

ORIGINAL RESEARCH

Retrospective analysis of the population dynamics and racing outcomes of the 2014 and 2015 UK and Ireland Thoroughbred foal crops

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Abstract

Background: Up-to-date figures on early losses of Thoroughbreds from the racing industry can inform strategies to improve retention and incentivise traceability of Thoroughbreds during this early life period.

Methods: Data on Thoroughbred mares bred in 2013–2014 and training, racing and sales information of their live offspring were analysed. The proportions and 95% confidence intervals (95% CI) of the entire 2014–2015 United Kingdom and Ireland foal crops that entered training, raced, were imported and/or exported between birth and the end of their third year of life, as well as the racing performance of these horses as 2- and 3-year-olds were described.

Results: A total of 20,661 mares produced 28,282 live foals. Of them, 47.2% (95% CI: 46.7–47.8; $n = 13,354$) entered training by the end of their third year of life. Of these, 10,595 (79.3%; 95% CI: 78.7–80.0) raced at least once. Around 20% ($n = 5712$) of horses were exported by the end of their third year of life, of which 3526 (61.7%) had been in training. The overall mortality during the study period was 7.6% ($n = 2123$).

Conclusion: A considerable proportion of Thoroughbreds had not entered training by 3 years of age but of those that had, the proportion that raced at least once was high. Further research is needed to establish reasons for premature losses from the industry.

KEYWORDS

racing, Thoroughbred horses, training, wastage

INTRODUCTION

The Thoroughbred horseracing industry is an important sector of the United Kingdom (UK) and Ireland's (IRE) economy. In the UK, horseracing contributed £427 m to the gross domestic product and supported over 19,000 jobs (direct, indirect and induced) in 2017.¹ In IRE, the total direct and stimulated expenditure of the horseracing industry was estimated as €1.84 billion in 2016 and generated 28,900 direct, indirect and secondary jobs.² The cost of production of a Thoroughbred from birth to entering training at 18 months has been estimated to be £30,000 excluding stallion covering fees which range from £1,000 to £250,000.¹ Returns on such investments are only achieved either by sale at 6 months of age or older, or from prize money won during their racing career from 2 years of age.³

Premature loss of individuals and failure to race raise both economic and welfare concerns.⁴ As a result, the industry has come under increasing pressure to improve the transparency and traceability around the fate of individuals bred for racing.⁵ It is therefore essential that up-to-date figures are produced to quantify apparent early losses, to understand import and export movements and analyse racing performance.

The causes of losses for the industry at different points in horses' life have been studied in New Zealand,⁶ Canada,⁷ Australia,⁸ South Africa,⁹ IRE¹⁰ and UK^{11–13} suggesting that this is an industry concern across different jurisdictions. To the best of our knowledge, to date, three studies have described training and racing outcomes of Thoroughbred foals born in the UK and IRE¹¹ or the UK.^{12,13} A retrospective analysis of outcomes of the foal crop of 1975 estimated

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that 62% entered training (by 4 years of age) of which 81% raced at least once (by 4 years).¹¹ Another study followed a cohort of 1022 Thoroughbred foals born in 1999 on 25 stud farms in the Newmarket area (UK).¹² Of these, the estimated proportion of foals entering training by 2 years was 52%, of which 61% raced at least once.¹² A more recent study analysed the outcomes of 399 foals over 3 seasons, originating from one farm in the UK, estimating that 95% entered training (the authors assumed that all horses which were named entered training), of which 64.5% raced at least once.¹³

As a result of advances in veterinary science,¹⁴ increased investment in breeding and training facilities³ and the evolution of management practices in the breeding and racing industries¹⁵ in the past decades, one might expect a higher proportion of Thoroughbreds bred for racing to enter training and appear on the racecourse than reported in these previous studies. Therefore, the objectives of the present study were 1) to describe the proportion of the 2014 and 2015 UK and IRE foal crops that entered training, raced and were imported and/or exported between birth and the end of their third year of life and 2) to provide descriptive statistics on racing performance (proportion of horses that ran, won and were placed, and prize money earned) of these 2014 and 2015 UK and IRE foal crops as 2- and 3-year-olds. Quantifying losses from the racing industry will help inform strategies to reduce their occurrence and provide a baseline against which to monitor the effect of interventions. In addition, a better understanding of the extent of losses can act as an incentive to improve transparency around the fate, and traceability, of Thoroughbreds bred for racing.

