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Horse-related incidents and factors for predicting injuries to the head

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Abstract

Objectives

Head injuries are the leading cause of death in horse-related injury events and, even since the introduction of helmets, represent a sizeable proportion of all horse-related injuries. Falls from horseback and kicks to the head are the most frequent type of incident causing head injuries, but it is unknown whether these incidents are predictors of head injury. This study aimed to investigate head injuries and the association between incident type and head injury.

Method

Retrospective review of 7815 horse-related injury events was conducted. Data were gathered from hospitals, local healthcare centres and public dental services in Skaraborg, Sweden. Binary logistic regression was used to analyse the association between the incident type and occurrence of head injury while controlling for risk factors.

Results

Approximately 20% of riders sustained a head injury, mostly soft tissue injuries (56.3%) and concussions (33.4%). A fall from or with the horse was the primary cause of head injury (63.9%). Those who fell from a carriage or other height or who were injured through contact with the horse had no difference in the likelihood of head injury when compared with those that fell from or with the horse. However, those who sustained an injury without any horse contact had lower odd of head injury (OR: 0.640, $p<0.00005$, 95% CI 0.497 to 0.734). Additionally, the older the rider, the lower the odds of head injury (OR=0.989, $p<0.00005$, 95% CI 0.985 to 0.993).

Conclusion

Improved protection for those suffering falls from horseback as well as those who are kicked in the head should be investigated.

Keywords: Horse, injury, epidemiology, head, helmet

What are the new findings?

- Most common causes of head injury were a fall from or with a horse (63.9%) or contact (kick, bite, trampled or crushed) with the horse (25.2%).

- There was no significant difference in the likelihood of head injury between those who fell from horseback and those who were contacted by the horse.
- Age was significantly associated with head injury, with older riders more likely to suffer a head injury.

Potential impact on clinical practice?

- The results indicate that head protection should be provided for unmounted riders and for protectionagainst concussion.
- Head injury prevention efforts should be targeted towards younger riders.

Introduction

Horse riding injury events have been found to affect approximately 35.7 persons per 100 000 population every year in the USA, typically involving females between the ages of 10–14 years.[1] Head injuries have been found to be one of the most frequently occurring injuries and is the leading cause of death in horse-related injury events.[2–4] Since the introduction of helmets, the frequency of head injuries reduced,[5 6] yet despite helmet usage, the overall number of riders sustaining head injuries is still high.[7]

There is overwhelming evidence to suggest that horse-related injuries are largely the result of by falls from horseback, which reportedly represent between 42.7%[8] and 82%[9] of the total number of people injured due to horse-related injury events. Falls from horseback have also been reported to most frequently involve the head[1] and to be the incident type mostly responsible for maxillofacial injuries.[10] Furthermore, falls have also been associated with intracranial haemorrhage.[11]

Unmounted injury events have also been found to frequently involve the head.[12] Some common incident types observed in unmounted injury events have been kicks, being crushed, trampled or trodden on or being bitten.[5 13 14] Body regions seen to be commonly injured due to horse kicks to an unmounted rider include facial injuries and head trauma as well as cause significant chest and abdominal injuries.[11 15 16] Eckert *et al* [17] reported a high number of hoof kick injuries to the head during horse care and suggested this may partially be linked to a lack of use of helmets in unmounted equestrians.

In order to design and improve protective devices for horse riders, it is essential to understand under which circumstances these injuries are occurring. This study aimed to investigate how incident type is associated with head injury while controlling for known risk factors such as age and gender.

