive in the process. A greater focus on self-extrication as a safe alternative to rescue service assisted extrication may in future reduce the number of medically trapped patients.

Not all patients trapped in a MVC were included in this study due to the TARN inclusion criteria. Of note, pre-hospital deaths from the most severe MVCs are not included, nor were patients who received minor injuries but were physically trapped by mechanical deformation of the vehicle. This study was unable to distinguish entrapment due to medical causes (e.g. pain or relative immobility) from physical entrapment due to vehicle deformity, which implies a greater energy transfer collision. This analysis did not discriminate between the type of vehicle (e.g. car or bus/coach or light/heavy goods vehicle) and includes all occupants of vehicles involved in a motor vehicle collision which is a heterogenous group. The "trapped" status recorded on TARN has high data completeness with only 2.4% of patients having this element missing; the route of completion varies between centres but is normally taken from the ambulance service patient report form. The "trapped" definition is open to interpretation and cannot distinguish between type and mode of entrapment. These limitations may hinder our interpretation of trapped status.

Conclusions

Male patients are more severely injured and die as a result of MVC than female patients. Female patients under 80 are more frequently trapped than male patients. Female patients are more likely to have spinal and pelvic injuries and male patients are more likely to have head, face, thoracic and limb injuries. Differences in driving behaviours, kinematics, collision type, position in vehicle, the efficacy of safety systems, biological vulnerability to certain injury types and post-injury behaviour may all have influence on these patterns.

Sex-disaggregated data on mortality, entrapment and injury patterns in motor-vehicle collisions may help to inform vehicle manufacturers, emergency services personnel and road-safety organisations 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. Future work should include appropriate sex- and gender-based analyses designed to shed light on the biological and sociocultural factors that create differential experience and outcomes for women and men involved in motor vehicle collisions.

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Declarations

Ethics approval

TARN data analyses are conducted using anonymised data which is governed by a code of practice approved by the Confidentiality Advisory Group who are appointed by the Health Research Authority as such additional individual ethical approval was not required for this analysis in the UK. The Faculty of Health Sciences Human Research Ethics Committee granted ethical approval for this study, Ref 180/2021.

Consent for publication

Not applicable.

Data availability statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Contributors

TN, LW, SH, RF, JS and WS contributed to the conception and study design, analysis and interpretation of data, drafting and revising the manuscript. OB contributed to the analysis and interpretation of the data and critically revised the manuscript. All authors read and approved the final manuscript.

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Figures tiles and legends:

Figure 1: Study profile

Figure 2: Adjusted mortality and age
Error bars = 95% Confidence Intervals.

Figure 3: Probability of entrapment and age
Error bars = 95% Confidence Intervals.