MATERIALS AND METHODS

Study design and study period

In this retrospective cohort study, foals born in 2014 and 2015 were followed up until the end of their third year of life (end of 2017 or 2018, respectively). The date of birth of each foal was set to the 1st of January of the corresponding year of birth, which is the official birth date of Thoroughbreds in the Northern Hemisphere.

Study population

The live progeny born in 2014 and 2015 of active mares registered in the General Stud Book (GSB) during the covering seasons 2013 and 2014 in the UK and IRE and for which information on sales, training and/or race performance was available were included in the study population. Horses born alive but that died before entering training or racing were also included in the study population as they were part of the live foal progeny. Data on horses born outside of the UK and IRE, but whose mares were covered in the UK or IRE were considered as the mares were registered in the GSB at the time of covering.

Data

Three databases ('Return of Mares', 'Sales and Training', and 'Race performance') were provided under non-disclosure agreements with both Weatherbys (www.weatherbys.co.uk) and the British Horseracing Authority. The Return of Mares database included 40,304 observations for all active mares in the GSB for the covering seasons 2013 and 2014, each observation corresponding to a covering certificate. For each mare in each breeding season, two documents should be submitted: the covering certificate and the return certificate. If a covering certificate was submitted, the mare was classified as being 'active' in that season. The return certificate stated the outcome of the covering (e.g., live foal, barren, aborted etc.). Therefore, it was possible for a mare to have a covering certificate submitted (be 'active') but have no return certificate submitted. Observations for which the name of the mare was not available were excluded ($n = 133$) from the analysis because it was not possible to determine how many mares were represented by these observations. The Sales and Training database included information (import and export events and whether the horse entered training between 2014 and 2018) on 27,860 horses born out of the active mares in 2014 and 2015. The Race Performance database included 28,393 observations summarising race performance data (number of runs, wins, places and prize money won per year and type of race) of these horses from 2016 to 2018 if they raced either in the UK/IRE or abroad. These three databases were merged into a single database in a two-step process, first merging the Sales and Training and Return of Mares databases, then merging the resulting database with the Race Performance database, using the foal's name as the key identification variable.

Statistical analyses

To determine our study population, the number of live foals was extracted from the total number of return certificates for the seasons 2013 and 2014. The percentages and 95% confidence intervals (CI) of horses that entered race training and raced, as well as the inputs (imports) and outputs (deaths and exports) during the study period, were estimated from the study population. The proportion of horses entering race training was derived from those known to have entered training in Great Britain (GB) (i.e., the date entered training in GB was provided in the dataset) plus those for which a trainer name was listed (but for which no date entered training in GB was provided) plus those that appeared in the race performance dataset but which neither had a date entered training in GB nor a trainer name listed (based on the assumption that they must have been in training before racing). For the latter category of horses ($n = 3,013$), the age at entering training was set to be the age at first appearance on a racecourse. All data processing and

