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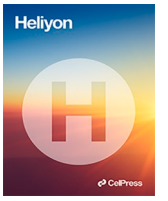

Research article

Does fasting increase rates of trauma in Ramadan? A systematic review

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ABSTRACT

Background: As part of their religious obligation, Muslims abstain from food and drink from dawn until dusk for a 30-day period during Ramadan. Fasting may affect daily functioning, such as increased risk of collision for drivers. A study of the impact of fasting during Ramadan on trauma incidence may allow for the creation of public health campaigns targeting this potential phenomenon. We aimed to determine whether trauma incidence increases during Ramadan, and to characterise the trauma occurring during Ramadan.

Methods: Both published and unpublished literature, along with conference proceedings and reference lists from the selected studies, were searched up until the 1st of July 2023. A narrative synthesis was conducted, and the included studies were evaluated using appropriate tools based on their study design.

Results: Seventeen studies (964,631 subjects) were included. There were methodological concerns pertaining to their low level of evidence and risk of bias. Of nine studies reporting on road traffic accidents (RTAs), six found a higher incidence during Ramadan. Road traffic accidents and occupational injuries (OIs) were more likely to occur near or at sunset (marking the end of the fast). Two studies presented conflicting evidence regarding the effect of fasting in Ramadan on sports-associated injuries. Current evidence suggests that falls and violence-related trauma do not occur more frequently during Ramadan, with insufficient evidence to determine the occurrence of other injury mechanisms.

Conclusion: Individuals who fast may be at a higher risk of RTAs and OIs during Ramadan than outside this month. Due to the lack of studies performed in the Americas and Europe, it is unclear whether the findings are applicable to these regions. Current evidence is limited by lack of stratification according to time of trauma occurrence, and high risk of bias.

1. Introduction

Ramadan is one of the most significant periods in the Islamic calendar. During this time, Muslims observe a religious obligation by

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abstaining from food and drink from dawn to dusk for 30 days. The duration of fasting can range from 11 to 18 h per day, depending on geographical location [1]. The timing of Ramadan varies by location and shifts backward by approximately 11 days each year, depending on the lunar cycle.

The reported benefits of fasting include weight loss, cancer prevention, enhanced hormonal regulation, and improved cardiovascular health [2]. However, fasting may affect daily functioning. Drivers may be subject to reduced attention span, reflexes, and cognitive capabilities, increasing the risk of collisions [3]. In athletes, fasting may reduce hepatic and muscular glycogen reserves and lead to dehydration. This may impact recovery following competitive sports, increasing the risk of injury [4,5].

Previous systematic reviews have analysed the effect of Ramadan on the risk of cardiovascular events [6] and on physical sports performance (with no mention of injuries) [7]. No systematic reviews aimed at establishing whether increased trauma incidence occurs during Ramadan have been conducted. Should there be increased trauma incidence during Ramadan, interventions may be developed to address such a potential phenomenon. Moreover, the types of trauma occurring during Ramadan should be explored to better characterise this population. The primary aim of this systematic review was to determine whether trauma incidence increases during Ramadan, including paediatric trauma. The secondary aim was to characterise the common types of trauma occurring during Ramadan.

2. Materials and methods

The reporting of this systematic review adhered to the PRISMA 2020 checklist [8]. The protocol was prospectively registered on PROSPERO (Registration: CRD42023423191). The review was conducted according to this publicly available protocol, which remained unchanged. A narrative synthesis of reported experiences was performed owing to heterogeneity of the data regarding study designs, outcomes reported, and varying geographical regions. Quantitative sensitivity analyses were therefore not performed. Heterogeneity between studies was identified during preliminary literature search.

2.1. Study eligibility

Studies comparing trauma incidence during and outside Ramadan, comparing trauma incidence in fasting and non-fasting groups, or describing the types of trauma occurring during Ramadan, were included. Studies reporting on non-contact injuries were included, as not all traumatic injuries in sports occur as a result of contact. Case series, cross-sectional, and case-control studies were included (both full texts and abstracts). Both retrospective and prospective studies were eligible. Studies were excluded if they pertained to fasting for reasons other than Ramadan. Case reports, systematic reviews and letters to the editor were excluded. Studies were included regardless of subject demographics or language. Two reviewers independently performed eligibility assessment (DAAL, PS).

2.2. Search strategy and data extraction

We conducted searches in the following electronic databases via OVID: MEDLINE, Embase, and Global Health. In addition, we reviewed currently registered studies using the ISRCTN registry, the WHO International Clinical Trials Registry Platform, the UK National Research Register Archive, the National Institute for Health Research Portfolio, and OpenSIGLE. Conference proceedings from the British Orthopaedic Association (BOA), European Federation of National Associations of Orthopaedics and Traumatology (EFORT), and British Trauma Society (BTS) were also searched. Reference lists of included studies were examined (backward-searching), and studies citing the included research were reviewed for eligibility (forward-searching).

The database search was independently performed by two reviewers (DAAL, PS), while data extraction was carried out by three reviewers (DAAL, JA, NC). To ensure quality, the searches were conducted twice, with the final search completed on the 1st of July 2023. The search strategy, detailed in Appendix A, was adapted for each respective database. Extracted data included baseline characteristics such as the number of subjects, sex, age, study location, observation period, and type of trauma. The primary outcome was trauma occurrence, with trauma type as the secondary outcome. Effect measures reported in the studies included were used.

