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Risk Factors for Horse Fatality in Thoroughbred Jumps Racing in New Zealand

Michaela J. Gibson[a,*], Kylie A. Legg[a], Erica K. Gee[a], Chris W. Rogers[a,b]

[a] School of Veterinary Sciences, Massey University, Palmerston North, New Zealand
[b] School of Agriculture and Environment, Massey University, Palmerston North, New Zealand

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ABSTRACT

The aim of this study was to examine the race-, horse- and jockey-level risk factors for race day fatality in New Zealand Thoroughbred jumps racing using retrospective race day data from the 2011/12 to 2021/22 seasons (n = 8,970 starts). There were 51 race day fatalities resulting in an incidence rate of 5.7 per 1,000 starts (95% C.I. 4.3–7.5). The majority of fatalities were the result of fractures (44/51, 4.9 per 1,000 starts, 95% C.I. 3.7–6.6). Steeplechase and hurdle races had the same incidence of fatal fractures of 4.9 per 1,000 starts (95% C.I. 3.7–6.6, $P > .05$). Most (70.5%) of the fatal fractures were due to a horse falling during the race. In steeplechase races, horses running in races over 4,201 m were 5.0 times (95% C.I. 1.2–33.0) more likely to sustain a fatal fracture than horses in racing over shorter distances. In hurdle races, horses racing during spring were 2.2 times (95% C.I. 1.0–4.8) more likely to sustain a fatal fracture compared to winter. Due to the low number of suspected cardiac failures and fatal soft tissue injuries, risk factors for these fatalities could not be identified. These data provide a baseline to enable evidence-based regulatory changes and prospectively monitor the effectiveness of changes made.

1. Introduction

In thoroughbred flat racing, the most common reason for race day horse fatality is musculoskeletal injury resulting in euthanasia (catastrophic musculoskeletal injury). Sudden athletic death and cardiac failure resulting in sudden death or euthanasia is the next largest category with reports of these accounting for 9% to 19% of racecourse fatalities [1–3]. Horse fatalities are often associated with the horse falling during the race, which additionally poses an injury risk to the jockey and the other participants in the race [4]. It has been estimated in flat racing that 32% of jockey falls were the result of a catastrophic injury or sudden death of the horse in-race [4]. Jockey injuries as a result of a horse catastrophic injury are more likely to result in a more substantial injury than jockey falls for other reasons [4]. Therefore, it is important to examine risk factors for horse fatality to provide evidence for changes in industry management and structure that aim to reduce horse fatality, improve horse and jockey welfare and enable the racing industry to maintain its social license to operate [5,6].

The incidence of injury and fatality in jumps racing is reported to be higher than in flat racing [2,7]. It has been proposed that contributing factors to the higher rate of injury and fatality are the greater race distances and the inclusion of jumping obstacles. The majority of jumps racing in New Zealand is conducted during the wetter winter season when track surfaces tend to be softer (greater penetrometer reading) [8]. Only 4% of Thoroughbred races in New Zealand are jumps races and these are limited to a select few racecourses [8]. Jumps racing in New Zealand is divided into two types: hurdles and steeplechase. Steeplechase races have jumps that are permanent (brush) or removable timber and brush fences with a height of 1.2 to 1.5 m, whereas in hurdle racing, jumps are padded and have a maximum height of 1.2 m [9]. Steeplechase races are run over a longer distance (3,100–6,400 m) with a minimum of 10 fences whereas hurdle races are run over a shorter distance (2,400–4,400 m) with a minimum of eight fences [10]. As horses progress through their jump racing career, they often start competing in hurdle races and progress to steeplechase races.

With increasing pressure from both society and from within the industry, the New Zealand Thoroughbred Racing (NZTR) industry has put measures in place to improve the accuracy of race day reporting, with a view to improve and track health and safety of all racing participants [11]. Within New Zealand, the Racing Integrity Board oversees the race day reporting for all three racing codes

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* Corresponding author at: Michaela J. Gibson, MSc PhD, School of Veterinary Sciences, Massey University, Palmerston North, New Zealand.
E-mail address: m.gibson@massey.ac.nz (M.J. Gibson).

