Causes of disease and death from birth to 12 months of age in the Thoroughbred horse in Ireland

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ABSTRACT

A retrospective study was carried out to investigate the causes of disease and death in a population of foals in Ireland during their first 12 months post partum. Foaling and veterinary records from 343 foals on four farms born between January 1, 2004 and May 30, 2008 were reviewed. Among 343 foals, 22 did not survive to 12 months of age. Over the five-year period, the incidence of stillbirth was 1.5% (5/343), mortality 5% (17/338) and overall morbidity was 88.5% (299/338). Morbidity was calculated to include all new conditions brought to the attention of the attending veterinary surgeon, no matter how minor. Of foals born alive: congenital abnormalities were the most common cause of death (35.3% 6/17 foals) followed by musculoskeletal trauma (5/17, 29.4%). Of 711 separate incidents of disease, 46.5% (331/711) were due to an infectious process, 25% (178/711) due to non-infectious musculoskeletal issues; and 14.9% (106/711) related to non-infectious gastrointestinal problems. Respiratory infection was the single most common disease accounting for 27.8% (178/711) of all disease incidents in this population. Findings from this study provide information regarding the causes and incidence of death and disease in the young Irish Thoroughbred population.

KEYWORDS: foal, horse, infectious disease, morbidity, mortality, non-infectious disease, stillbirth

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Information regarding disease incidence and mortality rates of animals at studs is essential for many reasons. Firstly, it can provide a yardstick against which rates of disease and death at other similar breeding operations can be judged so that excess disease rates can be identified and addressed early. Secondly, it provides important information for the financial planning of commercial breeding operations, veterinary practices and insurers. It also provides an overview of where research efforts should be focused to allow the opportunity of positively influencing animal welfare. To date, there has been little objective data available regarding disease incidence and mortality in the young Thoroughbred population in Ireland.

Reports on disease incidence and mortality rates in foals in other geographical locations show variation both in the age range of the study population and in their findings. Wohlfender *et al.* (2009) reported a 8.27% incidence of infectious disease in the first 30 days of life in Thoroughbred foals in the UK. Morley and Townsend (1997) described a 42% incidence of disease and 11% mortality rate in the first 12 months post partum in foals in Western Canada. Cohen (1994) demonstrated a 27% disease incidence and a 4.7% mortality rate in the first six months post partum in Texas, USA. Haas *et al.* (1996) reported a 22% mortality rate in the first 10 days of life. The objective of this retrospective study is to determine the causes and incidence of disease and mortality in a Thoroughbred population in the first 12 months of life on Irish stud farms.

MATERIALS AND METHODS

Study animals

Foaling data and veterinary records were reviewed for Thoroughbred foals born and kept on four stud farms in Co. Kildare, Ireland. All foals were born between January 1, 2004 and May 30, 2008. Foals that were born in Ireland, but subsequently left the country prior to 12 months of age were excluded. Still-births and deaths before weaning were included if the dam remained in Ireland until December of that year. Animals where death occurred after weaning, were included if they were part of a cohort that remained in Ireland until 12 months of age. Criteria for inclusion in the study population consisted of availability of foaling data, veterinary records until 12 months of age and availability of veterinary records of the dam for three months prior to parturition.

Data recorded

Data recorded for each mare included age, parity, health and vaccination status. Year and month of birth, gestation length, foaling difficulty and sex were taken from the foaling record. Birth weight was also recorded, where available. Routine veterinary examination was carried out at 12-24 hours post partum on all foals. Blood was taken for determination of Immunoglobulin G (IgG) concentrations. IgG was measured by turbidometric immunoassay (DVM stat. VDX Veterinary Diagnostics Inc, Belgium, WI, USA) or enzyme immunoassay (Immuno-Check-G Kit. Bio-Metallics, Princeton, NJ, USA.). Any clinical abnormalities noted were recorded and categorised as that foal's first disease incident. The findings of each veterinary examination, foal's age and subsequent diagnosis were recorded from the veterinary records. Conditions were categorised and recorded as infectious or non-infectious.

