Institution: University of Glasgow (UofG)		
Unit of Assessment: UoA 6 (Agriculture, Veterinary and Food Sciences)		
Title of case study: Raising the standard of equine welfare to reduce injury and death across race and endurance sports worldwide		
Period when the underpinning research was undertaken: 2007–2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): **(1)** Prof Tim Parkin; **(2)** Dr Stamatis Georgopoulos; **(3)** Dr Euan Bennet.	**Role(s) (e.g. job title):** **(1)** Professor of Veterinary Epidemiology; **(2)** Research Associate; **(3)** Research Associate.	**Period(s) employed by submitting HEI:** **(1)** 2007–2020; **(2)** 2017–2018; **(3)** 2015–2020.
Period when the claimed impact occurred: 2014–2020		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact

Horse racing and endurance riding have faced criticism owing to high levels of equine injury and death. UofG researchers worked with the leading organisations in these sports to identify risk factors affecting equine welfare. Their findings supported initiatives taken by The Jockey Club of North America to minimise racehorse injuries. Such actions have resulted in a 24% reduction in equine fatalities since 2014, equivalent to approximately 135 fewer deaths during racing per year. In 2020, the Fédération Equestre Internationale (FEI) revised its mandatory rules for endurance riding worldwide in line with UofG evidence, embedding practices that safeguard the welfare of approximately 10,000 horses participating in 300 events annually.

2. Underpinning research

For the past 20 years, research conducted by veterinary epidemiologist **Prof Tim Parkin** has focussed on preventing equine injury and death in race and endurance sports. His early work in this area (conducted at the University of Liverpool Veterinary Teaching Hospital; 1999–2005) evaluated the risk of fatal distal limb fractures among racehorses. Since moving to UofG in 2007, he has collaborated with leading sporting bodies to address key issues in equine welfare.

Flat racing

The Jockey Club of North America oversees the improvement of Thoroughbred breeding and racing across this region. In 2008, this organisation created the Equine Injury Database (EID) to improve safety and prevent injuries. The EID receives data from 110 participating racetracks and associations, comprising approximately 97% of all flat racing days in North America. **Parkin** has been the epidemiological consultant for the EID since its inception. This database includes more than 6,500 fatal injuries recorded in almost 3.7 million race starts (2009–2019), providing unparalleled levels of statistical power to identify novel risk factors.

From 2013–2017, The Jockey Club of North America funded a PhD student (**Dr Stamatis Georgopoulos**) to work with **Parkin** on a large-scale analysis of the EID to identify risk factors for fatal injury during flat racing [3.1, 3.2]. Working with local jurisdictions, they identified areas for investigation and used statistical modelling to create and test multiple potential risk factors for different fatal or non-fatal injury outcomes. This research involved multivariable techniques that can accurately model associations between risk factors and injuries, and account for confounding factors that are missed by univariable analyses. In all, 22 risk factors for fatal injury were identified [3.1, 3.2]. Race-related risk factors included the track (surface and condition) and the distance run. Horse-related risk factors included previous injuries; being on the veterinary examiner's list; age at first race start; present age; sex; time with same trainer; and racing history. Of these factors, racing a horse that had sustained a previous injury (or was flagged on a prerace veterinary examiner's list) increased risk by 35%; dirt track surfaces increased risk by 32%; and male sex increased risk by 47%. Risks were also increased by long between-race intervals and late onset of racing career. These models were validated with respect to their predictive ability, where they provide estimates of risk for individual horses or groups of similar horses entering a race. This approach enables data-driven evidence-based decisions about whether horses should compete in particular races.

Parkin has also investigated medications as potential risk factors for injury during racing. Phenylbutazone is an analgesic and anti-inflammatory drug that is authorised for administration to horses before competing in specific races throughout the Americas. A retrospective study of 283,193 race starts at two tracks in Argentina during 2006–2015 identified an increased risk of fatal and non-fatal injury associated with prerace administration of phenylbutazone (**Parkin**) [3.3]. These results did not imply a direct causal relationship; however, they flagged the need to develop equine welfare-oriented medication policies to minimise risk.