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(Standardbred, Thoroughbred and Greyhound racing). Race day reporting includes stipendiary stewards reports of every race and the clinical outcomes of veterinary examinations as requested by the steward [12]. During the 2014/15 racing season, the RIB restricted race day veterinarians to a cohort of contracted specialist equine veterinarians rather than any veterinarian from the local clinic, as had been used previously. In addition, incident report forms were introduced to standardize the veterinary reports and enable the collation of race day incident data [12]. However, the use of a manually entered paper-based recording system resulted in errors such as misspelt horse names and variation in the terms used to describe race day events and clinical outcomes [13]. This system was updated to an online app-based system in the 2019/20 racing season. The app-based system used a sequence of drop-down boxes that further standardized the data entry process and provided consistent descriptors of each incident, as well as anatomical descriptors and clinical outcomes of any injuries sustained [14].

Risk factors for fatalities in flat racing have been extensively reported, both in New Zealand and overseas [3,15–18]. Possibly reflecting the restriction of jumps racing to fewer international racing jurisdictions, and in some of these countries relatively few jumps races relative to flat races [19], there are fewer publications describing jumps racing, and the incidence and risk factors of fatalities. Risk factors for jumps racing fatalities have been reported for only a limited number of international racing jurisdictions such as Australia and the United Kingdom [2,7,20]. There are distinct differences in the style and structure of jumps racing between the United Kingdom and Australasia, such as the construction of the jumps material, and the relative frequency of jumps racing [19,21–23]. These differences may alter the risk factors identified and their relative magnitude. Within flat racing the differences in racing industry structure are reflected in the incidence of, and the magnitude of the risk factors for, horse fatality [15]. In order to develop and optimize strategies to reduce race day fatalities it is important to examine the risk factors using data specific to the type of racing and jurisdiction. Therefore, the aim of this study was to examine the race-, horse- and jockey-level risk factors for race day fatalities in New Zealand Thoroughbred jumps racing.

2. Materials and Methods

The data were obtained for all jumps racing starts during and including the 2011/12 to 2021/22 racing seasons (11 seasons) as a Microsoft Excel (Microsoft Corporation, Redmond, WA) spreadsheet from the NZTR (the official governing body for Thoroughbred racing in New Zealand). The output contained race information including season, track condition, race distance, track direction, number of starters, and horse information such as horse name, barrier position, age, sex, and jumps rating. Jockey variables included experience, gender, age, race number for the day and carried weight. In addition, all race day fatalities for the same racing period, as recorded by race day stipendiary stewards, were obtained from the RIB as an MS Excel file. The race day fatality data provided the descriptor of the cause of death/reason for euthanasia and a free text note field describing the causative event from the veterinary report [3].

2.1. Definitions

The horses included in the fatality dataset were those that died or were euthanized on a race day or were euthanized within 72 hours of competing in a race (in the seasons 2017/18 onwards), as a result of catastrophic musculoskeletal injury (CMI) or sudden athletic death. Catastrophic musculoskeletal injuries were divided into fractures (fatal fracture) and soft tissue injuries (fatal soft tissue injury) that resulted in elective euthanasia of the horse [3]. Sudden athletic death was defined as sudden death occurring during or after a race [24]. Horses that died or were euthanized on race day were examined by the race day veterinarian and the findings were either reported in a paper version of a veterinarian report (seasons 2011/12–2018/19) or via the online recording app (seasons 2019/20–2021/22). From the season 2017/18 onwards, a regulatory change in the New Zealand rules of racing required trainers to declare if a horse was euthanized within 72-hours of a race [3]. Horses that did not start in a race (entered the racecourse but died prior to racing) were excluded from the analysis, as there were no race level factors contributing to the fatality (one cardiac failure that occurred prior to the race starting).