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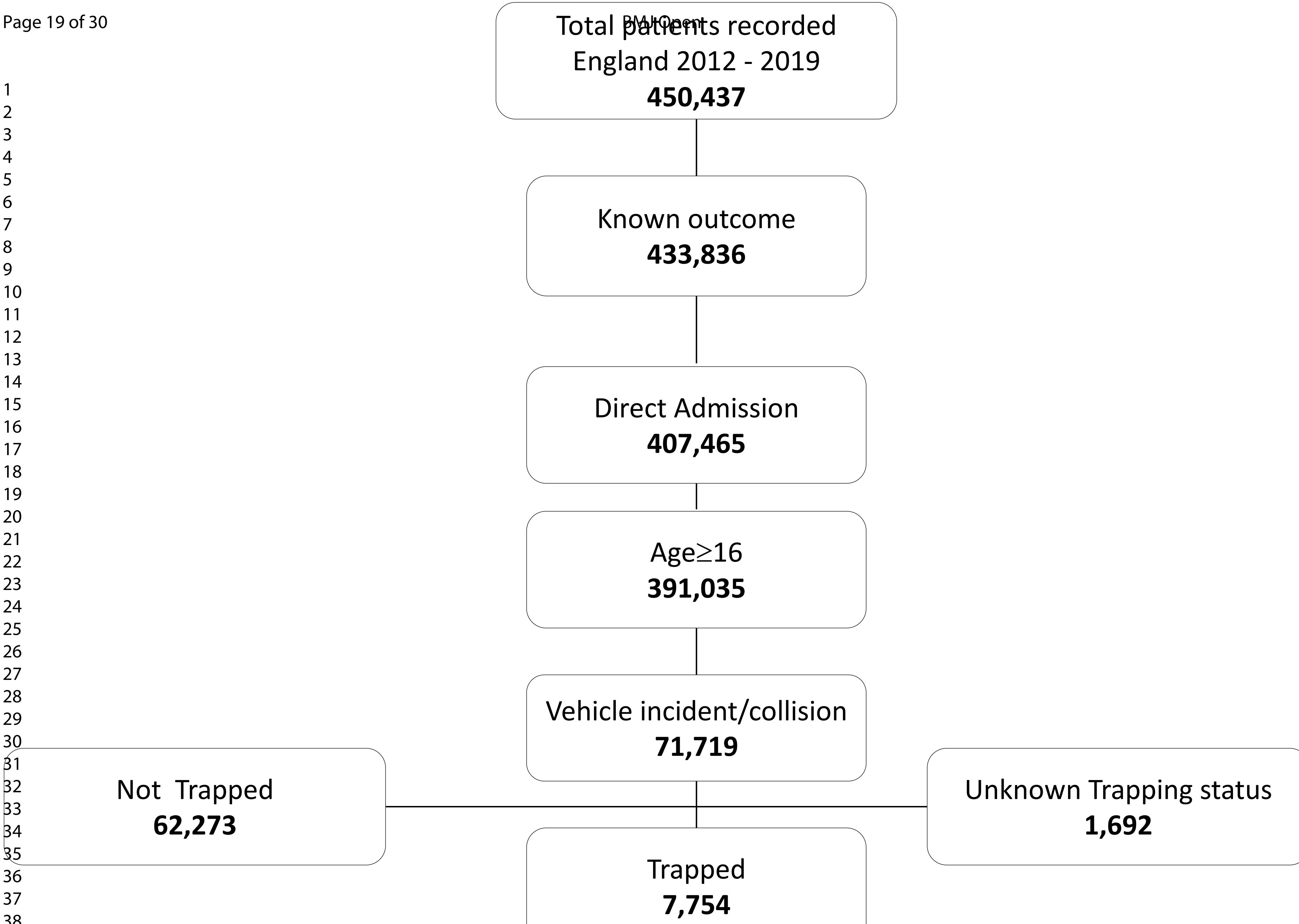
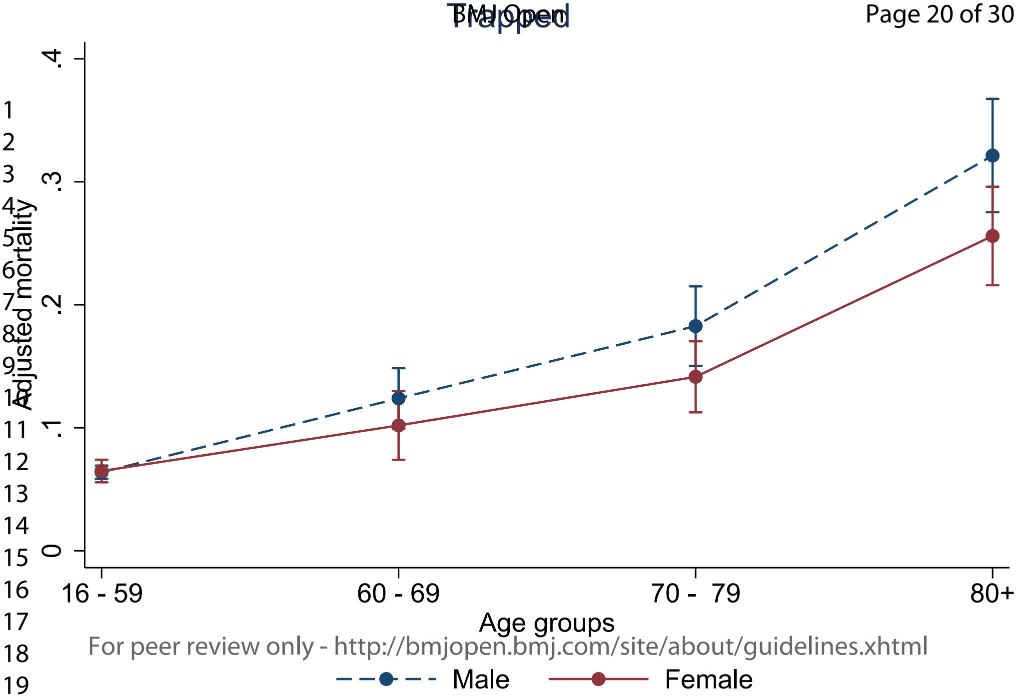