2.3. Methodological appraisal

The level of evidence for the studies was assessed using the March 2009 Oxford Centre for Evidence-Based Medicine: Levels of Evidence, where 5 represents the lowest level (case reports) and 1a the highest level (systematic reviews of randomized-controlled trials) [9]. Risk of bias was evaluated using the Institute of Health Economics quality appraisal checklist for case series [10] and the Downes and Black Tool for cross-sectional studies [11]. The level of evidence and risk of bias for each included study were independently assessed by two reviewers (JA, PS), with a third reviewer (DAAL) resolving any disagreements.

3. Results

3.1. Search results

In total, 6370 records were screened, of which 17 studies were eligible and evaluated 964,631 subjects (Fig. 1, Table 1). Mean subject age ranged from 8.0 to 39.9 years. Thirteen studies reported subject sex, representing 473,810 subjects (390,123 males, 82.3 % and 83,687 females, 17.7 %). Data from 11 Northern Hemisphere countries were included (Table 2).

3.2. Study quality assessment

All identified studies were either case series or cross-sectional studies, corresponding to a level of evidence of four. None of the studies provided justifications for their sample sizes (Table 3). In general, most of the included studies displayed methodological limitations, mainly due to the low level of evidence and concerns related to risk of bias.

3.3. Road traffic accidents

Akman and Kuru analysed emergency department presentations due to injuries from RTAs (collisions between vehicles) and pedestrian strikes (collisions between vehicles and pedestrians) [12]. Of 798 accidents (323 RTAs and 475 pedestrian strikes), only four RTAs (0.5 %) occurred during Ramadan, which was significantly lower than the rest of the year. In addition, RTAs as a result of alcohol were lower in Ramadan. Alsofayan et al. analysed nation-wide data in Saudi Arabia of patients attending the emergency department following a RTA [13]. 8.8 % of 112,188 RTAs, occurred during Ramadan. A higher percentage of accidents occurred during Ramadan compared to other months among males (82.2 % vs. 79.6 %, $P < 0.01$) and non-Saudis (42.7 % vs. 38.9 %, $P < 0.01$). Additionally, the RTA-related mortality rate was significantly higher during Ramadan ($P = 0.04$). There were no significant differences in RTAs across different age groups ($P = 0.6$) or regions of Saudi Arabia ($P = 0.2$). However, the proportion of RTAs occurring at sunset was greater during Ramadan compared to other months (24.5 % vs. 21.5 %, $P < 0.01$).

Mohseni and Molla analysed RTA and fight-related trauma in an eight year period. There were 168,753 admissions, of which 59,085 (35.0 %) were RTAs, with only 8.3 % occurring during Ramadan [14]. The average monthly RTAs were 615.3 and 615.5 during Ramadan and outside of it respectively. There was no significant difference in the average number of monthly RTAs between Ramadan and non-Ramadan months ($P = 0.997$) [14]. Kumar et al. analysed RTAs presenting to emergency departments within a 12-month period [15]. There were 30,274 RTA injuries, of which 6,770 (22.4 %) occurred during Ramadan. Overall, 29,207 injuries (96.5 %) were non-fatal, and the remaining 1067 (3.5 %) were fatal. A greater number of monthly RTA injuries was reported during Ramadan months, and males were involved in a higher number of accidents (83 %). Whether these differences were statistically significant was not reported. Extremity and pelvic girdle injuries were the most common, followed by external injuries, and head and neck injuries (29 % vs 28 % vs 23 %, respectively). Head and neck injuries had the highest mortality rate (53 %), followed by extremity and pelvic girdle injuries (17 % mortality), and external injuries (0 % mortality).

Mehmood et al. retrospectively analysed 163,022 RTAs, of which 8.4 % occurred during Ramadan [16]. A greater mortality rate