2.2. Data Cleaning

A single database containing race-, horse- and jockey- level information, and fatality reports was generated. Apparent errors such as misspelt horse names and incorrect race dates were manually checked against the official race transcript of the original stipendiary stewards' report. The cause of death or the reason for euthanasia was identified using descriptors in the stipendiary stewards' report. If the affected bone or limb could not be identified in the report, it was recorded as "not specified."

To reflect changes in recording practice a variable coding for recording systems was generated as previously described [3]. These descriptors were: "local veterinarian" for the years (2011/12–2013/14), "contracted veterinarian", (racing seasons 2014/15–2018/19), "online system", after the implementation of the online system (racing seasons 2019/20–2021/22). Track conditions were defined as "firm" (penetrometer reading 1.0–2.0) "good" (penetrometer reading 3.0–4.0), "soft" (penetrometer reading 5.0–7.0) and "heavy" (penetrometer reading 8.0–11.0).

Due to the low number of starts by stallions (16 starts, 5 horses, and 0 fatalities), sex of the horse was grouped into either male (stallion or gelding) or female (mare). Horse rating was specific to the race type and is a dynamic measure of a horse's performance calculated within 48 hours of their most recent start [9]. Horse rating was grouped based on the definitions used by NZTR as "maiden" (rating $\leq$55), "rating 65" (rating 56–65), "rating 75" (rating 66–75), "rating 85" (rating 76–85) and "open" (rating $\geq$86) [9]. Most races in NZ are handicap races (where higher weights are assigned to each horse based on their merits), and apprentices claim a weight reduction (allowance) of 0 to 4 kg on the handicap weight of horses they ride based on their experience (measured by previous wins). Jockey experience was defined as either apprentice or jockey. An apprentice was defined as any rider with a weight reduction of $>$1 kg from the handicap weight assigned to the horse.

Race distance, horse age, field size (number of participants in a race), barrier position, jockey age, ride number for jockey on race day and carried weight were examined with descriptive statistics and plots. These variables were subsequently categorized into groups based on quartiles or levels containing approximately equal numbers, based on the descriptive statistics or on clustering due to the underlying biology or structure of the racing programme.

2.3. Data Analysis

Descriptive statistics were used to summarize the data, with differences between groups for each fatality type tested examined using Kruskal–Wallis tests for nonparametric data. Incidence rates for an event occurring were described as the number of events per 1,000 starts with 95% confidence intervals (95% CI) [12]. Differences in the incidence rate between recording systems and track direction for sudden athletic death, fatal fracture, and fatal soft tissue injury were examined using a Wald test.

The incidence rate ratio of a fatal fracture and 95% CI at a univariable level were calculated for the following variables; season, track condition, race distance, track direction, field size, barrier position, age category, horse sex, steeplechase or hurdles rating, jockey experience, jockey gender, jockey weight, jockey age, ride number for the day and carried weight using a Poisson regression in a generalized linear mixed model. Variables were screened in univariable models, and, if obtaining the significance threshold ($P < .2$), were included in the multivariable model. The multivariable models were built using a backwards selection procedure whereby variables that improved the model, based on a chi-squared likelihood ratio test ($P \leq .05$), were retained in the model. There were no fatal fractures in hurdle races in autumn or for horses with a rating over 85 (open) so starts for these categories were omitted from their respective univariable and multivariable analyses.

Risk factor analysis could not be conducted for sudden athletic death or fatal soft tissue injuries due to their low incidence and heterogeneous distribution across risk factor categories. All statistical analyses were conducted using RStudio (version 3.5.1, 2018; R Foundation for Statistical Computing, Vienna, Austria) with a level of significance set at $P < .05$.

3. Results

There were 8,970 jumps racing starts over the 2011/12 to 2021/22 racing seasons. There were 1,241 horses that participated in at least one jumps race during the observed seasons. Horses had a median of three jump race starts per season [IQR 1–5]. The median age for a starter was 7 years old [IQR 6–9].