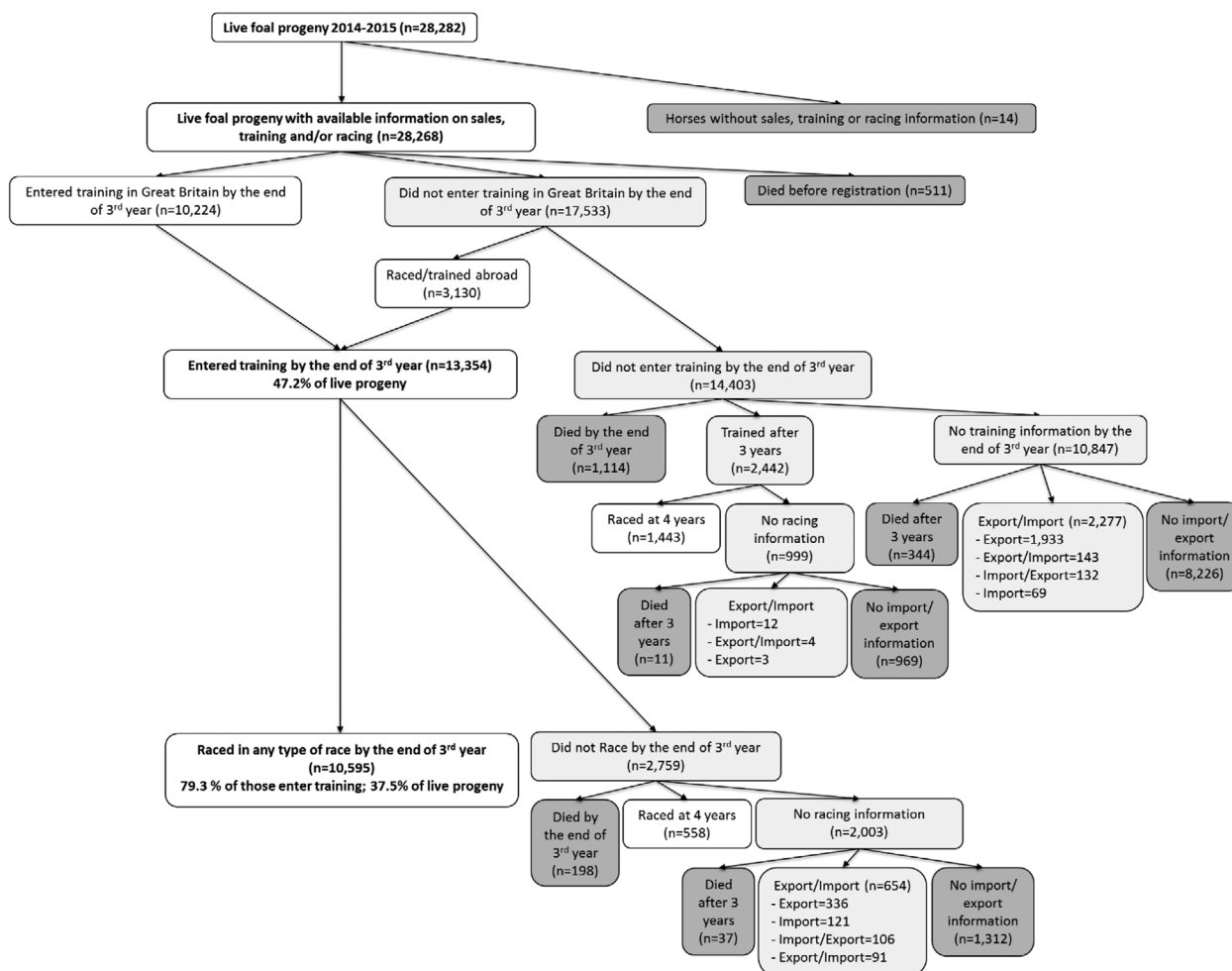


FIGURE 1 Flowchart describing the training and racing outcomes of the 2014 and 2015 United Kingdom (UK) and Ireland (IRE) Thoroughbred foal crops and the outcomes for horses that did not enter training nor raced by the end of their third year of life

analyses were conducted in Stata (Release 15, Stata-Corp LP, College Station, TX).

Ethical approval

This study received ethical approval from the Royal Veterinary College's Clinical Research Ethical Review Board (URN: 2018 1843-2).

RESULTS

Study population

A total of 25,649 mares were active in the GSB for the covering seasons 2013 and 2014. Over the two seasons, 33,329 return certificates were submitted for 22,018 of the active mares. No return certificate was submitted for 3631 active mares. Of those with a return certificate, 20,661 mares (13,299 covered in both seasons and 7362 covered only in one season) produced at least one live foal; 7613 mares gave birth to a live foal in both seasons. The total number of live foals for the covering seasons 2013 and 2014 was 28,282 (13,742 born in 2014 and 14,540 born in 2015), which represented 84.9% of

the return certificates. Sex was evenly distributed in the live foal progeny population: 14,305 horses (50.6%) were males (geldings = 8915, colts = 5390 and rigs = 4), and 13,963 were fillies (49.4%). Fourteen horses had no available information on sales, training or racing; therefore, they were not considered in further analysis. The study population included 28,268 live horses (Figure 1), of which 95% ($n = 26,918$) were born in the UK and IRE. Of the live foals, 511 (1.8%; 95% CI: 1.7–2.0) died before registration in the GSB. A total of 27,771 live foals from 20,661 mares were registered over the two seasons.