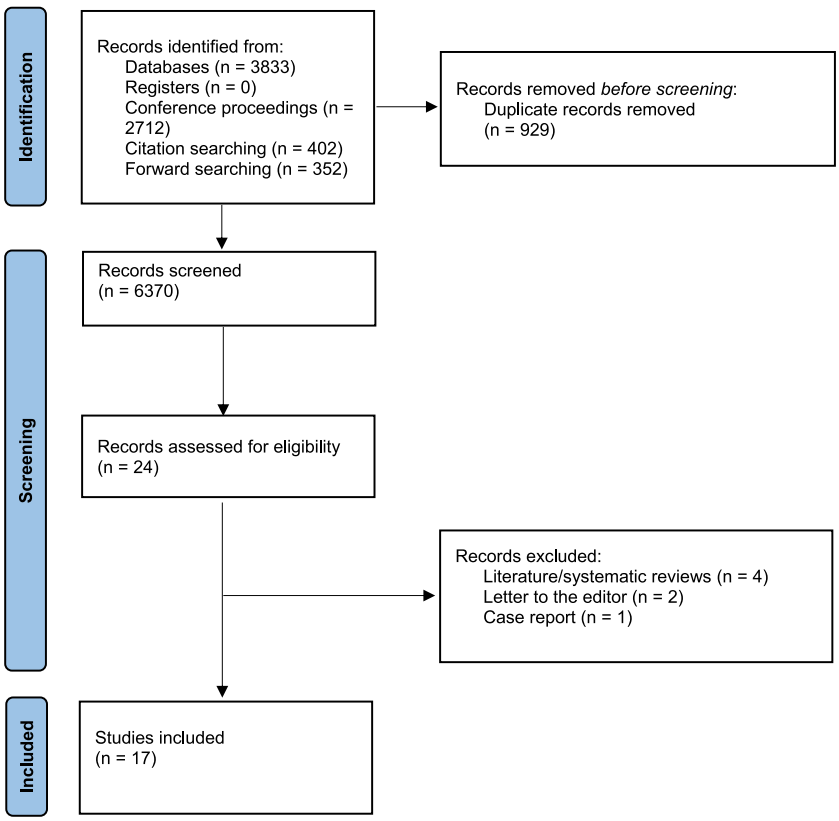

Fig. 1. PRISMA diagram depicting the study collection process.

Table 1
Characteristics of studies included.

Study	Location	Observation period	Season in which Ramadan takes place	Number subjects (males, females)	Type of trauma	Mean subject age (years) ± SD
Akman and Kuru, 20201 [2]	Çanakkale Province, Turkey	December 2019–May 2020 Six months (one Ramadan month, five non-Ramadan months)	Spring	798 (596, 202)	RTAs: 323 (40.5 %) PS: 475 (59.5 %)	39.9 ± 15.9
Alnasser et al., 2012 [24]	Jeddah, Saudi Arabia	May 2001–May 2009 95 months (8 Ramadan months and 87 non-Ramadan months)	Summer, autumn, winter	non-Ramadan months: 3414 (2537, 877) Ramadan months: 352 (266, 86)	non-Ramadan months: Blunt (2682, 78.6 %), penetrating gunshot (28, 0.8 %), penetrating stab wound (87, 2.5 %), penetrating other (229, 6.7 %) Ramadan months: Blunt (270, 76.6 %), penetrating gunshot (3, 0.9 %), penetrating stab wound (5, 1.4 %), penetrating other (32, 9.1 %)	Ramadan months: 8.04 non-Ramadan months: 8.07
Aldoais et al., 2020 [25]	Sana'a, Yemen	July 2016 A single Eid	Summer	160 (160, 0)	Ocular Trauma (160)	9.59 ± 4.92
Alsofayan et al., 2022 [13]	Saudi Arabia	January 2021–December 2021 12 months (one Ramadan month, 11 non-Ramadan months)	Spring	non-Ramadan months: 102266 (81304, 15610, 5290 unknown) Ramadan month: 9922 (8156, 1255, 508 unknown)	RTAs: 112188	NR
Chamari et al., 2012 [21]	Tunisia	August 2010–September 2010, Agust 2011 3 months of two consecutive years. Football players followed four weeks prior, during, and after Ramadan each time	Summer	Before Ramadan: 9 During Ramadan: 19 After Ramadan: 9	Injury rates (injuries per 1000h exposure) in fasting vs non-fasting group: Contact injury: 1.3 vs 0.7 Non-contact injury: 6.8 vs 3.2 Overuse injury (during training): 5.6 vs 3.2 Overuse injury (during matches): 1.2 vs 0	24 ± 4
Eirale et al., 2013 [22]	Qatar	August 2008–April 2011 36 months (3 Ramadan months and 33 non-Ramadan months)	Summer	Muslims: 462 (462, 0) non-Muslim: 65 (65, 0)	Injury rates (injuries per 1000h exposure) in Muslims vs non-Muslims: Matches: 17.5 vs 16.7 Training: 2.7 vs 3.3 Overall: 4.4 vs 5.0	Muslims: 26.2 ± 5.0 non-Muslims: 28.9 ± 4.9
Mohseni and Molla, 2016 [14]	Kermanshah, Iran	2001–2008 8 Years (8 Ramadan months, 88 non-Ramadan months)	Summer, autumn	Total: 168753 (NR) Ramadan months: 13048 (NR) Non-Ramadan months: 155705 (NR)	Ramadan months: RTAs: 4922 Physical aggression: 1168 Gunshot: 101 Falling from height: 6857 Non-Ramadan months: RTAs: 54163 Physical aggression: 14759 Gunshot: 3356 Falling from height: 83607	NR
Kumar et al., 2016 [15]	Karachi, Pakistan	January 2014–December 2014 12 months (2 Ramadan months, 10 non-Ramadan months)	Summer	Total: 30274 (25263, 5011) Ramadan months: 6770 (NR) Non-Ramadan months: 23493 (NR)	RTAs: 30274	NR
Riccò et al., 2019 [23]	Autonomous Province of Trento, Italy	2000–2013 156 months (13 Ramadan months, 143 non-Ramadan months_	Summer, autumn	Total: 147024 (114470, 32557)	Falls to a lower level: 8543 Falls to same level: 23448 Manual handling: 20050 Use of tools, machinery: 28558 Others: 66458	NR

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Table 1 (*continued*)