Most starts were run on a heavy track (n = 7,111 starts, 79.3%), followed by soft (n = 1,377, 15.4%) and good (477 starts, 5.3%). Only one race was run on a firm track (5 starts, 0.06%). Most starts were run in an anticlockwise direction (n = 6,110, 68.1%), rather than a clockwise direction (n = 2,860, 31.9%). There were fewer steeplechase racing starts (n = 3,526 starts, 39.3%) than hurdle racing starts (n = 5,444 starts, 60.7%). The median race distance for a steeplechase race was 4,000 m [IQR 3,500 – 4,200 m] and for a hurdle race was 3,000 m [IQR 2,800–3,100 m]. The majority of starts were by males (n = 8,047 starts, 89.7 %) followed by mares (n = 923 starts, 10.3%).

3.1. Fatalities

There were 51 race day fatalities resulting in an incidence rate of 5.7 per 1,000 starts (95% C.I. 4.3–7.5). Of these fatalities, five were suspected cardiac failures (IR 0.6 per 1,000 starts, 95% C.I. 0.2–1.3), two were soft tissue injuries (IR 0.2 per 1,000 starts, 95% C.I. 0.06–0.8) and 44 were fractures (4.9 per 1,000 starts, 95% C.I. 3.7–6.6). Steeplechase races accounted for less (37.3%, 5.4 per 1,000 starts 95% C.I. 3.5-8.4) of the fatalities (two fatal soft tissue injuries and 17 fatal fractures) whereas over half (62.7%, 5.9 per 1,000 starts, 95% C.I. 4.2–8.3) of the fatalities were in hurdle races (five suspected cardiac failures and 27 fatal fractures). However, the incidence of fatalities reflected the distribution of starts for each race type ($P > .05$).

The median age for fatalities was 8 years old (IQR 7–9) and did not differ between cause of death/reason for euthanasia ($P > .05$). The incidence rate of suspected cardiac failure, fatal fracture or soft tissue injury did not change over the time period investigated ($P > .05$), in which the recording system for race day incidents changed from local veterinarian (2011/12–2013/14 seasons), to contracted veterinarian (2014/15–2018/19 seasons), to the current online system (2019/20–2021/22 seasons).

3.1.1. Sudden Athletic Death

All sudden athletic deaths (n = 5) occurred in hurdle racing. Of the sudden athletic deaths, three (60%) resulted in sudden death (two during the race and one after the race) whilst the other two (40%) required euthanasia (one during the race and one after the postrace inspection).

3.1.2. Catastrophic Musculoskeletal Injury

One of the two horses with a fatal soft tissue injury completed the race but was diagnosed with a failure of the suspensory apparatus (Left fore) and euthanized on the race day. The other horse with a fatal soft tissue injury was pulled-up (did not complete the race) and had suffered a ruptured suspensory ligament (Right fore) and was euthanized within 48 hours of the race.

Of the fatal fractures, 43 (97.7%) resulted in euthanasia on race day and one resulted in sudden death (neck fracture, 2.3%). The majority of fractures were for races run in an anticlockwise direction (30/5,570, 68.2% of fractures) with fewer in a clockwise direction (14/2,860, 32.8%). However, the incidence of fractures in each track direction reflected the distribution of starts in each direction ($P = .874$).