Endurance riding

Endurance riding is governed by the FEI, an international body acting on behalf of 136 national federations. This sport involves controlled long-distance rides (50–100 miles), with compulsory halts for veterinary inspection after each stage, during which heart rate must reduce to a specified level before horses are allowed to continue the ride. Any horses exhibiting lameness or metabolic problems (which can lead to death) are withdrawn from the ride and classified as 'failure to qualify' (FTQ).

In 2014, UofG researchers and the FEI initiated a research collaboration—the Global Endurance Injuries Study (GEIS)—to assess risk in this sport. **Parkin** and **Dr Euan Bennet** conducted statistical modelling using 5 years of endurance ride data to identify factors associated with FTQ [3.4, 3.5]. Key factors increasing risk of FTQ included fast riding speeds early in the event (greater than approximately 19.5 km/hour) and short between-ride rest periods, especially after a previous FTQ. Additional actionable risk factors included field size (the number of competing riders, age and distance), with rides of 160 km associated with metabolic problems. **Parkin** and **Bennet** also identified specific geographical regions with increased risk of FTQ owing to metabolic problems, which were partly associated with climatic conditions [3.5]. Together, this research suggested that horses would benefit from an extended between-competition rest period after recording any type of FTQ [3.6].

The GEIS was renewed to evaluate predictive models across equine populations participating in endurance rides (2017–2021). This work has potential applications for event management through exploring the impacts of changes in weather, terrain, speeds and other factors on equine welfare. It has also developed a risk calculator for use by veterinary delegates to risk-assess all horses before and during rides, drawing on research by **Bennet** and **Parkin** [3.7].

3. References to the research

1. Georgopoulos SP, Parkin TDH (2016) Risk factors associated with fatal injuries in Thoroughbred racehorses competing in flat racing in the United States and Canada. *J Am Vet Med Assoc*;249:931–939. doi:10.2460/javma.249.8.931 [Available on request from HEI]
2. Georgopoulos SP, Parkin TDH (2017) Risk factors for equine fractures in Thoroughbred flat racing in North America. *Prev Vet Med*;139(Pt. B):99–104. doi:10.1016/j.prevetmed.2016.12.006
3. Zambruno T, Georgopoulos SP, Boden LA, Parkin TDH (2020) Association between the administration of phenylbutazone prior to racing and musculoskeletal and fatal injuries in Thoroughbred racehorses in Argentina. *J Am Vet Med Assoc*;257:642–647 doi:10.2460/javma.257.6.642 [Available on request from HEI]
4. Bennet ED, Parkin TDH (2018) Fédération Equestre Internationale (FEI) endurance events: riding speeds as a risk factor for elimination (2012–2015). *Vet J*;236:37–43 doi:10.1016/j.tvjl.2018.04.012
5. Bennet ED, Parkin TDH (2018) Fédération Equestre Internationale endurance events: risk factors for failure to qualify outcomes at the level of the horse, ride, and rider (2010–2015). *Vet J*;236:44–48 doi:10.1016/j.tvjl.2018.04.011 [Available on request from HEI]
6. Bennet ED, Parkin TDH (2020) The impact of the mandatory rest period in Fédération Equestre Internationale endurance events. *Equine Vet J*;52(2):268–272 doi:10.111/evj.13148
7. Bennet ED, Hayes ME, Friend L, Parkin TDH (2020) The association between clinical parameters recorded at vet gates during Fédération Equestre Internationale endurance rides and the imminent risk of elimination. *Equine Vet J*;52:832–840 doi:10.111/evj.13264

Parkin was Principal Investigator for the following grants:

- Grayson–Jockey Club Research Foundation and The Jockey Club of North America: *Predicting the risk of equine fatal injury during racing* (April 2017–March 2019; GBP65,096).
- FEI: *Maximising the impact of GEIS across endurance and other FEI disciplines* (November 2015–October 2021; GBP305,876).