Study	Location	Observation period	Season in which Ramadan takes place	Number subjects (males, females)	Type of trauma	Mean subject age (years) ± SD
Mehmood et al., 2015 [16]	Karachi, Pakistan	September 2006–September 2011 60 months (5 Ramadan months, 55 non-Ramadan months)	Summer	Total: 163022 (142289, 20633, 100 unknown) Non Ramadan: 149382 (130364, 18922, 96 unknown) Ramadan: 13640 (11925, 1711, 4 unknown)	RTAs: 163022	NR
Tahir et al., 2013 [17]	Punjab, Pakistan	January 2011 – Agust 2011 8 months (one Ramadan month, 7 non-Ramadan months)	Summer	Total = 92,587 (NR) During Ramadan: 14788 (11633, 3155).	Motorcycle accidents: 9101 (57 %) Car crashes: 2118 (13 %) Rickshaw crashes:1407 (9 %) Coach/van crashes: 514 (3 %), Bus crashes: 352 (2 %)	NR
Kalafat et al., 2016 [18]	Turkey	January 2011–December 2011 12 months (one Ramadan month, 11 non-Ramadan months)	Summer	Total number = 238074. non-Ramadan months: 213551 Ramadan = 24523	RTAs	NR
Khammash et al., 2006 [19]	Irbid, Jordan	October 2004–November 2004 2 months (one Ramadan month, one non-Ramadan month)	Autumn	Total: 228 (178, 50) Ramadan: 96 non-Ramadan month: 132	RTAs	23
Kavalci et al., 2013 [27]	Turkey	Agust 2011, October 2011 Two months (one Ramadan month, and one non-Ramadan month)	Summer	Total: 607 Ramadan: 355 (267, 88) non-Ramadan: 252 (186, 66)	Ramadan: RTAs: 60 Pedestrian injury: 43 Violence: 64 Falling: 95 Other: 70 non-Ramadan: RTAs: 75 Pedestrian injury: 32 Violence: 81 Falling: 26 Other: 38	Ramadan: 35.4 ± 16.6 Non-Ramadan: 34.4 ± 13.5.
Sawaya et al., 2021 [26]	Beirut, Lebanon	May 2016–July 2016, May 2017–July 2017 12 months (1 Ramadan month, 11 non-Ramadan months)	Summer	160 Ramadan: 71 non-Ramadan: 49	Paediatric trauma	NR
Shanks et al., 1994 [20]	Jeddah, Saudi Arabia	July 1990–June 1991 12 months (1 Ramadan month, 11 non-Ramadan months)	Spring	361 (291, 70)	RTAs	NR
Tlemissov et al., 2017 [28]	Semey, Kazakhstan	2010–2012 36 months (3 Ramadan months, 33 non-Ramadan months)	Summer	6065 (2000, 4065)	Falls: 4988 (1515, 3473) Exposure to inanimate mechanical forces: 465 (219, 246) Exposure to animate mechanical forces: 279 (123, 156) RTAs: 141 (53, 88) Contact with heat and hot substances: 94 (42, 52)	Median age: Male: 68 Female: 71

Key:
RTAs: road traffic accidents.
PS: pedestrian strikes.
NR: not reported.

from RTAs was reported during Ramadan months ($P < 0.001$). More RTAs occurred at 6pm during Ramadan than outside Ramadan, which corresponds to the time near to when the fast is broken. Tahir et al. retrospectively analysed 92,587 RTAs over eight months [17]. The highest number was reported during Ramadan (12,969 RTAs, *P*-value not reported). The majority of RTAs occurred in the

Table 2
Number of subjects and trauma evaluated according to country.

Study location	Number of studies	Number of subjects	Trauma evaluated
Pakistan	3 [15–17]	285883	Road traffic accidents
Saudi Arabia	3 [13,20,24]	116315	Road traffic accidents
Turkey	3 [12,18,27]	239479	Road traffic accidents
Iran	1 [14]	168753	Road traffic accidents
Jordan	1 [19]	228	Road traffic accidents
Yemen	1 [25]	160	Ocular trauma
Qatar	1 [22]	527	Sports injuries
Tunisia	1 [21]	37	Sports injuries
Italy	1 [23]	147024	Occupational injuries
Kazakhstan	1 [28]	6065	Emergency department trauma admissions
Lebanon	1 [26]	160	Paediatric emergency department trauma admissions

afternoon, between 2 p.m. and 6 p.m. (5516, 43 %).

Kalafat et al. reported an average 25,857 RTAs over a year [18]. During Ramadan, the number of RTAs was 28,447 (9.1 %), higher than the average for other months (OR = 1.11, 95 % CI: 1.09 to 1.13, $P < 0.001$). Accidents resulting in fatalities and injuries were higher during Ramadan, while incidents causing material damage were less frequent. In Ramadan, 339 accidents resulted in death (1.2 %), compared to a total of 2,735 deaths in the non-Ramadan months (1 %) (OR = 1.24, 95 % CI: 1.11 to 1.39, $P < 0.001$). Additionally, 12,838 of accidents resulted in injuries during Ramadan (45.1 %), while 115,913 (40.8 %) resulted in injury during the non-Ramadan period (OR = 1.20, 95 % CI: 1.17 to 1.23, $P < 0.001$). There was a lower number of drunk-driving penalties during than outside Ramadan (OR = 0.36, 95 % CI: 0.35 to 0.38, $P < 0.001$).

Khammash et al. analysed RTAs occurring over two months (228 patients): 96 during Ramadan, 132 outside of it [19], with a lower number of accidents during the former ($P = 0.004$). However, there was no difference in the severity of injuries, nor in the number of injuries based on the time of day or the day of the week.