Total patients recorded
England 2012 - 2019
450,437
Known outcome
433,836
Direct Admission
407,465
Age≥16
391,035
Vehicle incident/collision
71,719
Not Trapped
62,273
Unknown Trapping status
1,692
Trapped
7,754



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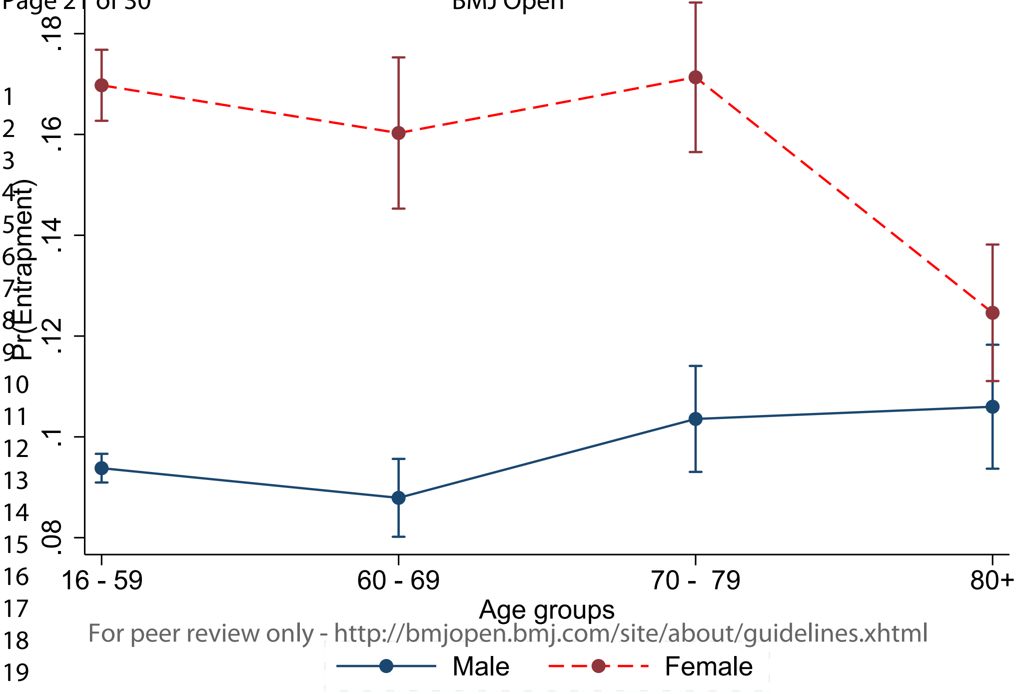
.18
.16
.14
.12
.1
.08
Pr(Entrapment)
16 - 59
60 - 69
70 - 79
80+
Age groups
Male
Female