Most fractures leading to euthanasia were associated with a horse falling or being brought down by another horse (31/44, 70%). The remainder of the horses sustaining a fatal fracture leading to euthanasia were either pulled up (10/44, 23%), or recorded as losing their rider (7%, 3/44). Only one horse that sustained a fatal fracture of the metacarpus completed the race (1/44, 2%) although the fatality report stated it was brought down. Of the horses that fell (n = 28) and sustained a fatal fracture, the majority fell in the middle of the race (15/29, 55%), followed by the end of the race (11/29, 37.9%) and start of race (2/31, 6.9%)

In both steeplechase and hurdle racing, the majority of fatal fractures occurred in the appendicular skeleton (Table 1), with the forelimb having the highest proportion of fractures (61%) with fewer hind limbs (30%). Fatal fractures in the axial skeleton (spine or neck) contributed to 9% of fatal fractures. Overall, six (14%) of fatal fracture reports did not state which bone was affected and six (14%) did not state which limb was affected. The "local veterinary" recording system had the greatest proportion of unknown (not specified) categorizations for either affected limb or bone (5/16, 31.3%), followed by "contracted veterinarian" (4/21, 19.0%). All online recording system reports specified the affected limb and bone.

There were 17 fatal fractures in steeplechase races (4.8 per 1,000 starts, 95% C.I. 3.0–7.7). In steeplechase races, there was an association of longer race distance and middle barrier position with a higher incidence of fatal fractures at a univariable level (Table 2). Horses running in races over 4,201 m were 5.0 times more likely to sustain a fatal fracture compared to those running in races ≤3,800 m. There were no fatal fractures for steeplechase races in autumn, so races for autumn were omitted from the univariable model. None of the variables reached the threshold to remain in the multivariable model ($P > .05$).

There were 27 fatal fractures in hurdles races (5.0 per 1,000 starts, 95% C.I. 3.4–7.2). In hurdle races, there was an association of season, track condition and jockey gender with fatal fractures at a univariable level ($P < .2$, Supplementary table 1). Track condition failed to meet the threshold to be included in the final multivariable model ($P > .05$). In the multivariable model, season and jockey gender had a significant effect on the incidence of fatal fracture ($P < .05$). Horses racing in spring were 2.2 times more likely to sustain a fatal fracture than horses racing in winter. Horses with a female jockey were 2.6 times more likely to sustain a fatal fracture than horses ridden by a male jockey (Table 3).

Table 1
Anatomical site and event description of fatal fractures associated with race day fatalities in New Zealand Thoroughbred jumps (steeplechase and hurdle) racing from the 2011/12 to 2021/22 racing seasons.

Anatomical Site					Event Description (% of Anatomical Site)		
	Left Limb	Right Limb	Not Specified	Total (% of Fatal Fractures)	Horse Fell/Brought Down	Lost Rider	Pulled Up
Thoracic				**4 (9%)**			
Neck				3 (7%)	3 (100%)		
Spine				1 (2%)	1 (100%)		
Forelimb				**27 (61%)**			
Humerus	3	9	1	13 (30%)	9 (69%)	2 (15%)	2 (15%)
Radius	3	5	1	9 (20%)	7 (78%)	1 (11%)	1 11%)
Metacarpus	2			2 (5%)	1 (50%)		1 (50.0%)
Proximal phalanx	1			1 (2%)	1 (100%)		
Bone not specified	1	1		2 (5%)	1 (50%)		1 (50.0%)
Hindlimb				**13 (30%)**			
Pelvis			3	3 (7%)	3 (100%)		
Femur		2		2 (4.5%)	1 (50%)		1 (50.0%)
Tibia	3			3 (5%)	2 (67%)		1 (33%)
Sesamoid			1	1 (2%)	1 (100%)		
Bone not specified		4		4 (9%)	1 (25%)		3 (75%)
Total	13	21	6		31 (70%)	3 (7%)	10 (23%)

4. Discussion

The overall incidence rate for jumping race fatalities in New Zealand was similar to values reported in the UK (5.6 per 1,000 starts) [25] and lower than values reported for Victoria, Australia (8.3 per 1,000 starts) [2]. The use of equine veterinarians and the online recording system did not alter the frequency of fatal events being recorded but improved the detail of reporting for the events and clinical outcomes. Earlier reports particularly in the local veterinarian recording system often stated that a fracture had occurred, but there was limited information on which bone and/or limb was affected. The improvement in the description of clinical outcomes is promising for future research to identify risk factors to specific clinical presentations of CMI.