Proportion of horses entering race training

Of the 28,268 live foals, 36.2% ($n = 10,224$) entered training in GB (Figure 1). An additional 3130 horses were known to have trained outside of GB and/or raced outside of the UK and IRE, resulting in an overall estimate of 13,354 horses entering training between birth and the end of their third year of life, which represents 47.2% (95% CI: 46.7–47.8) of the 2014–2015 live foal crops. Most of the horses that entered training (82%, $n = 11,013$), did so at 1 or 2 years of age (Table 1).

TABLE 1 Age at entering training of 13,354 horses from the 2014 to 2015 United Kingdom (UK) and Ireland (IRE) Thoroughbred live foal crops ($n = 28,268$) that entered training by the end of their third year of life

Age at entering training (years)	Foal crop				Total	%	(95% CI)
	2014		2015				
	Born in UK/IRE	Born outside of UK/IRE	Born in UK/IRE	Born outside of UK/IRE			
1	2088	37	2087	37	4249	31.8	(31.0-32.6)
2	3260	45	3423	36	6764	50.7	(49.8-51.5)
3	1023	15	1171	15	2224	16.6	(16.0-17.3)
Unknown†	38	30	38	11	117	0.9	(0.7-1.0)
Total	6409	127	6719	99	13,354	100	–

†Includes horses that did not race and for which a trainer name was listed, but no date entered training in Great Britain was provided.

TABLE 2 Number and type of races ran by 10,595 horses, from the 2014 to 2015 United Kingdom (UK) and Ireland (IRE) Thoroughbred live foal crops ($n = 28,268$), by the end of their third year of life

Number of type of races	Type of race			Number of horses	
1 (<i>n</i> = 9394)	UK/IRE-Flat			8120	
	Abroad-Flat			1136	
	UK/IRE -NH-Flat			100	
	UK/IRE -Hurdle			25	
	Abroad-Jump			13	
2 (<i>n</i> = 1163)	UK/IRE –Flat	Abroad-Flat		589	
	UK/IRE –Flat	UK/IRE -Hurdle		485	
	Abroad-Flat	Abroad-Jump		51	
	UK/IRE -Flat	UK/IRE -NH-Flat		17	
	UK/IRE -Hurdle	UK/IRE -NH-Flat		12	
	UK/IRE -Flat	UK/IRE -Point to point		4	
	UK/IRE -Hurdle	Abroad-Flat		3	
	UK/IRE -Hurdle	Abroad-Jump		2	
3 (<i>n</i> = 37)	UK/IRE -Flat	UK/IRE -Hurdle	Abroad-Flat	16	
	UK/IRE -Flat	Abroad-Flat	Abroad-Jump	11	
	UK/IRE -Flat	UK/IRE -Hurdle	UK/IRE -NH-Flat	5	
	UK/IRE -Flat	UK/IRE -Hurdle	UK/IRE -Point to point	2	
	UK/IRE -Hurdle	UK/IRE -NH-Flat	UK/IRE -Chase	2	
	UK/IRE -Hurdle	Abroad-Flat	Abroad-Jump	1	
4 (<i>n</i> = 1)	UK/IRE -Flat	UK/IRE -Hurdle	Abroad-Flat	Abroad-Jump	1
Total				10,595	

†NH: national hunt; Abroad: outside of UK and IRE.