Presumed infectious conditions were categorised by the body system affected. Within each body system, specific causes of infection such as *Rhodococcus equi* (*R. equi*) pneumonia and rotavirus diarrhoea were noted as subcategories. These diseases were diagnosed based on clinical likelihood, diagnostic imaging, where appropriate, and supporting laboratory data. All umbilical conditions were categorised as infectious. These included both omphalitis and omphalophlebitis treated either medically or surgically. Foals with a patent urachus, trauma to the umbilicus or a clinically thickened umbilicus that were placed on prophylactic antibiotic therapy were also included in this group. Within the musculoskeletal system, infectious conditions were defined as those affecting the joint, growth plate, bone, soft tissue or others. Generalised infection was categorised as septicaemia.

The non-infectious conditions were categorised as gastrointestinal, musculoskeletal, failure of passive transfer, congenital, ocular and prematurity. Gastrointestinal tract conditions were divided into gastric ulceration, enteritis, meconium retention, medical colic and surgical colic. Non-infectious enteritis was defined as the presence of diarrhoea without systemic illness or pyrexia. Where culture was performed, no significant pathogens were isolated. Musculoskeletal conditions were divided into developmental, traumatic and lameness. Perinatal asphyxia syndrome was divided into those exhibiting seizure activity and those which were not. Failure of passive transfer was defined as an IgG concentration < 8 g/l at 18-24 hours. Congenital disease was categorised by the body system affected i.e., ocular, umbilical hernia, upper respiratory tract.

Viable foals which died during or shortly after second stage labour without an underlying determined infectious cause were classified as stillborn. For non-survivors, post mortem reports were reviewed, and findings recorded.

Statistics

Statistics were performed using a spreadsheet programme (Microsoft Excel X for Mac. Microsoft Corporation, Redmond, WA, USA). Continuous variables were compared using the students T-test. The correlation of data was compared with the coefficient of determination (R^2). Non-continuous data was analysed using a Chi-squared test. Results were considered significant if the *p* value was less than 0.05.

RESULTS

Study animals

Three hundred and forty-three foals were identified as meeting the inclusion criteria and 174 (50.7%) of the animals were male. Birth weight was not recorded in 15 animals. Information regarding gestation length, birth weight and mare age is presented in **Table 1.** Male foals were, on average, 1.27 kg heavier than female foals, this was, however, not statistically different (p=0.06). There was no statistical relationship between mare age and either gestational length or foal birth weight. Foal birth weight did not vary linearly with gestation length (R^2=0.0092). However, the foal birth weight for the first and last quartiles of gestation length (312-333 days and 346-383 days) was 1.67 kg less than those born with a gestation length of 334-345 days (p=0.01). Six foals (1.7%) were delivered by Caesarian section, and three foals (0.9%) were delivered by assisted vaginal delivery under general anaesthesia. Two of the six foals delivered by C-section and two of the three foals delivered by assisted vaginal delivery survived to one year of age.

Table 1: Distribution of gestation length, foal weight and mare age for 343 foalings on four stud farms in Kildare, Ireland between January 1, 2004 and May 30, 2008

	Average	Median	25th Quartile	75th Quartile	Minimum	Maximum
Gestation length (days)	340.03	339	334	345	312	383
Foal weight (kg)	53.58	54	50	58	36	68
Mare age (years)	10.6	10	7	14	4	23

Non-surviving animals

Twenty-two foals (6.4%) did not survive to one year of age. The disease conditions of these foals are presented in **Table 2.** All of the stillborn foals had an apparently normal vaginal delivery. Three of the five stillbirths were associated with asphyxia during second stage of labour with no dystocia reported, one was associated with dystocia and one had umbilical pathology. These foalings were attended.

Of 338 foals alive at birth, 17 (5%) did not survive to one year of age. Nine of these foals were clinically abnormal at birth, eight of which were subsequently euthanased within 24 hours of birth and one died at 10 days of age. Of the four foals with arthrogryposis, three were delivered by C-section and one was delivered by assisted vaginal delivery. The majority of all deaths occurred by 30 days of age (11/17, 64.7%). Of these, the causes of death or reasons for euthanasia were congenital abnormalities (5/11, 45.5 %); perinatal asphyxia syndrome (PAS) (2/11, 18.2%); musculoskeletal trauma (2/11, 18.2%); and, prematurity-septicaemia (2/11, 18.2%). Three foals subsequently died between 30 days of age and six months of age, meaning that 82% of deaths occurred within the first six months of life.