4. Details of the impact

UofG expertise in veterinary epidemiology identified risk factors for injury and fatality among horses participating in **flat racing** and **endurance riding**, which in turn has raised awareness of the risks and driven improvements in equine welfare across these sports.

Benefits for flat racing in North America

Flat racing is a popular spectator sport, with prestigious races such as the 2019 Kentucky Derby attracting considerable interest in terms of track attendance (150,729 people); TV coverage (16.5 million viewers on US network NBC); and betting (USD165.5 million wagered). Racing also contributes USD15.6 billion directly to the US economy and supports more than 241,000 jobs across the sector. However, in 2008, a US Congressional committee called on the racing industry to improve its equine welfare record following three high-profile deaths, leading to creation of the EID. An average of 1.91 deaths per 1,000 race starts was recorded during 2009–2014 (4,165 deaths in total). With the average cost of a racehorse approximately USD80,000, and annual stud fees for a single elite male potentially worth more than USD10 million, racehorse welfare is of considerable economic importance to the sport.

Parkin has been the EID epidemiological consultant since 2008 [5.A], with the outcomes of his analyses reported annually [5.B]. His research revealed key risk factors associated with track deaths and catastrophic injuries leading to death [3.1, 3.2], which have evolved as the amount of information available in the EID grows each year. The value of this work is highlighted by the Executive Vice President, The Jockey Club of North America: "*Parkin's guidance, direction and research have been mission critical in positioning the EID as the nation's go-to resource for understanding and mitigating factors associated with increased risk of injury or fatality. Many of the safety procedures now in place at racetracks across the US can trace roots to Parkin's research. He has materially reduced the incidence of injury and fatality to race horses in North America as evidenced by the national statistics*" [5.A].

Although The Jockey Club of North America lacks the power to enforce regulation change directly, it acknowledges that Parkin's findings have contributed to a considerable **attitudinal shift in the racing industry**: "*A culture of safety has been seeded in the US and germinated into an environment where stakeholders have all raised their level of focus upon the health, safety and welfare of the horse. His messages effectively distil a very complex and statistically sophisticated analysis into language everyone involved in the business of breeding, raising and racing horses can understand and execute upon*" [5.A]. Other racing organisations concur [5.C]: "*The public has no tolerance for the deaths of racing horses and the entire industry has had to perform serious self-examination to identify ways to improve racing safety and health outcomes. Parkin's identification of risk factors allowed for understanding of where and how risk could be mitigated and offered the opportunity for rational discussions and mindful decision making*" (Executive Director, Racing, Medication & Testing Consortium; RMTC); "*Risk analysis allows horseracing to better focus their safety efforts [through] understanding that there are horse factors and racecourse management factors that put horses more at risk of injury. Parkin's research using EID data has received much greater public and policy attention than most other academic research related to horseracing*" (Equine Medical Director, California Horse Racing Board; CHRB).

Working through an extensive network of participating stakeholders and racecourses, The Jockey Club of North America Thoroughbred Safety Committee has recommended actions based on the risk factors identified by Parkin [3.1, 3.2] to promote an **industry-wide improvement in safety records**. These recommendations have been re-enforced through racetrack accrediting organisations such as the RMTC and the National Thoroughbred Racing Association (NTRA) Safety and Integrity Alliance, as well as via biennial summits on the

Welfare and Safety of the Racehorse co-hosted with the Grayson–Jockey Club Research Foundation (Parkin presented EID findings at this summit in 2015, 2016, 2018 and 2020) [5.A, 5.C]. For example, the 2019 NTRA Code of Standards requires all of its members to report injuries and fatalities to the EID, including the findings of post-mortem veterinary examinations, with protocols in place at racetracks to monitor such events [5.D]. The efforts of these national bodies have led to local and regional changes in North America. In October 2018, the CHRB amended Rule 1588 on race start eligibility to require veterinary checks for all horses that had not raced for 12 months (affecting over 1,700 horses per year) and for first-time racers aged 4 years or older [5.C, 5.D]. This rule change was based on a review of racing-related fatalities that reflected key findings of UofG data analyses [3.2]. In March 2019, all 29 organisations representing the Mid-Atlantic region Thoroughbred racing industry voted to adopt and implement a five-point strategic plan to reduce equine fatalities, including establishment of best practices to identify horses at increased risk of injury and implementation of protective factors to reduce such risk, with all racetracks required to report to the EID [5.D]. This region comprises the largest concentration of Thoroughbred racing in the USA, with around 90,000 race starts at 14 racetracks annually.