Proportion of horses racing

Of the 13,354 horses that entered training, 10,595 (79.3%; 95% CI: 78.7–80.0), representing 37.5% (95% CI: 36.9–38.0) of the live foal progeny, raced at least once in any type of race by the end of their third year of life (Figure 1). Among them, 88.7% ($n = 9,394$) raced only in one type of race, and 86% of which ($n = 8120$) was UK/IRE Flat racing. The remaining 11.3% ($n = 1201$) raced in more than one type of race. Details of the number of horses participating in different types of races are presented in Table 2. Seventy per cent of the horses that raced did so for the first time at 2 years old ($n = 7497$; Table 3).

TABLE 3 Age entered training and age at first race of 10,595 horses from the 2014 to 2015 United Kingdom (UK) and Ireland (IRE) Thoroughbred live foal crops

Age entered training (years)	Age at first race (years)		Total	%	(95% CI)
	2	3			
1	2638	889	3527	33.3	(32.4–34.2)
2	4737	1062	5799	54.7	(53.8–55.7)
3	0	1269	1269	12.0	(11.4–12.6)
Total	7375	3220	10,595	100	–

TABLE 4 Overall inputs and outputs per year of age of the 2014 and 2015 United Kingdom (UK) and Ireland (IRE) Thoroughbred live foal crops from birth to the end of their third year of life

Category of events		Age				Total
		<1 year	1 year	2 years	3 years	
Initial number of individuals [†]		28,268 [‡]	26,303	25,262	23,732	–
<i>Outputs</i>						
Deaths	Born in the UK or IRE	605 (2.1%)	195 (0.7%)	482 (1.9%)	826 (3.5%)	2108
	Born abroad	0	2 (0.01%)	5 (0.02%)	8 (0.03%)	15
Last export transaction	Born in the UK or IRE	1422 (5.1%)	1349 (5.1%)	1268 (5.0%)	1563 (6.6%)	5602
	Born abroad	2 (0.01%)	15 (0.06%)	29 (0.1%)	64 (0.3%)	110
<i>Inputs</i>						
Last import transaction	Born in the UK or IRE	18 (0.06%) [§]	373 (1.4%)	196 (0.8%)	419 (1.8%)	1006
	Born abroad	46 (0.2%)	147 (0.6%)	58 (0.2%)	59 (0.2%)	310
Total		26,303	25,262	23,732	21,749	–

Each percentage is calculated over the initial number of individuals in the correspondent age category. Abroad: Outside of UK and IRE.

[†]The initial number of individuals for years 1–3 is calculated as the total number of individuals from the precedent year minus the outputs (deaths and exports) plus the inputs (imports).

[‡]Total number of live foals for the covering seasons 2013 and 2014 excluding 14 horses with no information available.

[§]Imported after being exported.

Inputs and outputs (deaths, imports and exports)

In total, 2123 horses (7.5% of the live foal progeny; 95% CI: 7.2–7.8) died between birth and the end of their third year of life. The proportion of deaths was higher for 3-year-old horses (3.5%; 95% CI: 3.3–3.8) compared to other ages (<1 year: 2.1% [95% CI: 2.0–2.3]; 1 year: 0.7% [95% CI: 0.6–0.9]; 2 years: 2.0% [95% CI: 1.8–2.1]). A summary of the inputs and outputs of the population over the study period, stratified by country of birth and age from birth to the end of the third year of life, is presented in Table 4. The overall proportion of exported horses was higher for 3-year-olds (6.9%; 95% CI: 6.5–7.2) compared to other ages (<1 year: 5.1% [95% CI: 4.8–5.3]; 1 year: 5.2% [95% CI: 4.9–5.5]; 2 years: 5.1% [95% CI: 4.9–5.4]). The overall proportion of imported horses was higher for 1- and 3-year-olds (both 2.0%; 95% CI: 1.8–2.2) compared to other ages (<1 year: 0.2% [95% CI: 0.1–0.3]; 2 years: 1.0% [95% CI: 0.9–1.1]).

Outcomes for horses that did not enter training nor raced by the end of their third year of life

The outcomes for horses that did not enter training nor raced by the end of their third year of life are illustrated in Figure 1. It is important to highlight that this information is incomplete for the full live foal crop; full 4-year information was only available for the 2014 foals, which also have partial 5-year information, and only partial 4-year information was available for the 2015 foals. Of the 14,403 horses that did not enter training by the end of their third year of life, 2,442 horses (17%) are known to have entered training later in life ($n = 2192$ at 4 years and $n = 250$ at 5 years). Of these, 1443 horses raced for the first time as 4-year-

olds at least once in any of the available type of races (Table S1). Of the 2759 horses that entered training but did not race in any of the available type of races by the end of their third year of life, 558 horses (20.2%) raced as 4-year-olds.