Overall, congenital abnormalities were the predominant cause of death (6/17, 35.3%) with musculoskeletal trauma accounting for five deaths (29.4 %). There was no statistical association of non-survival to one year with mare age at delivery, presence of disease in the mare, month of birth, foal weight at birth or sex of the foal.

Diseases in foals

Diseases occurring within the first year of life are presented in **Table 3.** Of the 338 foals born alive, 299 foals (88.6%) had at least one disease incident. The number of separate disease processes requiring veterinary intervention varied from zero to seven per foal, with an average of 2.1 and a median of 2.0. One hundred and nine foals had at least one disease incident recorded during the first seven days of life (123 separate disease incidences). Two hundred and thirty-three foals had at least one disease incident in their first 30 days of life (251 separate disease incidences). There was no statistical association of presence of disease in the first year with mare age at delivery, presence of disease in the mare, month of birth, foal weight at birth or sex of the foal.

DISCUSSION

To the authors' knowledge, this is the first published study of disease incidence and death in foals during the first year of life in Ireland. Although the study design was retrospective in nature, full records (except some birth weights) were available for all animals that met the inclusion criteria, therefore, the data is complete. In this population, over the five year period, the rate of stillbirth was 1.5%, mortality was 5% and incidence of disease was 88.5%

Several studies have been carried out on the incidence of disease and death in equine populations in other countries (Platt 1973; Cohen 1994; Haas 1996; Morley and Townsend 1997; Wohlfender *et al.* 2009). The methodology and age range examined varied between these studies. Most of these previous studies were performed by survey either of attending veterinary surgeons (Platt 1973, Cohen 1994, Haas 1996) or of owners (Morley and Townsend 1997). Similar to the current study, Wohlfender *et al.* (2009) used the records of a limited number of veterinarians on a limited number of stud farms. The maximum age has varied from 10 days (Haas 1996), to 30 days (Wohlfender *et al.* 2009), to six months (Cohen 1996). Morley and Townsend's 1997 study alone used a cut-off of 12 months old, as in this study. There have also been different inclusion and exclusion criteria. For example, for the purpose of their study, Wohlfender *et al.* (2009) excluded 28 foals that were considered abnormal at birth. All foals that were abnormal at birth were included in this current study. In addition to the studies mentioned above, Jeffcott *et al.* (1982) conducted a study, which reported on the wastage in Thoroughbred racing from conception to four

Table 2: Last diagnosis of 22 foals not surviving to 12 months of age in a population of 343 foals born on four stud farms in Kildare, Ireland between January 1, 2004 and May 30, 2008

	Number of foals	Average age at onset (days)	Age range at onset (days)	Length of therapy range (days)
Stillborn	5	0	0	0
Arthrogryposis/contracture	4	0	0	0
Fracture	3	155	1-235	0-28
Perinatal asphyxia syndrome	2	0	0	2-10
Musculoskeletal trauma (not fracture)	2	-	24-150	0-2
Other congenital	2	2	0-4	0-61
Septicaemia	1	0	0	2
Prematurity and septicaemia	1	0	0	1
Cervical vertebral malformation	1	150	150	90
Osteomyelitis Rhodococcus equi	1	90	90	20
Total	22	-	-	-

(0 days = at birth)

Table 3: Recorded disease incidence among 343 foals from birth to 12 months of age on four stud farms in Kildare, Ireland (born between January 2004 and May 30, 2008)