The incidence of sudden athletic death was similar to that reported for jumps racing in Victoria, Australia (0.4 per 1,000 starts) [2], and the UK (0.7 per 1,000 starts) [26]. Although there were only five events of sudden athletic death, the incidence rate (0.6 per 1,000 starts) was higher than for Thoroughbred flat racing in New Zealand (0.1 per 1,000 starts) [3], which reflects reports from Australia of higher incidence of sudden athletic death in jump versus flat races [16]. Due to the low frequency of jumps racing in New Zealand, there were insufficient events of sudden athletic death to examine the risk factors of these events. It is possible that if there were more data (i.e., more seasons observed), additional risk factors may have been identified. Therefore, potential risk factors for sudden athletic death such as age and race distance can only be hypothesised using flat racing data and overseas jumps racing data.

In Thoroughbred flat racing, horse age has been suggested as a risk factor for sudden athletic death [24], with horses aged five years and over 2.1 times more likely than horses aged four and under to suffer a suspected cardiac failure [3]. As older horses compete in jumps racing, this may be a contributing factor to the higher rate of suspected cardiac failures observed in jumps compared to flat racing.

In the current study, there was a similar incidence of fatal fractures in steeplechase and hurdle races. However, data from Melbourne, Australia and the United Kingdom have suggested that there is a greater incidence of CMI in steeplechase races [7,20,21]. The incidence of fatal fracture in the current study was lower than has been previously reported in Melbourne, Australia for both steeplechase (14.3 per 1,000 starts) and hurdle races (6.3 per 1,000 starts) [20]. In the Australian study, it was suggested that differences in the rate of fatal fracture between race types may be due to the solid structure and size of the jumps and longer racing distances in steeplechase races resulting in a greater number of horse falls [20]. In New Zealand, there was a greater incidence of horse falls in steeplechases compared to hurdle races [22], but similar fatal fracture incidence. The restricted data set size and low incidence does preclude speculation as to the causative factors. It may be of interest to examine the nature of horse falls in hurdle versus steeplechase races in New Zealand to explore the reason for this difference.

In flat racing, fractures typically occur in the distal limb bones such as the metacarpal, metatarsal and proximal phalanx [3,4,27], often due to cyclic fatigue. However, in jumps racing, a greater proportion of fractures occurred in the proximal limb and in the axial skeleton. In Australia, 50% of fatal fractures in jumps racing were associated with the shoulder region [20], which was similar to our dataset. Fractures of this nature tend to be related to external trauma, such as from a horse falling. In flat racing, a greater association with a horse being pulled up has been observed [3]. Jumps racing is run over a greater distance and includes jumping elements thus increasing the likelihood of horse fatigue-related accidents and time at risk. This is reflected in the association of fatal fractures in steeplechase racing with race distance where races over 4,200 m had a greater risk of a fatal fracture. This effect was not present in hurdle racing and may be due to races being of a shorter race distance, having less jumping efforts and lower jump height, reducing the likelihood of horse and jockey fatigue and the time at risk. [21,22]. However, the majority of falls that resulted in a fatality occurred in the middle of the race. Due to the limited description of the fall event in the veterinary report, the jump at which the fall occurred, and the nature of the fall could not be determined to provide greater detail on how the fall occurred or predisposing factors (such as jockey or horse fatigue). The use of an “out of contention” caveat permitting jockeys to pull up or retire from the race horses either obviously out of contention or fatigued has been demonstrated to reduce the incidence of horse falls [22,23]. However, the introduction of this caveat did not appear to change the incidence of fatal fractures in New Zealand. Due

Table 2
Univariable incidence rate ratios (IRR) and 95% confidence (95% CI) of a fatal fracture in steeplechase races occurring with the effects of season group, track condition, race distance, track direction, field size, horse age, horse rating, horse sex, jockey experience, and carried weight in the 2011/12 to 2021/22 racing seasons.