Of the 8,226 horses (29% of the live progeny) that did not enter training nor raced and for which no import or export transactions were reported (Figure 1), 3177 (38.6%) were sold at least once ($n = 2178$ had one sale transaction; $n = 894$ had two sale transactions; $n = 105$ had three or more sale transactions) and had their last transaction between 10 months and 5 years (<1 year = 767, 1 year = 734, 2 years = 105, 3 years = 1463, 4 years = 96 and 5 years = 12). Of them, 57% were males ($n = 1811$), and 43% ($n = 1,366$) were fillies.

Race performance (runs, wins, places and prize money earned)

Of the 10,595 horses that raced by the end of their third year of life, 9456 (89.2%) ran at least once in UK/IRE Flat racing, 1778 (16.8%) ran at least once in a flat race abroad, 538 (5.1%) ran at least once in UK/IRE Hurdle racing, 168 (1.6%) ran at least once in a UK/IRE National Hunt Flat race, and 79 (0.7%) ran at least once in a jump race abroad. The summary of numbers of runs, wins, places and prize money earned by type of race and age of the horse is presented in Table 5.

DISCUSSION

This study provides up-to-date figures on population dynamics and racing outcomes in UK and IRE Thoroughbred racehorses. To the best of our knowledge, only three studies on the subject, conducted in the

TABLE 5 Race performance as 2- and 3-year-olds of 10,595 Thoroughbred horses from the United Kingdom and Ireland 2014 and 2015 foal crops

Type of race	2 years					3 years					All				
	N†	Minimum	Median	Mean	Maximum	N†	Minimum	Median	Mean	Maximum	N†	Minimum	Median	Mean	Maximum
UK/IRE-Flat															
Runs	6666	1	3	3.6	17	8028	1	5	5.4	22	9456	1	6	7.1	32
Wins	1937	1	1	1.3	5	3271	1	1	1.6	6	4429	1	1	1.7	7
Places	3827	1	2	2	10	5556	1	2	2.5	13	6918	1	3	3.2	19
Prize money‡	4395	110	2892	7416	559,193	6446	106	4390	12,461	1,364,589	7623	110	5545	14,813	1,367,500
Abroad Flat															
Runs	871	1	2	2.8	19	1655	1	4	4.8	20	1778	1	5	5.6	33
Wins	280	1	1	1.3	5	693	1	1	1.4	5	860	1	1	1.6	7
Places	494	1	1	1.8	8	1091	1	2	2.4	9	1285	1	2	2.7	14
Prize money‡	649	221	7179	13,671	244,009	1324	85	11,222	25,694	2,441,880	1524	85	12,061	28,144	2,441,880
UK/IRE -Hurdle															
Runs	N/A	N/A	N/A	N/A	N/A	538	1	2	2.1	8	538	1	2	2.1	8
Wins	N/A	N/A	N/A	N/A	N/A	76	1	1	1.3	4	76	1	1	1.3	4
Places	N/A	N/A	N/A	N/A	N/A	216	1	1	1.6	5	216	1	1	1.6	5
Prize money‡	N/A	N/A	N/A	N/A	N/A	302	150	1308	3651	56,138	302	150	1308	3651	56,138
UK/IRE - National Hunt Flat§															
Runs	N/A	N/A	N/A	N/A	N/A	168	1	1	1.5	4	168	1	1	1.5	4
Wins	N/A	N/A	N/A	N/A	N/A	19	1	1	1.1	2	19	1	1	1.1	2
Places	N/A	N/A	N/A	N/A	N/A	53	1	1	1.2	3	53	1	1	1.2	3
Prize money‡	N/A	N/A	N/A	N/A	N/A	67	119	572	1011	4605	67	119	572	1011	4605
Abroad Jump															
Runs	N/A	N/A	N/A	N/A	N/A	79	1	2	2.7	13	79	1	2	2.7	13
Wins	N/A	N/A	N/A	N/A	N/A	18	1	1	1.2	2	18	1	1	1.2	2
Places	N/A	N/A	N/A	N/A	N/A	33	1	1	1.8	5	33	1	1	1.8	5
Prize money‡	N/A	N/A	N/A	N/A	N/A	43	500	7795	12,679	66,682	43	500	7795	12,679	66,682

Abroad: outside of UK and IRE.

