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AUTHORS: **S. M. Rosanowski**, Y. M. Chang, A. J. Stirk and K. L. P. Verheyen

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1 Descriptive epidemiology of veterinary events in flat racing
2 Thoroughbreds in Great Britain (2000 to 2013)

3

4 S.M. Rosanowski^a, Y.M. Chang^b, A.J. Stirk^c, K.L.P. Verheyen^a

5 ^a Veterinary Epidemiology, Economics and Public Health Group, Department of Production and
6 Population Health, The Royal Veterinary College, University of London, North Mymms, Hatfield,
7 Hertfordshire AL9 7TA, United Kingdom

8 ^b Research Office, The Royal Veterinary College, University of London, London, NW1 0TU, United
9 Kingdom

10 ^b British Horseracing Authority, 75 High Holborn, London WC1 6LS, United Kingdom

11 Corresponding author

12 srosanowski@rvc.ac.uk

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16

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18 **Ethical animal research**

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20 Horseracing Authority. The project was approved by the Clinical Research Ethical Review Board
21 (CRERB) at the Royal Veterinary College, URN 2015 1362.

22

23 Abstract

24 **Background:** To date, no large scale studies have reported race-day events requiring veterinary
25 attention in British Thoroughbreds racing on the flat. Quantifying and describing common injuries and
26 health conditions affecting racehorses will enable targeted risk factor analysis aimed at reducing their
27 occurrence.

28 **Objective:** To describe the type and incidence of race-day veterinary events experienced by
29 Thoroughbred racehorses participating in flat racing in the United Kingdom.

30 **Study design:** Retrospective cohort study (2000 to 2013).

31 **Methods:** Veterinary events recorded by race-day veterinarians were retrieved and linked to race start
32 data. Race-day veterinary events were described by type, location and anatomical structure(s)
33 affected and whether the outcome was fatal or not. Incidence per 1000 starts was calculated, both
34 overall and by year. Stratified incidence rates were calculated for selected event categories by specific
35 course- and horse-level variables.

36 **Results:** There were 7,993 events experienced by 6,727 horses, with an incidence of 9.37 events per
37 1000 starts. Soft tissue injuries other than tendon and ligament injuries were the most commonly
38 occurring veterinary events (24.1%), followed by gait observations (21.2%) and respiratory conditions
39 (21.2%). In total, 13.8% of events were bone injuries. The incidence of fatality (n=628) was 0.76 per
40 1000 starts. Most (485/628, 77.2%) fatal events were bone injuries, 64 were due to cardiac conditions
41 and 54 due to tendon and ligament injuries. All-weather tracks had a higher incidence of veterinary
42 events and fatalities than turf tracks. Firmer (turf) or faster (all-weather) going were associated with
43 a higher incidence of all veterinary events.

44 **Main limitations:** Events were based on presumptive, rather than definitive veterinary diagnosis.

45 **Conclusion:** The most common events experienced by racehorses on race-day were relatively minor
46 and not career-ending. Although more severe bone, joint, tendon and ligament injuries were less
47 common, they had a greater impact on whether the outcome of the event was fatal.

48

49 Introduction

50 Injuries to the musculoskeletal system are the most common reason for fatality on race-day
51 worldwide [1-4]. In flat racing in Great Britain, a fatality incidence of 0.8 per 1000 starts [5] has been
52 reported, with 3.07 limb injuries per 1000 starts [4]. Sudden death in apparently healthy
53 Thoroughbred racehorses, and where death was not attributed to catastrophic injury, has been
54 reported at between 0.07 and 0.09 per 1000 flat racing starts [1; 6].

55 A number of studies have described the incidence of specific injuries or conditions in
56 racehorse populations [7-10] or have focused specifically on fatality [1-4]. While impact of racehorse
57 fatality on horse welfare, jockey safety and the public perception of the racing industry is widely
58 acknowledged, less is known about non-catastrophic injuries. In Thoroughbred racehorses worldwide,
59 injuries are one of the main reasons for retirement from racing [10; 11]. Similarly, respiratory and
60 cardiac conditions can lead to poor racing performance, retirement from racing or death [1; 4; 12].
61 However, to date, no large scale studies have specifically investigated the injuries and conditions
62 experienced by flat racing horses on race-day. It is essential to describe and quantify the occurrence
63 of events where the horse required veterinary attention in order to elucidate risk factors and evaluate
64 the effectiveness of subsequent interventions. Therefore, the objectives of the current study were to
65 describe the incidence and distribution of different veterinary events occurring on flat race-days in
66 Great Britain over 14 years.