Method

This investigation used data from an ongoing registration called the Injury Database (IDB Sweden).[18] The local database, IDB Skaraborg used in this study, contains information from both inpatient and outpatient visits to hospitals, local healthcare centres and public dental services within the Skaraborg district in the south-west of Sweden (population about 255 000). Participating medical facilities included emergency departments at all hospitals within the Skaraborg district (2001–2016), emergency departments at healthcare centres in the study district (2001–2011) as well as all local healthcare centres (2001–2008, 2011) and public dental services (2001–2008, 2011) in the district. Data loss was

internally documented to be an estimated 10%. Cases involving horse-related injury events between January 2001 and December 2016 were extracted from IDB Skaraborg and retrospectively reviewed (n=7815). A horse-related injury was defined as an injury that occurred as a direct result of participating in any activity involving either horseback riding, horse care and maintenance, horse transportation or maintenance of the horse's environment such as building a paddock or cleaning a stall. Cases were excluded where the patient had suffered a bite from another animal such as an insect or dog bite while riding a horse or being in paddock and the only injury suffered was the animal bite. Additionally, transport-related injury events were excluded where the patient was in a vehicle that hit a car with a horse trailer.

Analysis

Variables were initially investigated using descriptive statistics. Variables investigated included injury event details (date, time, place), rider demographics (age, gender) and injury details (type and location). Information on the use of protective clothing was obtained in the IDB questionnaire, with patients providing a free-text response regarding whether they considered themselves to be wearing any sort of protective clothing and were also encouraged provide more detail on the type of protection. This included helmets, vests, gloves and any protective footwear. This response was then coded by use of any protective clothing (yes/no) (including helmet use) and a second variable specifically for the use of helmet (yes/no). No information was provided in 9% of the cases. The primary incident type was categorised as either a fall from or with the horse, fall from carriage or other height, other injury due to contact with horse (including kick, bite, trampled or trodden on, crushed by horse against a wall or the ground and pushed by or headbutted by horse) and other injury without contact with the horse (trip/slip, road transport injury event, crush/cut or impact with sharp or blunt object, pulled by the horse while holding lead or reins, electric shock, foreign object in eye, general sprain). Injury events with multiple incident types were also noted. For riders who suffered a concussion following a fall from horseback, the type of ground surface they contacted was also investigated. The type of ground surface was categorised into: hard floor surface, including asphalt, concrete or other processed surface; grass or dirt surface; indoor riding arena floor surfacing or other/unknown.

To explore the effect of incident type on head injury, incident type, as well as any variables that were found to be significant during univariate regression exploration, was entered in to a multivariate binary logistic regression. Whether an injury event involved multiple incident types (yes/no) was also included even when not independently significantly associated with head injury, due to previously found association with severity of injury.[19] The ground surface type was not included in the logistic regression model as it was only applicable to those injury events where the rider fell from horseback and suffered a concussion due to impact with the ground. Analysis was conducted using IBM SPSS Statistics 24.

Results

During the 16-year period, there were 7815 visits to one of the participating medical facilities due to an injury from a horse-related incident. Most (68.8%) visited the emergency department in hospital, 30% went to local healthcare centres and 0.8% visited a dentist; however, data were not collected from local healthcare centres and public dental services throughout the entire study period. The majority (51.5%) of the injury events occurred in an open field or forest area; however, injury events also frequently took place in riding schools and other dedicated sporting facilities (37.7%). Injuries occurred more frequently in the summer months, with only 18.7% of injury events occurring in winter. The largest proportion of injury events occurred between 16 and19 (38.8%).

Females represented 88% of the total sample. A higher proportion of males were riding in an open field or forest when injured, while females were almost equally represented in injury events in both open fields and forests as in riding schools or other dedicated sporting facilities (figure 1).