			No. of incidencts (% of total n=711)	No. (%) of foals affected	% surviving	Average range of affected (Average) days	Length of therapy-Range (Average) day
Stillbirth			5 (0.7)	5 (1.5)	0	0	0 (0)
Infectious		All	331 (46.5)	212 (62.7)	98.6	1-340 (104)	1-63 (8.4)
	Respiratory	All	198 (27.8)	143 (42.3)	99.3	3-340 (143.9)	1-63 (9.5)
		Viral	54 (7.6)	51 (15.1)	100	64-250 (170)	1-10 (3.1)
		Bacterial	99 (13.9)	82 (24.3)	100	3-340 (153.8)	1-21 (6.2)
		R. equi	45 (6.3)	43 (12.7)	97.7	21-237 (90.8)	10-63 (24.3)
	GIT	All	32 (4.5)	32 (9.4)	100	10-240 (51.9)	1-28 (5.5)
		Rotavirus	21 (2.9)	21 (6.2)	100	10-91 (40)	1-5 (2.4)
		Others	11 (1.5)	11 (3.3)	100	15-240 (74.6)	5-28 (11.1)
	Umbilical	All	58 (8.2)	56 (16.6)	100	1-130 (15)	1-14 (6.3)
		Medical	55 (7.7)	55 (16.3)	100	1-130 (15)	3-14 (6.5)
		Surgical	3 (0.4)	3 (0.9)	100	11-22 (15)	1-5 (3.7)
	MS	All	23 (3.2)	22 (6.5)	95.5	9-315 (193.2)	4-30 (9.7)
		Septic arthritis	1 (0.1)	1 (0.3)	100	17 (17)	18 (18.0)
		Septic physitis	4 (0.6)	4 (1.2)	100	20-300 (103.8)	10-26 (16.0)
		Osteomyelitis	1 (0.1)	1 (0.3)	0	90 (90)	30 (30.0)
		Cellulitis	13 (1.8)	12 (3.5)	100	9-315 (193.2)	4-21 (7.0)
		Others	4 (0.6)	4 (1.2)	100	19-120 (51)	5 (5.0)
	Septicaemia		20 (2.8)	20 (5.9)	90	1-35 (9.7)	1-15 (6.9)
PAS	All		10 (1.4)	10 (2.9)	80	1 (1)	2-14 (4.8)
	Seizuring		1 (0.1)	1 (0.3)	100	1 (1)	3 (3.0)
	Non-seizuring		9 (1.3)	9 (2.6)	77.8	1 (1)	2-14 (5.0)
GIT- Non-infectious	All		106 (14.9)	93 (27.5)	100	1-320 (64.6)	1-35 (9.3)
	Meconium		2 (0.3)	2 (0.6)	100	1 (1)	1-2 (1.5)
	Colic-medical		14(2.0)	14 (4.1)	100	1-320 (102.2)	1-5 (1.7)
	Colic-surgical		1 (0.1)	1 (0.3)	100	175 (175)	21 (21)
	Gastric ulcers		61 (8.6)	57 (16.8)	100	10-210 (68.2)	7-35 (121.8)
	Enteritis/colitis		28 (3.9)	27 (8)	100	8-210 (38.6)	1-21 (5.2)
MS	All		178 (25)	138 (40.1)	92.8	1-335 (48.5)	0-90 (6.5)
	Developmental	All	66 (9.2)	63 (18.6)	92.0	1-335 (48.5)	0-90 (4.8)
		Contracture/laxity	55 (7.7)	53 (15.6)	92.5	1-330 (22.1)	0-42 (3.1)
		DJD complex	7 (1.0)	7 (2.0)	85.7	150-335(241.4)	1-90 (18.6)
		ALD surgery	4 (0.6)	4 (1.2)	100	35-145 (74.8)	3-5 (3.5)
	Trauma	All	69 (9.7)	65 (19.2)	92.3	1-334 (126)	0-60 (9.8)
		Fractures	23 (3.2)	23 (6.8)	86.9	1-235 (106.5)	10-60 (20.7
		Other	46 (6.5)	42 (12.4)	95.2	2-334 (135.9)	0-10 (4.4)
	Lameness	All	43 (6.0)	40 (11.8)	100	2-235 (126)	1-10 (3.8)
		foot	32 (4.5)	31 (9.2)	100	2-235 (144)	1-10 (3.1)
		Other	11 (1.5)	9 (2.6)	100	5-200 (73.2)	1-10 (5.9)
Congenital	All		49 (6.9)	49 (14.4)	95.9	1-180 (90.6)	0-61 (3.3)
	Eye	All	6 (0.8)	6 (1.77)	83.4	1-4 (1.5)	0-1 (0.8)
		Entropion	5 (0.7)	5 (1.5)	100	1-4 (1.6)	1 (1.0)
		Micro-opthalmia	1 (0.1)	1 (0.3)	0	0 (0)	0 (0)
	URT	Cleft soft palate	1 (0.1)	1 (0.3)	0	4 (4)	61 (61)
	Umbilical hernia	All	41 (5.8)	41 (12.1)	100	17-180 (105.4)	1-7 (2.4)
		Ring	29 (4.1)	29 (8.6)	100	17-160 (100)	1-5 (1.1)
		Surgery	12 (1.7)	12 (3.6)	100	90-180 (117)	3-7 (5.3)
	Dentig. cyst	All	1 (0.1)	1 (0.3)	100	106 (106)	1 (1)
Occular	All		11 (1.5)	11 (3.25)	100	10-327 (126.5)	2-14 (7.4)
	Ulcer		7 (1.0)	7 (2.0)	100	2-9 (5.4)	2-14 (8.3)
	Conjunctivitis		4 (0.6)	4 (1.2)	100	60-245 (121.8)	3-10 (5.8)
FPT			19 (2.7)	19 (5.6)	100	1-4 (1.8)	1-5 (1.8)
Prematurity			1 (0.1)	1 (0.3)	0	1 (1)	1 (1)
Other			1 (0.1)	1 (0.3)	100	6 (6)	3 (3)