Shanks et al. analysed all RTA over a 12 month period [20]. 361 RTAs occurred in total, of which 70 (19.4 %) occurred during Ramadan, the highest number of monthly RTAs throughout the study period. The most common injury suffered was head injuries (101, 22.05 %), followed by multiple trauma (97, 21.17 %) and facial injuries (49, 10.69 %).

3.4. The effect of Ramadan on sports-associated injuries

Chamari et al. reported on 37 male professional football players in Tunisia for 3 months of two consecutive years [21]. They were followed for four weeks prior, during, and after Ramadan. During Ramadan, the fasting group experienced more overuse and non-contact injuries than outside of it. The non-fasting group did not experience such differences. P-values were not reported, nor were the number of subjects in each group.

Eirale et al. analysed injury rates in football players during and outside of Ramadan over three consecutive seasons [22]. Overall injury rate during Ramadan was 4.4 versus 5.0 injuries per 1000 h outside of Ramadan ($P > 0.05$). When analysing Muslims and non-Muslims separately, neither exhibited a higher injury rate in Ramadan compared to non-Ramadan. Muslims experienced a uniform injury rate throughout the Islamic calendar, without a higher injury rate during Ramadan. Non-Muslims exhibited a higher injury rate than Muslims during matches, both in Ramadan and outside of it ($P < 0.05$). Upon multi-variate adjustment, the odds ratio (OR) of injury among non-Muslims compared to Muslims during Ramadan was 3.7 (95 % confidence interval [CI]: 1.7 to 7.9, P = 0.001). Injury cause, mechanism, and severity were not different between during and outside Ramadan, nor between groups.

3.5. The effect of Ramadan on occupational injuries

Riccò et al. analysed data on OIs in an Italian province across 13 years. Of 147,024 patients suffering from OIs, 92.5 % were European, and 4.2 % were Eastern Mediterranean [23]. Occupations pertained to industrial settings, including property and business services (25,576, 17.4 %), manufacturing (27,524, 18.7 %), transport, storage and post (5,223, 3.6 %), wholesale and retail trade (6,099, 4.1 %), agriculture (6,726, 4.6 %), construction (22,346, 15.2 %), services (5,196, 3.5 %) and others (48,256, 32.8 %). These tally to 146,946 rather than the reported 147,024. Both cohorts included participated in all professions listed. Overall, 8.9 % OIs occurred during Ramadan. Eastern Mediterraneans experienced a higher percentage of OIs than Europeans during Ramadan (9.9 % vs 8.9 %, $P = 0.004$). There was a greater number of OIs at 13.00–18.00 during Ramadan (46.2 % vs 39.0 %, $P = 0.004$). Odds ratio for risk of OI during Ramadan was 1.131 (95 % CI: 1.038 to 1.231, $P = 0.005$). No differences in OIs between Ramadan and non-Ramadan periods were noted in different industrial settings nor in the type of injury inflicted.

3.6. Paediatric trauma

Alnasser et al. analysed trauma in the paediatric age group during and outside Ramadan [24]. Whether the admitted patients were observing Ramadan fasting was not reported. Average episodes per non-Ramadan month was 39.2, compared to 44 in Ramadan months ($P = 0.79$). Both groups had equal median injury severity scores. Mean BMI was significantly lower in Ramadan trauma

Table 3
Results of risk of bias assessment.

Appraisal tool for cross-sectional studies (Downes et al., 2016)									
Questions	Tahir et al., 2013	Kalafat et al., 2016	Khammash et al., 2005	Mohseni and Mollas, 2018	Kumar et al., 2016	Riccò et al., 2019	Mehmood et al., 2015	Tlemissov et al., 2017	Akman and Kuru al, 2020
Were the aims/objectives of the study clear?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the study design appropriate for the stated aim(s)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the sample size justified?	No	No	No	No	No	No	No	No	No
Was the target/reference population clearly defined? (Is it clear who the research was about?)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the sample frame taken from an appropriate population base so that it closely represented the target/reference population under investigation?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the selection process likely to select subjects/ participants that were representative of the target/reference population under investigation?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were measures undertaken to address and categorise non-responders?	No	No	No	No	No	No	No	No	No
Were the risk factor and outcome variables measured appropriate to the aims of the study?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the risk factor and outcome variables measured correctly using instruments/ measurements that had been trialled, piloted or published previously?	No	No	No	No	No	Yes	Yes	Yes	Yes
Is it clear what was used to determined statistical significance and/or precision estimates? (e.g. p-values, confidence intervals)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Were the methods (including statistical methods) sufficiently described to enable them to be repeated?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Were the basic data adequately described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Does the response rate raise concerns about non-response bias?	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
If appropriate, was information about non-responders described?	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Were the results internally consistent?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the results presented for all the analyses	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

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Table 3 (*continued*)

Appraisal tool for cross-sectional studies (Downes et al., 2016)									
Questions	Tahir et al., 2013	Kalafat et al., 2016	Khammash et al., 2005	Mohseni and Mollas, 2018	Kumar et al., 2016	Riccò et al., 2019	Mehmood et al., 2015	Tlemissov et al., 2017	Akman and Kuru al, 2020
described in the methods?									
Were the authors' discussions and conclusions justified by the results?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the limitations of the study discussed?	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Were there any funding sources or conflicts of interest that may affect the authors' interpretation of the results?	No	No	Not reported	Not reported	Not reported	No	Not reported	No	No
Was ethical approval or consent of participants attained?	Not reported	Not reported	Not reported	Yes	Not reported	Yes	Not reported	Yes	Yes
Risk of bias assessment	High	Some concerns	High	Some concerns	High	Some concerns	Some concerns	Some concerns	Some concerns