Univariable	Number of Fatal Fractures (%)	Starts	IRR [95% CI]	*P*-Value	Wald *P*-Value
Season					
Autumn	0	483			
Winter	14 (82.3%)	2,351	1.4 [0.4–6.0]	0.618	
Spring	3 (17.7%)	692	(Ref)		0.606
Track condition					
Good	1 (5.9%)	188	(Ref)		0.962
Soft	2 (11.8%)	493	0.8 [0.1–16.4]	0.825	
Heavy	14 (82.3%)	2,845	0.9 [0.2–16.8]	0.940	
Race distance (m)					
≤3,800	2 (11.8%)	957	(Ref)		0.054
3,801–4,000	2 (11.8%)	647	1.0 [0.1–8.4]	0.992	
4,001–4,200	5 (29.4%)	854	2.8 [0.6–19.6]	0.218	
4,201+	8 (47.1%)	768	5.0 [1.2–33.0]	0.042	
Track direction					
Clockwise	6 (35.3%)	1,237	1.0 [0.3–2.7]	0.985	
Anticlockwise	11 (64.7%)	2,289	(Ref)		0.985
Field size					
≤6	4 (23.5%)	560	2.3 [0.5–9.5]	0.251	
7–8	7 (41.2%)	943	2.3 [0.7–8.9]	0.175	
9–10	4 (23.5%)	1,261	(Ref)		0.333
11+	2 (11.8%)	762	0.8 [0.1–4.2]	0.827	
Barrier position					
1–3	2 (11.8%)	1,114	(Ref)		0.061
4–7	11(64.7%)	1,352	4.5 [1.2–29.3]	0.049	
8+	4 (23.5%)	1,060	2.1 [0.4–15.2]	0.391	
Horse age (years)					
≤6	4 (23.5%)	594	(Ref)		0.352
7	1 (5.9%)	602	0.2 [0.01–1.7]	0.211	
8	2 (11.8%)	700	0.4 [0.1–2.2]	0.322	
9+	10 (58.8%)	1,630	0.9 [0.3–3.3]	0.875	
Horse sex					
Male (gelding or stallion)	15 (88.2%)	3,230	0.7 [0.2–4.4]	0.635	
Female (filly or mare)	2 (11.8%)	296	(Ref)		0.635
Steeplechase rating					
Maiden (≤55)	5 (29.4%)	1,193	0.6 [0.2–2.2]	0.454	
Rating 65 (56–65)	5 (29.4%)	742	(Ref)		0.825
Rating 75 (66–75)	3 (17.6%)	714	0.6 [0.1–2.5]	0.518	
Rating 85 (76–85)	2 (11.8%)	400	0.7 [0.1–3.4]	0.721	
Open (86+)	1 (5.9%)	470	0.3 [0.02–2.0]	0.293	
Jockey experience					
Apprentice	5 (29.4%)	833	(Ref)		0.576
Jockey	12 (70.6%)	2,693	0.7 [0.3–2.3]	0.576	
Jockey gender					
Male	16 (94.1%)	3,057	2.5 [0.5–44.3]	0.384	
Female	1 (5.9%)	469	(Ref)		0.318
Jockey age (years)					
<25	7	1,185	(Ref)		0.270
25–29	5	953	0.9 [0.3–2.8]	0.840	
30–34	1	738	0.2 [0.01–1.3]	0.168	
35+	1	570	0.3 [0.02–1.7]	0.256	
Ride number for the day					
1–2	11	1,889	(Ref)		0.353
3+	6	1637	0.6 [0.2–1.7]	0.362	
Carried weight (kg)					
<65	4	396	1.9 [0.5–6.2]	0.313	
65	7	1,304	(Ref)		0.398
66–67	2	745	0.5 [0.1–2.1]	0.387	
68+	4	1,081	0.7 [0.2–2.3]	0.553	

Table 3
Multivariable incidence rate ratios (IRR) and 95% confidence interval of a fatal fracture in hurdle races occurring with the effects of season and jockey gender in the 2011/12-2021/22 racing seasons.