Local changes have resulted in a **year-on-year decrease in the rate of fatal injuries** across North America. The rate dropped by 24% between 2014 and 2019 (equating to approximately 135 fewer racecourse deaths/year) [5.B, 5.E]. Indeed, the 2019 fatality rate (reported in March 2020) was the lowest within the past decade (1.53 per 1,000 race starts versus 2.00 per 1,000 in 2009), with the rate on dirt surfaces also falling to a low of 1.60 per 1,000 race starts (versus 2.10 in 2009) [5.B, 5.E]. These findings were widely reported by the racing and equine media [5.E]. As highlighted above, reductions in fatal injuries have been realised through increasing industry awareness and scrutiny of equine welfare. An EID evaluation presented by Parkin at the Seventh Welfare and Safety of the Racehorse summit (June 2016) demonstrated that approximately 35% of the reported drop in fatal injuries could be attributed to mitigations of risk factors identified through UofG research [3.1, 3.2]; namely, race distance, race intensity, time with same trainer, age at first start, male horses and dirt track in sloppy/muddy condition ('off-dirt') [5.E]. The remaining 65% reflected veterinary history, training records, changes to medication regulations, local modification and natural/random variation [5.E].

In August 2020, the Kentucky General Assembly's Interim Joint Committee on Licensing, Occupations, and Administrative Regulations passed a raft of **medication rules**, including prerace withdrawal time for phenylbutazone extended from 24 to 48 hours [5.F]. This decision was based on Parkin's demonstration of phenylbutazone as a risk factor for injury and fatality [3.3]. The wider role of medication in race-related risk was acknowledged by the US Congress on passing the Horseracing Integrity and Safety Act to develop and implement a medication control programme (September 2020) [5.F]. Finally, The Jockey Club of North America has launched an electronic equine treatment records system that will enable analysis of medication patterns (type/frequency) for potential associations with increased risk of injury or fatality [5.A].

Global benefits for endurance riding

Each year, approximately 300 endurance rides take place under mandatory FEI rules in 50 countries worldwide. During the period 2010–2017, 32% of all horses participating in these events were eliminated owing to FTQ. Endurance riding had been criticised for an excessive rate of injuries and fatalities. In November 2013, the FEI Endurance Strategic Planning Group called for immediate and sustainable action to provide a permanent solution to this problem [5.G, 5.H]. As a result, the Injuries Surveillance System (ISS) was created to enable a consistent approach to managing the FEI data (February 2014) [5.G, 5.H].

The GEIS uses ISS data to identify risk factors for FTQ during endurance rides [3.4–3.7]. Parkin's findings were first announced at the FEI Sports and Endurance Forums in 2017 [5.I]. These presentations provided a clear message that speed and insufficient rest periods are key factors for FTQ. The UofG data also provided crucial evidence to substantiate **regulatory change** by the FEI General Assembly to revise mandatory rest periods and so minimise equine injury (November 2017) [5.I]. The proposed changes added 7 days to between-competition rest

periods across all distances for horses with an average ride speed greater than 20 km/hour (even if they do not complete the ride) and where there is evidence of irregular gait or any invasive treatment [5.I]. These changes would prevent up to 10% of FTQs and had been due to take effect in January 2019 [5.I]. However, the FEI decided to postpone as it had plans to go further with the rule changes.