Appraisal tool for cross-sectional studies (Downes et al., 2016)							Case series quality appraisal checklist (IHE, 2014)		
Questions	Alnasser et al., 2012	Alsofayan et al., 2022	Chamari et al., 2012	Eirale et al., 2013	Sawaya et al., 2021	Shanks et al., 1994	Questions	Kavalci et al., 2013	Aldoais et al., 2020
Were the aims/objectives of the study clear?	Yes	Yes	Yes	Yes	Yes	Yes	Was the hypothesis/ aim/objective of the study clearly stated?	Yes	Yes
Was the study design appropriate for the stated aim(s)?	Yes	Yes	Yes	Yes	Yes	Yes	Was the study conducted prospectively?	Yes	Yes
Was the sample size justified?	No	No	No	No	No	No	Were the cases collected in more than one centre?	No	Yes
Was the target/reference population clearly defined? (Is it clear who the research was about?)	Yes	Yes	Yes	Yes	Yes	Yes	Were patients recruited consecutively?	No	No
Was the sample frame taken from an appropriate population base so that it closely represented the target/reference population under investigation?	Yes	Yes	Yes	Yes	Yes	Yes	Were the characteristics of the patients included in the study described?	Yes	Yes
Was the selection process likely to select subjects/participants that were representative of the target/reference population under investigation?	Yes	Yes	Yes	Yes	Yes	Yes	Were the eligibility criteria (i.e., inclusion and exclusion criteria) for entry into the study clearly stated?	Yes	Yes
Were measures undertaken to address and categorise non-responders?	No	No	No	No	No	No	Did patients enter the study at a similar point in the disease?	No	Yes
Were the risk factor and outcome variables measured	Yes	Yes	Yes	Yes	Yes	Yes	Was the intervention of interest clearly described?	Yes	Yes

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Table 3 (*continued*)

Appraisal tool for cross-sectional studies (Downes et al., 2016)							Case series quality appraisal checklist (IHE, 2014)		
Questions	Alnasser et al., 2012	Alsofayan et al., 2022	Chamari et al., 2012	Eirale et al., 2013	Sawaya et al., 2021	Shanks et al., 1994	Questions	Kavalci et al., 2013	Aldoais et al., 2020
appropriate to the aims of the study?									
Were the risk factor and outcome variables measured correctly using instruments/ measurements that had been trialled, piloted or published previously?	Yes	Yes	Yes	No	Yes	No	Were additional interventions (co-interventions) clearly described?	No	No
Is it clear what was used to determined statistical significance and/or precision estimates? (e.g. p-values, confidence intervals)	Yes	Yes	Yes	Yes	Yes	No	Were relevant outcome measures established a priori?	Yes	Unclear
Were the methods (including statistical methods) sufficiently described to enable them to be repeated?	Yes	Yes	Yes	Yes	Yes	No	Were outcome assessors blinded to the intervention that patients received?	No	Unclear
Were the basic data adequately described?	Yes	Yes	Yes	Yes	Yes	Yes	Were the relevant outcomes measured using appropriate objective/subjective methods?	No	Yes
Does the response rate raise concerns about non-response bias?	Not reported	Not reported	Not reported	No	Not reported	Not reported	Were the statistical tests used to assess the relevant outcomes appropriate?	Yes	Yes
If appropriate, was information about non-responders described?	Not reported	Not reported	Not reported	No	Not reported	Not reported	Was follow-up long enough for important events and outcomes to occur?	N/A	Yes
Were the results internally consistent?	Yes	Yes	Yes	Yes	Yes	Yes	Were losses to follow-up reported?	N/A	No
Were the results presented for all the analyses described in the methods?	Yes	Yes	Yes	Yes	Yes	No	Did the study provide estimates of random variability in the data analysis of relevant outcomes?	No	No
Were the authors' discussions and conclusions justified by the results?	Yes	Yes	Yes	Yes	Yes	Yes	Were the adverse events reported?	No	No
Were the limitations of the study discussed?	Yes	Yes	No	Yes	Yes	No	Were the conclusions of the study supported by results?	Yes	Yes
Were there any funding sources or conflicts of interest that may affect the authors' interpretation of the results?	No	No	Not reported	No	No	Not reported	Were both competing interests and sources of support for the study reported?	No	No
Was ethical approval or consent of participants attained?	Yes	Yes	Yes	Yes	Yes	Not reported			
Risk of bias assessment	Some concerns	Some concerns	High	Some concerns	Some concerns	Some concerns		High	High

patients (17.3 kg/cm^2) than in non-Ramadan trauma patients (19.2 kg/cm^2) ($P = 0.004$). A higher percentage of patients required ventilation during Ramadan (3.9 % vs 2.1 %, $P = 0.03$). However, there was no difference in mean number of days for which ventilation was needed ($P = 0.94$). Whether difference in mortality between groups was statistically significant was not reported. Neurological and vascular injuries occurred more frequently during Ramadan compared to outside of it (P = 0.021 and P = 0.031, respectively).