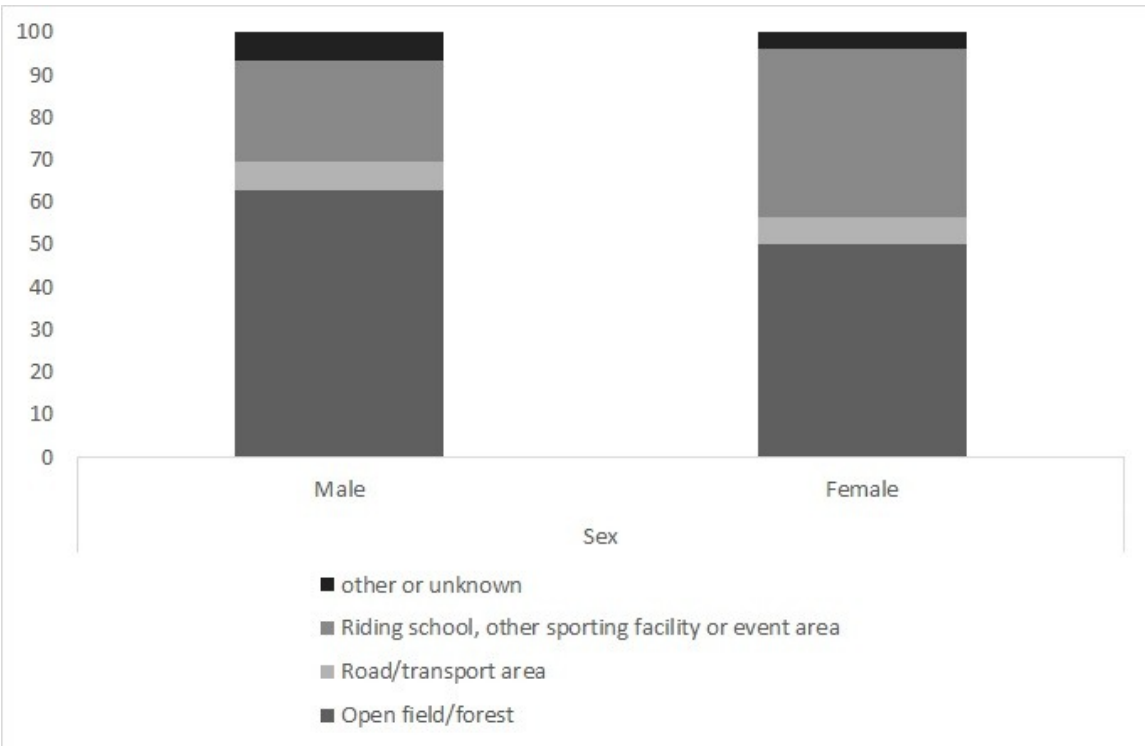

Figure 1

Percentage of males and females at each injury event place (males n=939, females n=6876).

The median age was 22 years (range 0–84 years). A larger number of those under the age of 20 were injured while riding in riding school or other sporting facility, while those over 20 were more commonly injured in an open field or forest (figure 2).

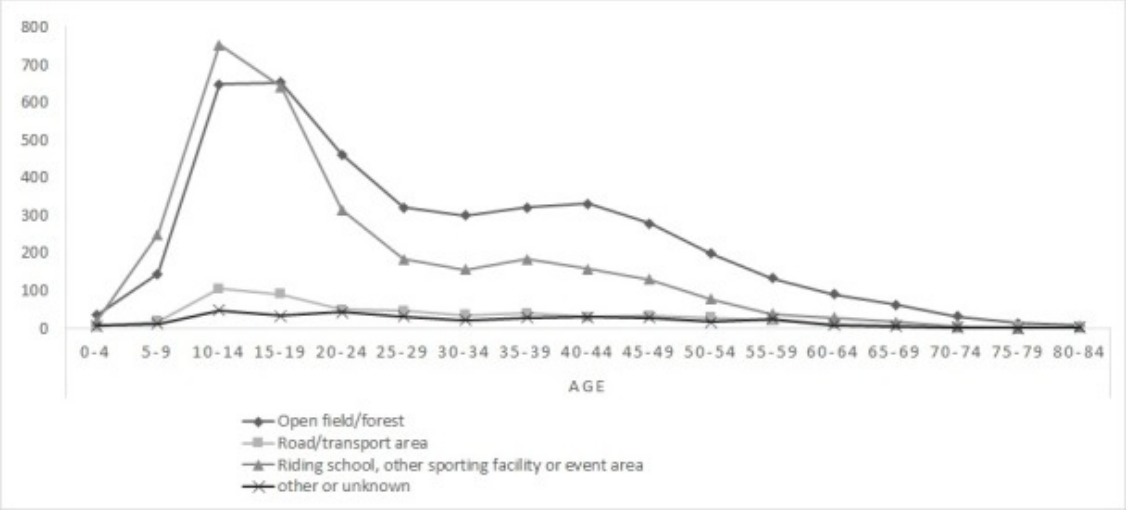

Figure 2

Number of injury events occurring in each place by 5-year age group.