†N: number of horses.

‡Prize money in GBP.

§N/A: not applicable.

UK, have been previously published.^{11–13} One of the particular features of the present study is the use of the entire UK and IRE 2014 and 2015 live foal progeny population to produce these figures.

Nearly half of live UK and IRE Thoroughbred foals (47%) entered training by the end of their third year of life. A previous study conducted in the UK estimated the proportion of horses entering training at 2 to 4 years as 62%,¹¹ although this was based on a different denominator (horses 'named and eligible for training') and also included the fourth year of life. Using a comparable denominator to that in the current study ($n = 9675$ horses 'eligible for naming'), the proportion of horses entering training by 4 years of age in the Jeffcott's study¹¹ would be 49%. In our study, at least 61% of horses had entered training by the end of 4 years of age which is considerably higher. This is likely reflective of advances in veterinary science¹⁴ (e.g., improved diagnostic and treatment modalities, as well as greater focus on preventive medicine) along with increased investment in breeding and training facilities³ and changes in management practices in the racing industry¹⁵ since the 1970s. Although the current estimate of horses entering training by 3 years of age (47%) seems lower than that reported by Wilsher et al¹² (55%), that study was based on a convenience sample of 1022 foals, followed from birth (1999) to 3 years and used questionnaires completed by the owners to estimate losses.¹² In a third UK study, the percentage of horses that entered training by 3 years was estimated at 95%, using a sample of 399 foals originating from one farm and assuming that all horses that were named entered training.¹³ This makes it difficult to compare these findings with those observed in the present study.

Nearly 80% of the horses that entered training in our study raced at least once by the end of their third year of life. Although this figure is similar to that (83%) observed in Jeffcott et al¹¹ and higher than the proportion (61%) reported by Wilsher et al,¹² the timeline used in those studies varied from racing as 2-year-olds¹² to racing by 4 years of age.¹¹ In the present study, the proportion of horses in training by 2 years of age that raced was 67%, increasing to 87% of those in training by 4 years of age. This suggests that the proportion of horses entering training that raced is higher than previously reported in the UK. Our estimates also compare favourably with those reported in a study conducted in New Zealand, in which the proportion of horses from the 2001 and 2002 live foal crops registered with a trainer was 35% by 2 years of age, 51% by 3 years of age and 55% by 4 years of age.⁶ Of them, 22%, 54% and 50% raced by 2, 3 and 4 years of age, respectively.⁶

Horses that did not enter training or failed to race are considered a loss for the industry.^{9,16} Overall mortality in the current study (7.5%) was between the estimates of 3.5%¹¹ and 8%¹² reported previously in the UK. However, the lower of these mortality estimates¹¹ did not include deaths before horses were named and thus was likely to be an underestimate,

given that mortality between birth and 1 year of age can be around 5%.¹⁰

Horses not appearing on the racecourse may still generate income for the owners through sales. We observed import and/or export transactions for 10% of horses that did not enter training and/or raced beyond the study period. Moreover, 11% of the live foal progeny that did not enter training nor raced and for which no import or export transactions were reported were sold at least once. These figures are relevant for the industry and the general public as they suggest that these horses are still contributing economically to the horseracing industry. Nonetheless, there was still an important proportion of the live progeny (18%) that did not enter training and/or raced beyond the study period, and for which no information about import, export or a sale transaction was reported.