67

68 Methods

69 Study design, period and population

70 A retrospective cohort study of Thoroughbreds racing in flat races between 1st January 2000
71 and 31st December 2013 in Great Britain was conducted. The study population consisted of all horses
72 declared to race in at least one flat race during the study period. The declaration to race is confirmed
73 45 minutes prior to the start of the race and all horses declared to race were in attendance at the
74 racecourse at this time. Flat race meetings were held at 35 turf tracks and five all-weather tracks.

75 Data collection

76 As part of normal race-day procedure, official racecourse veterinarians recorded events where
77 horses present at the racecourse required and received veterinary attention, including injuries,
78 medical and other conditions. Veterinary event reports were primarily based on clinical examination
79 without further diagnostic investigations (presumptive diagnosis). Events were recorded on race-day
80 into the British Horseracing Authority's (BHA) injury database. Additional data, including horse
81 demographics, race and course information for all horses declared to start in a flat race during the
82 study period were collated from the Weatherbys racing database (www.weatherbys.co.uk). A
83 custom-designed (SQL) database was created for the study reported here, to combine the race starts
84 and injury files, linking records by horse and race identification numbers.

85 Veterinary events

86 A veterinary event was defined as any event involving a horse that required veterinary
87 attendance on race-day and for which a report was generated in the BHA database. One veterinary
88 event could include multiple diagnoses and include more than one medical condition and/or injury
89 type and/or could affect multiple body regions. Veterinary events were categorised as: bone injuries,
90 joint injuries, tendon and ligament injuries, other soft tissue injuries, gait observations, cardiac,
91 respiratory, metabolic and digestive, or miscellaneous conditions. Events were not mutually exclusive,

92 so multiple diagnoses were classed across different categories, as appropriate. The bone injury
93 category comprised all injuries that affected bone, including fractures and possible fractures. Joint
94 injuries were all injuries to joints including dislocation and effusion but excluding fractures (which
95 were classed in the bone injury category). Other soft tissue injuries included those affecting the skin
96 and muscles; wounds and lacerations, punctures, haematomas and muscle strains. The category 'gait
97 observations' included lame horses or those with poor/abnormal action, but where no further
98 diagnosis was made. Gait observations also included horses with stringhalt and shivers. Metabolic
99 and digestive conditions included colic, choke, myopathy ('tying up'), fatigue, prolonged recovery and
100 distress. Miscellaneous conditions included allergies and skin conditions unrelated to injury (e.g. ring
101 worm and rain scald). Where appropriate, veterinary events included information regarding the
102 anatomical structure or body region affected. Veterinary events with a fatal outcome were defined
103 as events which resulted in the death or euthanasia of the horse on race-day, henceforth called
104 fatality.

105 Data analysis

106 The total number of starts per horse and starts per year were summarised as median and
107 interquartile range (IQR). A horse was deemed to have made a start when it was successfully loaded
108 into the starting gate, so one horse could start in multiple races during the study period. Horses that
109 were declared to race but did not race on that day were described as withdrawn.

110 Veterinary events and the outcome of veterinary events (fatal or not) were described as
111 counts and percentages, by event category and by injury types/conditions within each category.
112 Where appropriate, events were described by the location on the body where they occurred; distal
113 limb, proximal limb, or other body areas. Bone, joint and tendon and ligament injuries were further
114 described by the anatomical structure(s) affected.

115 Incidence was calculated as the number of events per 1000 starts for the overall study period
116 and by year, both for all veterinary events and for specific event categories. Stratified incidence rates

117 were calculated for selected event categories by surface (turf vs all-weather), going (for turf; heavy,
118 soft, good to soft, good, good to firm, firm and hard and for all-weather; slow, standard to slow,
119 standard, standard to fast, fast), sex (male vs female) and age group (in years; 2, 3, 4, 5, 6, 7 and 8
120 plus). Withdrawn horses were not included in either the numerator or denominator for incidence rate
121 calculations.