Characteristics and Mortality by Age 2012 - 2019 for Unknown trapped Status

			16 - 59	60 - 69
gender	Male	Count	956	98
		Column N %	74.6%	61.6%
	Female	Count	325	61
		Column N %	25.4%	38.4%
	Total	**Count**	**1281**	**159**
		Column N %	**100.0%**	**100.0%**
ISS	Median		16	17
	Percentile 25		9	9
	Percentile 75		26	24
prehosp_SBP	Mean		127	135
	Standard Deviation		28	32
prehos[_Pulse	Mean		91	88
	Standard Deviation		26	25
prehosp_RR	Mean		20	19
	Standard Deviation		8	6
prehosp_OxygenSat	Mean		96	95
	Standard Deviation		10	6
GCS	Count		1281	159
	Median		15	15
	Percentile 25		14	15
	Percentile 75		15	15
Alive	Count		1185	147
	Column N %		92.5%	92.5%
Dead	Count		96	12
	Column N %		7.5%	7.5%

		Driver	Passenger	
Male	Count	11468	3366	14834
	%	69.1%	43.9%	61.1%
Female	Count	5132	4301	9433
	%	30.9%	56.1%	38.9%
Total	Count	16600	7667	24267

A chi square test shows highly significant proportion of Male driver than passenger.

		2012	2013	2014	2015
ISS	Median	13	13	13	13
	Percentile 25	9	9	9	9
	Percentile 75	22	22	22	22
Age	Median	42	43	44	44

	Percentile 25		26.0	26.5	27.6	27.3
	Percentile 75		57.9	57.6	59.7	59.1
Head AIS3+		Count	1399	1572	1806	1958
		%	22.6%	22.0%	22.3%	22.4%
Face AIS3+		Count	27	33	37	49
		%	0.4%	0.5%	0.5%	0.6%
Thorax AIS3+		Count	2123	2650	3016	3336
		%	34.4%	37.1%	37.2%	38.1%
Abdo AIS3+		Count	460	561	633	685
		%	7.4%	7.8%	7.8%	7.8%
Spine AIS3+		Count	448	540	669	710
		%	7.3%	7.6%	8.3%	8.1%
Pelvis AIS3+		Count	456	468	535	579
		%	7.4%	6.5%	6.6%	6.6%
Limb AIS3+		Count	1888	2060	2343	2556
		%	30.6%	28.8%	28.9%	29.2%

				2012	2013	2014
Male Driver	ISS	Median		13	13	13
		Percentile 25		9	9	9
		Percentile 75		25	24	24
	Age	Median		42	43	43
		Percentile 25		26.0	26.3	27.0
		Percentile 75		60.3	61.1	60.3
	Head AIS 3+		Count	215	230	263
			%	20.7%	19.7%	20.5%
	Face AIS 3+		Count	9	8	10
			%	0.9%	0.7%	0.8%
	Thorax AIS 3+		Count	454	548	599
			%	43.8%	47.0%	46.7%
	Abdo AIS 3+		Count	86	92	115
			%	8.3%	7.9%	9.0%
	Spine AIS 3+		Count	98	85	135
			%	9.5%	7.3%	10.5%
	Pelvis AIS 3+		Count	67	62	72
			%	6.5%	5.3%	5.6%
	Limb AIS 3+		Count	262	247	280
			%	25.3%	21.2%	21.8%
Male Passenger	ISS	Median		14	16	13
		Percentile 25		9	9	9
		Percentile 75		25	25	22
	Age	Median		27	27	29
		Percentile 25		20.5	21.2	20.9
		Percentile 75		45.7	44.8	49.1
	Head3		Count	79	79	82
			%	23.5%	25.5%	22.3%
	Face3		Count	5	1	3

	%	1.5%	0.3%	0.8%
Thor3	Count	147	138	160
	%	43.8%	44.5%	43.6%
Abdo3	Count	38	22	46
	%	11.3%	7.1%	12.5%
Spine3	Count	38	32	56
	%	11.3%	10.3%	15.3%
Pelv3	Count	28	23	17
	%	8.3%	7.4%	4.6%
limb3	Count	59	64	51
	%	17.6%	20.6%	13.9%

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70 - 79	80+	Total
65	54	1173
44.5%	50.9%	69.3%
81	52	519
55.5%	49.1%	30.7%
146	**106**	**1692**
100.0%	**100.0%**	**100.0%**
17	13	16
9	9	9
25	24	26
143	149	131
35	32	30
90	84	90
22	19	25
21	21	20
6	7	8
95	95	95
9	5	10
146	106	1692
15	15	15
14	15	14
15	15	15
121	85	1538
82.9%	80.2%	90.9%
25	21	154
17.1%	19.8%	9.1%

Year

2016	2017	2018	2019	Total			
13	13	13	13	13	ISS:	p<0.0001	but not clinically sig.
9	9	9	9	9			
24	24	24	22	22	Age:		
46	46	47	48	45		p<0.0001	not clinically sig.