A higher percentage of riders were using protective clothing in a riding school or other sporting facility (81.8%) and on a road or other transport area (75.7%) than those who were riding in an open field of forest area (53.8%). Helmet use was reported most frequently while riding on a road or transport area (76.2%) or at a riding school (67.8%) (table 1).

Table 1

Proportion of riders using protective clothing by place of riding

	Place n (%)			
Open field or forest	Riding school or other sporting facility	Road or other transport area	Other	
Any protective clothing				
No	1471 (36.6)	374 (12.7)	87 (16.9)	118 (35.5)
Yes	2163 (53.8)	2411 (81.8)	390 (75.7)	102 (30.7)
Unknown	387 (9.6)	162 (5.5)	38 (7.4)	112 (33.7)
Total	4021	2947	515	332
Helmet				
No	1680 (41.8)	108 (21)	465 (15.8)	139 (41.9)
Yes	1872 (46.6)	349 (67.8)	2247 (76.2)	73 (22)
Unknown	469 (11.7)	58 (11.3)	235 (8)	120 (36.1)
Total	4021	515	2947	332

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Of the 7815 patients involved in this investigation, the highest proportion of riders suffered an injury to the upper extremity (33%) and 19.2% sustained a head injury. Of the 19.2% of riders who suffered a head injury (n=1502), there were 1680 head injuries among them. These head injuries consisted of soft tissue injuries (56.3%), concussion (33.4%), fractures or dislocation (7.9%), sprain or tear to the muscle or tendon in the jaw (0.1%) and other (2.1%). The anatomical locations of the head most frequently involved in head injuries were the brain (34.1%) and the skull (30%), followed by the lips and mouth cavity (6.2%).

Frequently occurring incident types were falls from or with the horse (58.4%) or contact with the horse (19.8%). Falls were the most common incident type for all injured body regions (table 2). However, a large proportion of lower extremity (37.6%) and head (25.2%) injuries also occurred due to contact with the horse, while 22.6% of upper extremity injuries occurred without direct contact with the horse. Head injuries caused by contact with the horse were most commonly due to being kicked by the horse (44%) or pushed/headbutted by the horse (39%). Concussions predominantly took place due to a fall from or with the horse (82%). Helmets were reportedly worn by 58.1% of all participants and 73.7% of

those with a concussion reported they were wearing a helmet at the time of the injury event. Of those who fell from horseback, 85.6% reported they were wearing a helmet, while only 18.7% reported wearing a helmet during an incident involving other contact with the horse.

Table 2

Number of riders who suffered an injury to the head, neck, torso, upper extremity and lower extremity by the primary incident type

Injured region	Primary incident type n (%)				
Fall from or with horse	Fall from carriage or other height	Injury due to contact with horse	Injury without direct contact with horse	Total	
Concussion	461 (82%)	7 (1.2)	78 (13.9)	16 (2.8)	562
Head	959 (63.9)	18 (1.2)	378 (25.2)	146 (9.7)	1501
Neck	437 (85.9)	6 (1.2)	48 (9.4)	18 (3.5)	509
Torso	1060 (75.8)	32 (2.3)	253 (18.1)	53 (3.8)	1398
Upper extremity	1657 (57.9)	51 (1.8)	505 (17.7)	648 (22.6)	2861
Lower extremity	1184 (49)	42 (1.7)	909 (37.6)	283 (11.7)	2418

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In riders who suffered a fall from horseback that resulted in concussion (n=461), 33.4% contacted a hard floor surface such as asphalt, 26.5% landed on grass or dirt surface and 20.8% landed on indoor riding arena floor surfacing. Of these 461 riders, 88% reported they were wearing a helmet.