122 As the study included the entire population of flat racehorses over the study period, the
123 precision for the incidence rates were not calculated. All analyses were conducted in Stata version
124 11¹.

125

126 Results

127 Over the 14-year study period there were 67,670 horses making 806,764 starts and 4,303
128 withdrawals in 77,336 flat races. Horses that started had a median of 7 (IQR 4 to 14) starts per horse;
129 the maximum was 231 starts. The median number of starts per year was 59,010 (IQR 54,309 to
130 60,087). Races were held over 11,412 race-days. In total, 51,574 races were run on turf surfaces and
131 25,762 on all-weather tracks.

132 Table 1 summarises the number and incidence of race-day veterinary events over the study
133 period. There were a total of 7,993 recorded veterinary events and 437 horses with veterinary events
134 were withdrawn prior to racing. Veterinary events involved 6,727 horses over 7,316 individual races
135 and across 5,069 race-days. The overall incidence of veterinary events was 9.37 per 1000 starts.

136 Bone injuries

137 The incidence of bone injuries was 1.32 per 1000 starts. In 41 events, horses with bone injuries
138 were withdrawn. Most bone injuries were described as fractures, comminuted fracture, compound

¹ StataCorp. 2009. *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.

139 fracture or possible fractures (n=1,045; 94.2%). Sixty-eight bone injuries did not specify the type of
140 bone injury that had occurred and seven bone injuries included more than one description of fracture
141 type.

142 Distal and proximal limb injuries accounted for 641 (57.8%) and 336 (30.3%) bone injuries,
143 respectively (Table 2). Five veterinary events described bone injuries in two locations and 10 distal
144 limb events included more than one bone. On the distal limb, the third metacarpal or metatarsal
145 (MC3/MT3) bone were the most commonly affected structures (n=261; 40.7%). Most proximal limb
146 fractures (67.3%; n=226) were of the pelvis.

147 Joint injuries

148 The incidence of joint injuries was 0.18 per 1000 starts; 13 horses with joint injuries were
149 withdrawn. Most joint injuries were strains (n=72; 45.3%), followed by enlargements and effusions
150 (n=32; 20.1%), dislocations (n=25; 15.7%), unspecified joint injuries (n=27; 17.0%) and penetration
151 injuries (n=3; 1.9%). The fetlock and carpus were affected in 64.5% (n=102) and 22.0% (n=35) of joint
152 injuries, respectively. Other structures affected included the sacroiliac joint (n=7; 4.4%), hock (n=5;
153 3.2%), stifle (n=3; 1.9%) and pastern (n=3; 1.9%).

154 Tendon and ligament injuries

155 The incidence of tendon injuries was 0.61 per 1000 starts; two horses with tendon and
156 ligament injuries were withdrawn. Most tendon and ligament injuries were to the superficial digital
157 flexor tendon (SDFT; n=365; 74.2%), followed by the suspensory ligament (n=84; 17.1%). Other
158 structures affected include, tthe deep digital flexor tendon (DDFT; n=25; 5.1%), Achilles mechanism
159 (n=10; 2.0%), check ligament (n=9; 1.8%) and sesamoidean ligament (n=8; 1.6%). In 18 tendon and
160 ligament injuries the affected structure was not listed. In 26 (5.3%) events, more than one tendon or
161 ligament was affected; DDFT and SDFT (n=13), DDFT, SDFT and suspensory ligament (n=1), suspensory

162 and SDFT (n=1). All injuries of the Achilles mechanism (n=10) and one injury of the sesamoidean
163 ligament included injury to the SDFT as well.

164 Overall, 210 (42.7%) tendon and ligament injuries were reported as moderate strains, 152
165 (30.9%) as severe strains or ruptures, 62 (12.6%) as slight strains. In 33 (6.7%) cases the tendon or
166 ligament was severed, 15 (3.0%) were reported as lacerations and 20 (4.0%) as other types of injury.

167 Other soft tissue injuries

168 A total of 178 horses with other soft tissue injuries were withdrawn and the incidence of other
169 soft tissue injuries was 2.17 per 1000 starts. The majority (n=1,349, 70.0%) of other soft tissue injuries
170 were lacerations and wounds, 291 (15.1%) were inflammation or soreness, 97 (5.0%) were bruises or
171 haematomas, 52 (2.7%) were muscle strains, 45 (2.3%) were punctures and 27 (1.4%) were other types
172 of injuries. In 69 (3.6%) cases the affected structure was not recorded. Most of the other soft tissue
173 injuries occurred in the distal limb (n=1,157; 60.1%) and 17.6% (n=399) in the proximal limb.