Aldoais et al. reported on 160 paediatric ocular trauma cases occurring during Eid festivities in Yemen [25]. 95 % of injuries took place in the street, with the remaining occurring at home. Hyphema was the commonest finding (78.8 %), followed by a ruptured globe (10.0 %), corneal abrasion (3.1 %), and limbal ischemia (1.9 %). Whether occurrence of ocular trauma was more common in Eid than during other times of the year was not reported.

Sawaya et al. analysed data from a paediatric emergency department over 12 months [26]. Of 5,711 patients, 160 (2.8 %) were trauma-related. Trauma-related complaints were significantly greater during Ramadan (2.9 % vs 1.8 %, $P = 0.005$). There was no significant difference in the frequency of trauma occurring during fasting hours (04:00–20:00) between Ramadan and non-Ramadan months (2.0 % vs 1.3 %, P = 0.15).

3.7. The effect of Ramadan on emergency departments trauma admissions

Kavalci et al. compared adult trauma admissions during Ramadan (n = 355) and the subsequent month (n = 252) [27]. There were no differences in mean age nor in percentage of males between the two groups. During Ramadan, the most frequent period for admissions was from 04:01 p.m. to 08:00 p.m. (41 %), while fewer admissions occurred from 08:01 p.m. to 12:00 a.m. In the control group (non-Ramadan month), the most common admission time period was from 04:01 p.m. to 08:00 p.m. (23.4 %), with fewer admissions occurring from 04:01 a.m. to 08:00 a.m. (P = 0.000). Falling was the most frequent cause of trauma during Ramadan (29.4 %), while violence was the most frequent cause during the non-Ramadan period (39.8 %). A higher percentage of patients were admitted to hospital during Ramadan (17.5 % vs 11.1 %, $P = 0.029$). In addition, a lower mean blood alcohol level was noted during Ramadan (23.8 vs 43.4 mg/dl, $P = 0.006$), with no difference in percentage of admissions attributable to RTAs during and outside of Ramadan (23.4 % vs 29.8 %, $P = 0.09$) or pedestrian injury (12.1 % vs 12.7 %, $P = 0.74$). However, violence-related trauma was less common in Ramadan (18.0 % vs 32.1 %, $P = 0$), whilst falling-related trauma was more common during the Islamic holiday (26.8 % vs 10.3 %, $P = 0.000$). Kavalci et al. reported on p values equal to 0 on two occasions, which suggests a zero chance of statistical error, which cannot be true.

Tlemissov et al. analysed trauma data on patients over 60 years of age over a three-year period [28]. A total of 6,065 injuries occurred during Ramadan. The majority of injuries incurred during Ramadan were from falls in both males and females (75.8 % vs 85.4 %, respectively), followed by exposure to inanimate mechanical forces (11.0 % vs 6.1 %), exposure to animate mechanical forces (6.2 % vs 3.8 %), RTAs (2.7 % vs 2.2 %), and contact with heat (2.1 % vs 2.6 %).

4. Discussion

This review identified multiple mechanisms of trauma during Ramadan. Nine studies reported on RTAs, of which six found a higher occurrence during Ramadan [13,15–18,20]. However, three of these did not report whether differences were statistically significant, which limits what conclusions may be drawn [15,17,20]. Individuals who fast may be at a higher risk of RTAs during Ramadan. This may reduce attention span, reflexes, and cognitive capabilities, increasing the risk of collisions [18]. These may explain the higher mortality due to RTAs during Ramadan observed in three studies [13,16,18]. Further work could measure the number of traffic accidents per number of kilometres driven during and outside of Ramadan (using fuel sales as a proxy) to more reliably evaluate the effect of fasting on RTA incidence.

As reported in three studies [13,16,17] a higher influx of RTAs may be expected during sunset. This marks the break of the fast, and it is the time in which patients have spent the longest time without food intake. Low blood sugar combined with potential haste to break the fast and high traffic during rush hour may explain the increased incidence of RTAs at sunset [13]. Emergency and trauma departments must be able to anticipate this and plan accordingly. However, Ramadan traffic may differ from that outside of Ramadan, as people drive to friends or relatives before the breaking of the fast to celebrate this event together.

Effective public health campaigns are required to mitigate the risk of RTAs during Ramadan. These could focus on raising awareness about the increased risk of accidents due to fasting-related fatigue. Targeted messaging in health centres emphasizing the importance of rest and safe driving practices is required. In addition, collaborations with local mosques and community leaders can be implemented to disseminate educational materials to mitigate the risk of accidents. Similar campaigns may be implemented to address paediatric trauma, and to encourage healthy behaviour in those engaging in sports. However, the uncertainty of evidence owing to risk of bias and conflicting findings warrants further robust research before investing on public health campaigns.

Similarly, a study found that OIs occurred more frequently during Ramadan, with a greater number of OIs at the latter stage of the fast (13.00–18.00) [23]. However, this relies on the assumption that the majority of Eastern Mediterranean inhabitants fast during Ramadan, which may not be accurate. Kavalci et al. reported the most frequent period for trauma admissions was from 04:01 p.m. to 08:00 p.m. during Ramadan (41 %). A lower proportion of trauma admissions occurred during this time interval for non-Ramadan months (23.4 %) [27]. This may be due to decreased blood sugars, attention spans, and reflexes, increasing the risk of trauma at the latter stage of the fast. Further work is required to corroborate this claim.