The most common activity performed at the time of the injury event was riding the horse (62.8%) followed by horse handling (28.5%). Injuries to all body regions most frequently occurred while riding a horse. However, head injuries (23.6%) and upper extremity injuries (29.2%) also occurred during horse handling activities (table 3).

Table 3

Number of riders who suffered an injury to the head, neck, torso, upper extremity and lower extremity by the activity at the time of the injury event

Injured region	Primary incident type n (%)				
Riding horse	Horse handling	Maintenance and care	Carriage or other transport vehicle	Mounting or dismounting	
Head	1024 (68.3)	354 (23.6)	99 (6.6)	22 (1.5)	1 (0.1)
Neck	451 (88.6)	40 (7.9)	7 (1.4)	10 (2)	1 (0.2)
Torso	1078 (77.1)	262 (18.7)	15 (1.1)	36 (2.6)	8 (0.6)
Upper extremity	1775 (62)	838 (29.2)	181 (6.3)	55 (1.9)	16 (0.6)
Lower extremity	1307 (54)	862 (35.6)	144 (6)	45 (1.9)	61 (2.5)

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Binary logistic regression examined the association between incident type and head injury, while controlling for other risk factors in horse-related injury events (table 4). Factors significantly associated with head injuries were age, type of incident and multiple incident types. The older the rider, the lower likelihood of suffering a head injury (OR=0.989, p<0.00005, 95% CI 0.985 to 0.993). Riders involved in only a single incident type had higher likelihood of suffering a head injury (OR=1.292, p=0.011, 95% CI 1.061 to 1.573). Last, riders whose primary incident type involved an injury without any horse contact had lower odd of head injury (OR=0.604, p<0.00005, 95% CI 0.497 to 0.734). Riders who fell from a carriage or other height and those who were injured through contact with the horse had no statistical difference in the likelihood of head injury when compared with those that fell from or with the horse.

Table 4

Predictors of head injury, results of the multiple logistic regression

Variable	OR	P values	95% CI
Gender			
Female	0.810	0.976	0.801 to 1.189
Male	Reference	–	–
Age	0.989	<0.00005*	0.985 to 0.993
Multiple incident types			
No	1.292	0.011*	1.061 to 1.573
Yes	Reference	–	–
Incident type			
Other injury with no horse contact	0.604	<0.00005*	0.497 to 0.734
Other injury due to contact with horse	0.930	0.303	0.809 to 1.068
Fall from carriage or other height	0.682	0.139	0.411 to 1.132
Fall from or with horse	Reference	–	–

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*P<0.05 indicating statistical significance.

Discussion

A fall from or with a horse was the main cause of head injury observed in this investigation, aligning with previous reports.[20] Most riders in this study were riding in the open field or forest when the injury event occurred, and this was the location where riders were less likely to be using protective clothing of any sort. These were also the male riders. There was higher usage of protective clothing in the riding schools and event areas. The riders who were typically in the riding schools were younger riders. However, there was also no correlation found between place of injury event and head injury when univariate logistic regression was explored. There was also no statistical difference found between the odds of suffering a head injury when a rider fell from or with a horse and when a rider was injured either due to contact with the horse or when they fell from a carriage or other height. There was, however, a significant difference in the odds of suffering a head injury due to a fall from horseback, compared with an injury without horse contact which indicates that of the unmounted incidents, mostly those where there was contact with a horse (rather than facility maintenance incidents) was involved in head injuries.

A kick to the head is another incident type which has been observed by other researchers to frequently cause head injuries,[20] which was also observed in the results presented here. Ueeck *et al* [10] reported that maxilla-facial injuries due to a horse kick resulted in a more serious injury than those head injuries caused by other incident types (p=0.048) and accounted for 13 of the 18 fractures seen to the sample of

injured patients. Eckert *et al* [17] reported that a high number of these hoof kick injuries to the face occurred during horse care activities. In fact, it has been suggested that injuries to the face occur as frequently to those who are unmounted as those who are mounted.[12] This is problematic, as helmets are not typically used by unmounted equestrians, leaving riders unprotected against these injuries.