174 Gait observations

175 'Gait observations' were recorded in 1,698 veterinary events. In 1,532 (90.2%) of these, horses
176 were reported as lame, poor movers, unlevel or stiff. The incidence of gait observations was 1.90 per
177 1000 starts (Supplementary Table 1).

178 Cardiac, respiratory, metabolic or digestive and miscellaneous conditions

179 There were a total of 283 cardiac events, the majority were dysrhythmias (n=166; 58.6%),
180 followed by vascular catastrophe (n=67; 23.7%). Twenty-one percent (n=1,698) of veterinary events
181 were recorded as respiratory conditions; most were episodes of epistaxis (n=1,026; 60.5%) with an
182 epistaxis incidence of 1.25 per 1000 starts. In 165 (9.7%) events, horses underwent airway endoscopy
183 and blood and/or mucopus was present; in 97 (5.7%) events, horses underwent airway endoscopy but
184 no abnormalities were detected. Metabolic and digestive conditions were reported in 370 (4.6%)

185 events. There were 388 other veterinary events. Supplementary Table 1 provides a more detailed
186 summary of cardiac, respiratory, metabolic and digestive conditions.

187 Fatalities

188 In total, 628 (7.9%) events had a fatal outcome, 18 of which occurred prior to the horse
189 starting in a race. The incidence of fatality was 0.76 per 1000 starts (Table 1). The most common
190 cause of fatality was bone injury (n=485; 77.2%), followed by cardiac conditions (n=64; 10.2%). The
191 distribution of fatal bone injuries is summarised in Table 2. Fatal cardiac conditions were described as
192 vascular catastrophe in 62 cases; the other two did not have further details recorded. All eight
193 respiratory fatalities were attributed to epistaxis. Two fatalities were reported in the 'other' category;
194 one fatality was due to concussion and one due to a neurologic condition. Seventeen events with a
195 fatal outcome had more than one condition and/or injury listed.

196 Stratified incidence rates

197 Table 3 summarises the incidence of veterinary events by categories of selected events and
198 outcome, stratified by sex, age, surface and going. All stratified incidence rates were higher on all-
199 weather tracks compared to turf tracks. Hard and firm, standard to fast and fast going had a higher
200 incidence of all types of events for turf and all-weather surfaces, respectively. The incidence of
201 veterinary events overall decreased with increasing age but rates of tendon and ligament injury,
202 epistaxis and fatality tended to increase with older age. The incidence of bone injury was lowest in
203 two-year-olds and highest in three-year-olds. Figure 1 summarises incidence rates by year for all
204 categories of veterinary events over the study period.

205

206 Discussion

207 This large-scale study has, for the first time, described the type and incidence of veterinary
208 events reported during race-days in flat racing Thoroughbreds in Great Britain. Soft tissue injuries
209 other than to tendon or ligament structures, lameness with no further diagnosis and respiratory
210 conditions were most commonly reported race-day events although none of these were associated
211 with substantial fatality rates. Whilst bone injuries comprised a relatively small proportion (14%) of
212 all race-day veterinary events, nearly half of these (44%) had a fatal outcome and the majority of
213 fatalities (77%) were associated with bone injuries. The overall incidence of fatality in this study of
214 0.76 per 1000 starts was similar to previously reported fatality rates in British flat racing of between
215 0.8 and 0.9 fatalities per 1000 starts [2; 5], suggesting that fatality rates in flat racing have remained
216 relatively stable in the past decade. However, they remain substantially lower than fatality rates in
217 jump racing, which have been reported as 4.9 and 6.7 fatalities per 1000 starts for hurdle and
218 steeplechase races, respectively [13].

219 Many veterinary events were classed as 'gait observations', where horses were examined for
220 lameness but where no conclusive diagnosis was achieved. In a study of 1,002 lame racehorses that
221 underwent nuclear scintigraphy at two equine hospitals in North America, 19% had stress fractures
222 [14]. It is arguable that further diagnostic investigation of the horses classed with 'gait observations'
223 in the current study would have revealed underlying pathology that would have allocated the
224 veterinary event to a different category and, as a result, the incidence of bone, joint or tendon injuries
225 reported here may reflect conservative estimates. Lameness horses are likely to have undergone further
226 investigations when they returned home after racing, although this information was not available for
227 the study and is not reported here.