Regarding the effect of Ramadan on sports-associated injuries, two studies had differing findings [21,22]. However, Eirale et al. had a larger sample size and spanned a longer time period (n = 527, 3 years) than Chamari's (n = 37, 6 months). In addition, Chamari's

study carries a high risk of bias, with concerns including the number of Muslim and non-Muslim players not being reported. Eirale et al. suggest Ramadan may not increase the risk of sports-associated injuries. However this is a single study, and pertains to football only [22]. The uncertainty of this claim is increased by the presence of a systematic review which found Ramadan had no effect on sports performance, with no mention of its effect on injuries [7]. Further research exploring the effect of Ramadan on injury in multiple sports is required, particularly those carrying high demanding endurance and strength. In addition, further work should evaluate the effect of Ramadan on the risk of contact injuries, since these may not be necessarily be considered within the same category of non-contact injuries.

Three studies reported on trauma mechanisms other than RTAs and sports injuries, with conflicting evidence. A study found falls occurred more frequently during Ramadan, with violence-related trauma being less common (n = 607) [27], whereas two others of greater sample sizes found this not to be the case (n = 174,818) [14,28], which strengthens their findings. Whether falls occur more commonly during Eid remains to be established. During Eid, the fast is broken. This may lead to glucose spikes and falls, particularly in individuals with diabetes, which is common in the Muslim population. Further research is required to test this hypothesis. Regarding whether paediatric trauma occurred more frequently during Ramadan, two large studies had conflicting findings [24,26] with further research required. Sawaya et al. found there was no difference in the frequency of trauma occurring during fasting times (04:00–20:00) between Ramadan and non-Ramadan months [26]. It is worth noting that children do not fast during Ramadan until puberty. Therefore, the risk factors for increased incidence of trauma are likely to differ to those observed in adult trauma. These include altered daily routines and increased engagement in outdoor activities.

Circadian rhythm alterations and increased activity at night during Ramadan may lead to children spending more time with family, potentially becoming sleep deprived. These may lead to the reported increased trauma in children during non-fasting times in Ramadan [26]. Eid marks its end, and is associated with festivities, in which pyrotechnics may be used. A single study reported on resulting paediatric ocular trauma [25]. Emergency departments may anticipate these injuries occurring at the end of the Islamic Holiday. However, whether these occur more frequently in Eid than during the rest of the year remains unclear, since this was not reported. In addition, this was a single study performed in a single country, and may not reflect all Eid celebrations around the world. Their findings may therefore be restricted to Yemen [25].

The limitations of current evidence must be addressed to increase the understanding of trauma during Ramadan. First, all studies carried a low level of evidence and risk of bias. Second, only two studies definitively stated the religious status of their participants, and analysed occurrence of trauma accordingly [21,22]. Therefore, even though current evidence suggests injuries such as RTAs or OIs may occur more frequently during Ramadan, it is not possible to determine whether it is Muslims who experience these increased rates. This could be attributed to large regional/national databases being used to explore RTAs and OIs. These may not necessarily include subjects' religious status, yielding a sub-group analysis unfeasible. Similarly, only Chamari et al. clarified whether subjects were fasting [21]. This hinders the claim that fasting individuals experience higher rates of trauma. The studies pertaining to the effect of Ramadan on trauma operate under the assumption that the entire Muslim population fasts during Ramadan, which may not necessarily be the case. Furthermore, no studies accounted for potential confounders that may increase the risk of RTAs, such as travelling in twilight hours with its associated lighting transitions, and travel being more likely during this month. This limits what conclusions may be drawn, with further research considering these required. Third, of the 11 different countries represented in this review, 10 have Islam as the most common religion [29]. In addition, seven were performed in the Middle East, three in Asia, and one in Europe. This hinders the ability to extrapolate findings of current evidence to other regions such as Europe or the Americas, or to other countries which do not have Islam as their most common religion. The lack of studies in these regions could be attributed to decreased observance of Ramadan fasting. The length of fast may vary greatly at certain times of the year depending on how far from the equator the country is. Further research in these regions is required. Fourth, multiple studies did not include all months of the year [2,17,19,21,27], which weakens their sampling. Finally, no study reported on the impact of Ramadan on treatment complications and outcomes. These could provide insight into the challenges physicians may encounter when treating patients observing Ramadan, providing further insight on how to deliver personalized and optimized patient care.

5. Conclusion

Individuals who fast may be at a higher risk of RTAs and OIs during Ramadan than outside this month. Effective public health campaigns are required to mitigate the risk of trauma. Due to the lack of studies performed in the Americas and Europe, it is unclear whether this is applicable to these regions. Further research conducted in these is required. Future studies should aim to report on the impact of Ramadan on treatment complications and outcomes.

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Data availability statement

No data was used for the research described in the article.

CRediT authorship contribution statement

Diego Agustín Abelleyra Lastoria: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jehad Feras AlSamhori:** Writing – original draft, Investigation. **Tin Lik Wong:** Writing – original draft, Investigation. **Pir Sameeullah Shah Rashdi:** Investigation. **Caroline Blanca Hing:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Catherine Kellett:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Co-author is Associate Editor of Heliyon - C.K If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. search strategy

Ramadan OR Ramathan OR Ramadhan OR Ramzan OR Eid al-fitr OR Eid.
AND.
Traum* OR Injur* OR accident*
Deduplicate

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