The overall number of import/export transactions observed in the present study at different points in horses' lives confirms the dynamism of the horseracing industry. Our figures suggest an increase in export transactions when compared to a previous study in which the percentage of horses exported by 4 years of age was 11%¹¹ (vs. 20% by 3 years of age in the current study). Moreover, figures presented in Table 4 might be conservative of the total number of import/export transactions given that only the last import/export transaction was recorded in the dataset. That imports were more frequently observed for 1- and 3-year-olds, while exports were higher for 3-year-olds likely reflects corresponding yearling and horses-in-training sales.

This study had some limitations. Available data were recorded for purposes other than research and thus, the analysis that could be performed was limited by the information available and its completeness. For instance, information on horses that may have entered training abroad (but did not race) was not available, which might have contributed to an underestimation of the proportion of horses entering training. Setting the age at first appearance on the racecourse as the age at entering training for horses that neither had a date entered training in GB nor a trainer name listed may have also contributed to an underestimate of the proportion of horses entering training by the end of their third year of life if horses appearing for the first time on the racecourse at 4 years had entered training at a younger age. Making this assumption about age at entering training is also likely to have underestimated the number of horses entering training as yearlings and racing for the first time at 2 as well as those entering training at 2 and racing for the first time at 3 years of age (Table 3).

One might consider that including horses that died before registration also led to an underestimate of the proportion entering, when these horses never had an opportunity to enter training. However, the impact of including them in our study population is minimal; when excluded, the proportion of horses entering training increased by 0.9%.

It is acknowledged that limiting the study period to the end of a horse's third year of life also led to a conservative estimate of the proportion entering training, as it did not consider those that entered training at a later age. Based on available information, nearly 9% of the live foal progeny entered race training after 3 years of age. A similar proportion (8.7%) of horses racing for the first time after 3 years was reported in an Australian study.¹⁷

The outcome for horses that did not enter training nor raced by the end of their third year of life could only be described in terms of the events reported in the databases. It is possible that a proportion of these horses could have transitioned to other equestrian sports or being used as leisure horses which, from a welfare perspective, is important as these horses are not 'wasted' even though they are lost from the racing industry. Improving the traceability of horses bred for racing, as recommended in the recently published Welfare Strategy,⁵ would help to determine the outcome of horses not appearing in training or on the racecourse and understand the fate of individuals after the end of their racing careers. Difficulties to determine the outcome of horses not entering training and/or racing have also been stated in a previous study aiming to quantify losses for the industry and risk factors for those losses in Australia.¹⁸

Notwithstanding these limitations, inherent to the use of existing, retrospective datasets for research purposes, analysis of these databases has generated valuable information for the UK horseracing industry. This study has provided baseline estimates of the proportion of UK and IRE Thoroughbred horses entering training and racing. Although these figures appear to have improved somewhat over the past decades, comparisons must be made with caution given differences in study design, populations and methods. The results obtained can be used to inform and monitor strategies aimed at reducing premature losses of Thoroughbreds from the horseracing industry. The study has also highlighted several knowledge gaps for the UK/IRE horseracing industry for which further studies are required. A better understanding is needed about the fate of a considerable proportion of horses bred for racing that never enter training and/or do not appear on the racecourse. Further investigation of the causes for horses prematurely leaving the horseracing industry can help prioritise interventions aimed at minimising such early losses and improve the efficiency and profitability of racehorse breeding. In this regard, a thorough economic analysis to estimate the profitability of breeding horses for racing may also help reduce the proportion of horses that will not provide an economic return for their owners/breeders and, as such, may end up contributing to the problem of 'unwanted' horses in the UK and IRE.^{19,20}

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AUTHOR CONTRIBUTIONS

Substantial contributions to conception and design: Verheyen, Mouncey and de Mestre. Acquisition of data: Verheyen. Analysis of data: Arango-Sabogal. Interpretation of data: Arango-Sabogal, Mouncey, de Mestre and Verheyen. Drafting of the article: Arango-Sabogal. Critical revision of the manuscript for important intellectual content: Arango-Sabogal, Mouncey, de Mestre and Verheyen. Final approval of the version to be published: Arango-Sabogal, Mouncey, de Mestre and Verheyen. Accountable for all aspects of the work: Arango-Sabogal, Mouncey, de Mestre and Verheyen. The corresponding author confirms that he had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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