228 The more severe veterinary events were bone, joint, tendon and ligament injuries, and most
229 of these injuries occurred in the distal limb. The structures most commonly affected were the third
230 metacarpal or third metatarsal, proximal phalanx, carpus, tarsus, sesamoid bones, SDFT and the

231 fetlock joint which is comparable to previous studies in the racing population in Great Britain [2; 15;
232 16]. The combined incidence of bone, joint and tendon and ligament injury in the current study was
233 lower than a previously reported estimate of 3.07 (95% CI 2.78 to 3.37) per 1000 flat racing starts for
234 all types of limb injury [4], although it is not exactly clear what types of limb injury were included in
235 the previous study and therefore whether estimates are directly comparable. The incidence of tendon
236 and ligament injuries in the current study (0.61 per 1000 starts) appeared to be slightly lower than
237 reported previously in Great British flat racing horses at 0.78 (95% CI 0.63 to 0.93) per 1000 starts [4],
238 although the latter study was smaller and thus the incidence estimate may be less precise. Overall,
239 the incidence of tendon and ligament injuries in flat racehorses is much lower compared with horses
240 starting in National Hunt races, with an incidence of 6.11 and 6.30 per 1000 starts for hurdles [7] and
241 steeplechase racing [8], respectively, due to the increased loading of limbs over jumps [12].

242 Similarly, the incidence of epistaxis remains much lower in flat racing than in jump racing; 1.25
243 per 1000 starts in the current study compared to 3.6 and 5.3 per 1000 starts for hurdles and
244 steeplechasing respectively, over a similar time period (2000 to 2009) [9]. Race type has previously
245 been identified as a risk factor for epistaxis, with horses involved in jumps races at a higher risk, due
246 in part to the increased loading on the forelimbs due to jumping [12]. However, regardless of race
247 type, the incidence of epistaxis (1.25 per 1000 starts in the current study) seems to have increased
248 compared to previously reported estimates of 0.33, 1.26 and 2.11 episodes per 1000 flat, hurdles and
249 steeplechase starts, respectively [4; 12]. Newton *et al.* [12] hypothesised that the incidence reported
250 was likely to be an underestimate of the total number of horses experiencing epistaxis on race-day, as
251 horses that win or place and/or horses with poor performance would be under greater veterinary
252 observation than other horses. It is likely however that under-reporting of epistaxis also affected
253 incidence estimates in the current study and so this may only partly explain the higher rates recorded.
254 Future risk factor analysis for epistaxis may identify underlying risk factors that could help to explain
255 the reported increase in this condition.

256 The observed incidence of injuries and fatalities varied by surface, sex, age and going. For all
257 injuries and fatalities, incidence rates were higher on all-weather tracks compared to turf tracks, and
258 on firmer and faster turf and all-weather going, respectively. This observation is consistent with
259 findings in previous studies assessing risk factors for epistaxis [9; 12], tendon injury [7; 8] and fatality
260 [2]. The general trend for increasing rates of tendon and ligament injury, epistaxis and fatality with
261 increasing age seen in this study is also consistent with findings in previous studies [17]. Although the
262 incidence of bone injury was lowest in two-year-olds and highest in three-year-olds, previous studies
263 using multivariable risk factor analysis have not identified associations between age and fracture [16;
264 18]. It would therefore be inappropriate to draw conclusions about potential associations between
265 age and bone injury based only on the descriptive incidence rates reported here. Similarly, although
266 the incidence of tendon and ligament injuries, epistaxis and fatality were higher in male horses
267 whereas females had a higher incidence of bone injuries, it would be prudent not to draw conclusions
268 about potential sex effects without conducting further multivariable analyses. Previous studies
269 identifying risk factors for tendon injuries in National Hunt racehorses in racing and training did not
270 identify differences between males and females in multivariable analyses [7; 8; 19] although in a Hong
271 Kong-based study, male horses were more likely to sustain SDFT injury than females [10]. Similarly,
272 although sex was not found to increase the risk of metacarpal or metatarsal joint fractures in some
273 studies [20], in others, male horses were more likely to sustain a fracture [21; 22]. Further
274 multivariable analyses will enable quantification of the associations between the stratification
275 variables reported here and specific outcomes, when adjusted for the effects of potential
276 confounders.