Wearing a helmet while unmounted has been suggested as a potential countermeasure to those head injuries that have been found to occur during horse-handling activities. Helmet use could potentially prevent some of these injuries, but may not be sufficient to protect those face injuries occurring due to a horse kick directly on the face. The helmet does not provide full coverage of the entire head and, furthermore, is only designed to protect against impacts. The most frequently occurring head injury in this study was found to be soft tissue injury, and as Antoun *et al* [21] reported, of the 49 facial injuries investigated in New Zealand, 35 were during unmounted activities, which were predominantly caused by kicks.[21] As such, face protection for unmounted riders should be investigated and wearing a helmet while unmounted should be encouraged, with only 18.7% found to be wearing a helmet when injured due to contact with the horse.

Previous work has suggested that helmet usage has been linked to a reduction in head injuries.[5] Yet, despite the reduction of head injuries seen due to helmet usage in previous studies, 19% of the patients involved in this study suffered a head injury. In our investigation, head injuries were found to be the third most frequently injured body region. Unfortunately, we were not able to investigate the severity of the head injury, as severity was not provided in the database. However, concussions accounted for approximately one-third of the total number of these head injuries, with the brain (34.1%) and the skull (30%) being the most frequently injured location of the head. This may partially be due to lack of helmet usage by all riders in this study with only 58.1% helmet usage found, especially in unmounted riders. Helmets have been investigated in Sweden in relation to bicycling and large improvements in concussion rates were found and linked to an increase in helmet use.[22] In the Skaraborg district, head injuries to children as a result of bicycle events were reduced by more than 90% as the result of bicycle helmet promotion and national policy changes that occurred in the latter half of this study period and the result of local collaborations based on a local safety model.[23] The perceived barriers of helmet use by riders both mounted and unmounted should be investigated to determine how to improve usage or design of the helmet.

The high numbers of head injury observed could also be due to suboptimal design of helmets designed specifically for horse riding injury events. Of those riders who sustained a concussion due to a fall from horseback, 88% were wearing a helmet. The energy absorbing liner provided in helmets is designed and tested for hard surfaces such as roadways and not necessarily for contact with softer grass or sand surfaces. Clark *et al* [24] assessed damage to helmets worn by riders involved in injury events (n=20), where four helmets involved impacts to a road and 16 to turf. Two of the impacts to road and 14 of the turf impacts resulted in concussion. Overall, all helmets involved in impacts with the road suffered some sort of damage. No damage was observed in 35% of the turf cases, and five of these seven suffered a head injury. Impacts to a road were found to have significantly higher residual crush of the helmet liner compared with impact to turf. The results seemed to suggest that the helmets absorbed insufficient energy to prevent head injury in riders who impacted turf.

In our investigation, 73.7% of the riders who suffered concussion reported to be wearing helmets. Over a quarter of concussions occurred when the rider impacted soft surface such as the grass or dirt floor, indicating many of these concussions could potentially be prevented with appropriately designed helmets. Appropriate design of helmets for horse riding injuries should be further investigated.

Conclusion

This study investigated the effect of the type of incident on the occurrence of head injuries. Head injuries were found to be associated with younger age and an injury event where only a single incident type took place. Riders injured without falling and had no contact with the horse were significantly less likely to experience a head injury than those who fell from horseback. Injuries to the head while unmounted were frequently observed. Strategies for prevention should focus on better design for helmets to prevent head injuries resulting from impact with a soft ground surface following a fall from horseback as well as providing protection from kicks to the face.

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Footnotes

Contributors: LM was responsible for conception and design of the study, conducting the analysis, interpreting of the data and writing the final report. RE was responsible for conception and design of the study, providing access to the data, interpretation of the data and critically reviewing the final report. RT was responsible for conception and design of the study, interpretation of the data and critically reviewing the final report.

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Data sharing statement: Currently, no unpublished data are available for sharing. Any requests, however, can be directed to the primary author lauren.meredith@chalmers.se.

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