Multivariable	n (%)	Starts	IRR [95% CI]	p-value	Wald p-Value
Season					
Autumn	0	836	-		
Winter	16 (59.3%)	3,522	(Ref)		0.048
Spring	11 (40.7%)	1,086	2.2 [1.0–4.6]	0.048	
Jockey gender					
Male	19 (70.4%)	4,701	(Ref)		0.039
Female	8 (29.6%)	743	2.6 [1.1–5.6]	0.026	

to the high incidence of horse falls related to fatal fractures, future research should continue to determine potential changes to reduce falls and therefore, fatal fractures.

The underlying reason for the higher incidence of fatal fractures in spring compared to winter for hurdle races is unclear. The even distribution of the jumps racing calendar in New Zealand does not provide dramatic changes with the season (Autumn, Winter, Spring) in the type of going the jumps horses are exposed to, with most of the racing being on heavy tracks. Thus, there is limited changes in going between seasons. There was no increase in the IRR for falls between Spring and Winter [21]. Given that most fatal fractures are associated with falls this implies that there may be some difference in the nature of the falls in hurdle races during spring than winter which increases the risk of fatal fracture.

Unlike in other overseas jurisdictions such as Victoria, Hong Kong, and California [1,28,29], postmortems are not routinely undertaken for race day fatalities in New Zealand unless requested by the owner, trainer or racing official. Therefore, the descriptors for the cause of death and reason for euthanasia are based on gross clinical findings during the veterinary examination, often leading to a presumptive diagnosis. As a result, many sudden deaths are classified as cardiac failure due to no other obvious clinical finding [24]. With limited resources on race day, there are few opportunities to radiograph and postmortem horses with catastrophic musculoskeletal injuries, limiting the ability to identify the precise bone and aetiology of the injury. Although the descriptive reporting of fatal fractures improved with the introduction of equine veterinarians and the online recording system, there is still room for further improvement. In many racing jurisdictions post-mortem examinations are routinely performed on race day fatalities [30]. The findings from postmortem schemes in other jurisdictions have improved the description of the underlying event and the identification of pre-existing pathology, and have contributed to the understanding of risk factors [24,29]. The implementation of a postmortem scheme in New Zealand would greatly enhance the reporting of race day fatalities in all racing disciplines.

5. Conclusions

Although the incidence of fatal fractures was similar between steeplechase and hurdle races, the risk factors for fatal fractures differed. Horses racing in steeplechase races were more likely to sustain a fatal fracture when racing a distance over 4,200 m than in a race less than 4,200 m indicating a fatigue effect often observed in the form of horse falls. In hurdle races, the risk of fatal fracture was higher for horses racing in spring compared to winter. The high percentage of fatal fractures as a result of a horse fall emphasises the importance of reducing the incidence of horse falls to indirectly reduce the incidence of fatal fractures. Future research should aim to investigate horse falls in greater detail. The increasing level of detail for recorded fatality events over the eleven seasons reflects the proactive changes in the industry regulatory reporting practices through the use of an online app-based system and equine veterinarians. This improvement in recording and the implementation of a race day fatality postmortem scheme should provide more robust data to enable risk factors for fatality and horse falls to be identified at a greater depth. Evidence-based changes to racing regulations can then be imposed and the effectiveness of these changes to be monitored.

Declaration of Competing Interest

The authors declare no real or perceived conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

CRediT authorship contribution statement

Michaela J. Gibson: Formal analysis, Data curation, Methodology, Writing – original draft, Writing – review & editing. **Kylie A. Legg:** Formal analysis, Writing – review & editing. **Erica K. Gee:** Writing – review & editing, Funding acquisition. **Chris W. Rogers:** Methodology, Writing – original draft, Writing – review & editing, Funding acquisition.

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