277 Over the 14-year study period the incidence of some conditions, particularly gait observations
278 and respiratory conditions seemingly increased from 2004 onwards, while the incidence of fatalities,
279 joint and tendon and ligament injuries remained relatively stable. In 2004, the BHA's injury database
280 moved to entirely electronic recording of events, which became rigorously enforced. Increased
281 reporting is a likely explanation for the apparent rise in less severe veterinary events over the study

282 period, whereas it is likely that more severe veterinary events would have been reported regardless
283 of the method of recording. The incidence of bone injuries, which fluctuated between 2000 and 2006,
284 increased from 2007. This apparent increase requires further investigation, given the severity of type
285 of veterinary event and associated fatality rate.

286 The categorisation of veterinary events was based on race-day reports and the pro-forma
287 recording systems developed by the BHA and, given the limited diagnostic facilities on British
288 racecourses, it is likely that some reported injuries or conditions were misclassified. Many of the
289 veterinary events described were based on the signs identified during a clinical examination
290 (presumptive diagnosis) rather than on a definitive diagnosis. Further diagnostic techniques were
291 used in some cases, although it was not always clear from the records why these occurred and some
292 resulted in no abnormal findings being reported (e.g. in 97 veterinary events, horses categorised as
293 having a respiratory condition, underwent endoscopic examination but no abnormalities were
294 detected). Also, horses could leave the racecourse before an injury was diagnosed, even when it was
295 sustained during racing. Some events, like tendon and ligament injuries, may have been under-
296 reported, or misclassified based on the presenting signs at the time of the event [10]. Consequently,
297 it is likely that incidence rates reported here, particularly for less severe events, are under-estimates
298 of the true incidence.

299 Bone injuries reported as fractures may also have been misclassified to some extent. Reardon
300 *et al.* [23] reported that race-day veterinarians correctly identified that a horse had a fracture on
301 greater than 90% of occasions. However the correct recording of at least one of the fractured bones
302 occurred on between 65% and 90% of occasions, based on subsequent post mortem examination.
303 Additionally, between 5% and 6% of injuries reported as fractures were not fractures but, most
304 commonly, suspensory ligament rupture or sesamoidean ligament damage. The authors reported
305 that injuries in these misclassified cases were still severe enough to justify euthanasia. Given that the
306 current study has utilised the same data recording methods, albeit over a longer time period, similar

307 misclassification errors would be expected. The routine availability of basic diagnostic facilities on
308 British racecourse would reduce the potential for misclassification of veterinary events and increase
309 the accuracy of incidence rate estimates. Furthermore, ability to access on-course diagnostic facilities
310 to aid in the diagnosis of injury could improve the prognosis for non-catastrophic injuries, in particular
311 fractures [24]. However, there are issues associated with this including the practicality, costs and lack
312 of infrastructure on-course.

313 This study has identified the most commonly occurring race-day veterinary events for flat
314 racing Thoroughbreds in Great Britain. Soft tissue injuries other than tendon or ligament injuries were
315 most commonly reported, followed by gait observations and respiratory conditions. The incidence of
316 bone injuries was lower, but these were associated with the highest incidence of fatality, followed by
317 cardiac conditions. The findings from this study will now inform further multivariable statistical
318 analysis to determine modifiable risk factors for selected outcomes, in particular injuries. The results
319 also provide a baseline against which to measure the effect of potential interventions aimed at
320 reducing injury and fatality occurrence in flat racing in Great Britain.

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322

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327 Veterinary College research committee.

328 **Conflict of interest**

329 The authors report no conflict of interest.

330

331

332 Figure 1 – Incidence of veterinary events experienced by flat racing Thoroughbreds in Great Britain as
333 reported by race-day veterinarians (2000 to 2013), by year. (A) Bone, joint and tendon and ligament
334 injuries, (B) Respiratory conditions, gait observations and soft tissue injuries (other than to tendon or
335 ligament structures), (C) Cardiac, metabolic and digestive and other conditions, (D) Fatalities.

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