28.2	28.1	29.4	30.5	28.1		
61.1	61.0	62.3	63.3	60.6		
2134	2215	2329	2211	15624	Head:	Test on proportion not significant
22.9%	22.1%	22.8%	21.5%	22.3%		
63	66	68	56	399	Face:	p=0.171
0.7%	0.7%	0.7%	0.5%	0.6%		
3567	3883	4071	4085	26731	Thorax:	p<0.0001 small increase in%
38.2%	38.8%	39.9%	39.7%	38.2%		
704	803	855	831	5532	Abdo:	p=0.388
7.5%	8.0%	8.4%	8.1%	7.9%		
784	819	879	877	5726	Spine:	p=0.027
8.4%	8.2%	8.6%	8.5%	8.2%		
568	727	806	758	4897	Pelvis:	p<0.0001
6.1%	7.3%	7.9%	7.4%	7.0%		
2651	2984	2872	2884	20238	Limb:	p=0.005
28.4%	29.8%	28.2%	28.0%	28.9%		

		Year				
2015	2016	2017	2018	2019	Total	
14	14	14	16	14	14	p=0.033
9	9	9	9	9	9	
24	25	25	25	22	24	
43	42	43	45	45	43	p<0.0001
26.7	28.4	27.6	29.1	29.3	27.6	
64.1	63.1	61.5	63.8	66.0	62.7	
295	342	341	354	332	2372	p=0.496
21.4%	22.7%	22.0%	22.6%	20.8%	21.4%	
9	10	10	6	12	74	p=0.886
0.7%	0.7%	0.6%	0.4%	0.8%	0.7%	
646	747	750	761	764	5269	p=0.168
46.9%	49.6%	48.4%	48.5%	47.8%	47.5%	
136	122	152	168	164	1035	p=0.070
9.9%	8.1%	9.8%	10.7%	10.3%	9.3%	
146	164	174	177	169	1148	p=0.024
10.6%	10.9%	11.2%	11.3%	10.6%	10.4%	
65	69	71	109	83	598	p=0.034
4.7%	4.6%	4.6%	6.9%	5.2%	5.4%	
286	325	333	357	314	2404	p=0.057
20.8%	21.6%	21.5%	22.8%	19.6%	21.7%	
13	16	16	17	16	16	p=0.040
9	9	9	9	9	9	
22	26	25	29	25	25	
27	27	27	29	30	28	p=0.234
21.0	21.4	20.9	21.7	21.8	21.3	
44.2	47.7	43.7	48.3	50.1	46.8	
79	120	108	106	107	760	p=0.484
19.8%	26.0%	22.5%	25.1%	23.1%	23.5%	
6	4	5	6	3	33	p=0.695

1.5%	0.9%	1.0%	1.4%	0.6%	1.0%	
164	222	206	212	200	1449	p=0.156
41.1%	48.2%	43.0%	50.1%	43.2%	44.7%	
46	54	57	60	57	380	p=0.228
11.5%	11.7%	11.9%	14.2%	12.3%	11.7%	
56	59	50	50	68	409	p=0.241
14.0%	12.8%	10.4%	11.8%	14.7%	12.6%	
19	26	38	36	29	216	p=0.139
4.8%	5.6%	7.9%	8.5%	6.3%	6.7%	
101	87	95	80	99	636	p=0.011
25.3%	18.9%	19.8%	18.9%	21.4%	19.6%	

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: p=0.300

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	8/9
Outcome data	15*	Report numbers of outcome events or summary measures over time	9/10

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9/10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11/12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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