In October 2018, a new five-person FEI Temporary Committee, which included Parkin, was created to review the entire rule book, and re-focus the sport on endurance *riding* rather than endurance *racing* [5.G, 5.J]. The **key rule changes** were presented at the 2019 FEI Sports Forum in April 2019 [5.J]. Substantial changes were made, with many rules altered based on analysis and evidence provided by Parkin and Bennet [3.4–3.7]. These included changes to the penalties for riding fast and not completing; extended mandatory out of competition periods; stricter regulations at veterinary inspections; changes to qualification regulations based on previous successful completion of rides, including as a specific horse–rider combination; and course design. Evidence demonstrating the clear link between his analyses and the most contentious rule changes was presented by Parkin to all national federations prior to the 2019 FEI General Assembly [5.J]. The new set of welfare rules was voted through by the National Federations at the FEI General Assembly meeting in November 2019 [5.J], with some changes coming into force on 1 January 2020, and the remainder introduced on 1 July [5.J]. The 2020 endurance riding season saw many events cancelled owing to COVID-19 lockdown and travel restrictions; therefore, the full benefits of these rule changes will be seen only from 2021.

5. Sources to corroborate the impact [PDFs uploaded for all listed items]

A. Testimonial, Executive Vice President, The Jockey Club of North America.
B. The Jockey Club of North America EID reports 2014–2019, citing Parkin as the analyst.
C. Testimonials from (1) Executive Director, RMTC; (2) Equine Medical Director, CHRB.
D. Action on equine welfare in racing: (1) NTRA Safety and Integrity Alliance Code of Standards (2019); see p.10–p.12; (2) CHRB Safety and Welfare Committee Meeting (2018); see p.3-1–p.3-7 for rule 1588, including amendments ‘n’ and ‘o’ (p.3-6) and UofG data slide (p.3-7), with citation of Georgopoulos and Parkin [3.2]; (3) Mid-Atlantic Thoroughbred racing Strategic Plan and press release (2019); see Goals I, III and IV.
E. Improved equine welfare in racing: (1) EID statistics for fatality by year and risk factor; (2) Media coverage of the 2019 EID statistics: BloodHorse, Paulick Report, The Horse, Thoroughbred Daily News; (3) The Seventh Welfare and Safety of the Racehorse summit (June 2016). See conference brochure (p.2, p.22, p.57–p.61) and presentation (slides 25–26).
F. Prerace medication: (1) Kentucky medication rules: BloodHorse (2019), BloodHorse (2020), Paulick report (2020); (2) Horseracing Integrity and Safety Act HR1754 (2020), with coverage by Paulick Report.
G. Testimonial from the FEI Veterinary Director.
H. FEI Endurance Strategic Planning Group: (1) Call for creation of Injuries Surveillance System, citing UofG (Nov 2013); (2) Final report and recommendations (Feb 2014); see p.33 (citing UofG), p.40, p.48, p.89, p.97.
I. Mandatory rest periods: (1) FEI Sports Forum (Apr 2017); see p.157; presentation p.166–p.200; p.239–p.241. (2) FEI Endurance Forum (May 2017); see p.2; presentation p.4–p.64; reason for modification p.216; (3) FEI General Assembly (Nov 2017); see Annex point 20.3, p.13–p.14 (rule 815.3.1); (4) FEI press release confirming 10% drop in FTQ owing to proposed rule changes and continued relationship with UofG (Nov 2017); (5) FEI endurance rules (Jan 2019); see p.20 (rule 815.3.1).
J. Changes to FEI endurance riding rule book: (1) FEI Endurance Temporary Committee press releases (Oct 2018 and Dec 2018); (2) FEI Sports Forum Reshaping Endurance session and speakers (Apr 2019); (3) Summary of proposed changes to endurance rules Horse Canada (Apr 2019); (4) FEI General Assembly (Nov 2019) session 3 and documents in Annex point 20.1 (evidence supporting mandatory out of competition periods; and comments on evidence); (5) Rule changes: transitional (January, 2020) and full (July, 2020).