Foals with more than one disease process in the first year will be classified more than once

GIT: Gastrointestinal tract
MS: Musculoskeletal
PAS: Perinatal asphyxia syndrome
Dent. Cyst: Dentigerous cyst
FPT: Failure of passive transfer

years of age. In this study, data was examined from the Irish Turf Club.

Findings in this study of a 1.5% stillbirth rate are similar to that of other studies (Platt 1973; Cohen 1994; Ginther and Williams 1996), but less than that reported by Morley and Townsend (1997) (3.1%). Intrapartum stillbirth (IPSB) has been defined as the death of a viable foal during or shortly after the second stage of labour without an underlying infectious cause (Smith *et al.* 2003).

Dystocia, delayed stage two of parturition, premature placental separation and birth trauma are all reported causes of stillbirth (Williams 2009). In a survey of causes of abortion, stillbirth and perinatal death, most of the losses due to asphyxial incidents at birth occurred in unattended foalings (Giles *et al.* 1993). In this population, the majority of deaths occurred in the first 30 days (64.7%). This concurs with the findings of Sturgill and Carter (2008) (67.2%) and Cohen (1994) (57.8%).

Of foals born alive, 6/338 (1.8%) had congenital defects that necessitated euthanasia and this was the predominant cause of death (35.3%) in this study. Crowe and Swerczek (1985) estimated that approximately 1% of foals born in Kentucky in a 13-year-period had congenital defects requiring euthanasia. Giles *et al.* (1993) showed that congenital abnormalities constituted nearly 10% of all cases of abortion, stillbirth and perinatal death examined over a six-year-period in Kentucky. A survey in the UK on perinatal mortality found that structural abnormalities were the cause of death or reason for euthanasia in nearly 8.7% of all foals up to three months of age submitted for a post mortem over a five-year-period (Platt 1973). The exact cause of these congenital defects is unknown, but it is thought that there are multiple factors involved including genetic defects, extraneous teratogenic substances, infections and trauma (Crowe and Swerczek 1985).

Musculoskeletal trauma was a significant cause of mortality in this study (29.4%), Both Cohen (1994) and Sturgill and Carter (2008) reported musculoskeletal and other traumas as a significant cause of death up to six months of age, 21.6% and 16.2%. All but one of the traumatic incidences in this study occurred on pasture. Traumas of this nature are accidental and unpredictable, and apart from minimising the risk of injury with good farm management, these incidents can never be completely avoided.

Septicaemia has been implicated as a major factor in equine perinatal morbidity and mortality (Koterba *et al.* 1984; Sturgill and Carter 2008). Stoneham (1994) found the incidence of septicaemia in the UK to be substantially lower than that in the USA. Failure of passive transfer has been implicated as a factor in the development of sepsis in the equine neonate (McGuire *et al.* 1977; Raidal 1996; Tyler-McGowan 1997).The reported incidence of FPT shows variation with 31% of foals in a UK study (Stoneham *et al.* 1991) and 9.6% of foals in an Australian study (Raidal 1996) found to have IgG concentrations <8 g/l. The lower incidence of FPT in this study (5.6%) may be related to the management practices and availability of colostrum banks for the farms that allow for early identification of poor quality colostrum and supplementation where necessary.

Septicaemia related death in this population occurred in two foals (11.8%), however, both were septicaemic at birth and one foal was also premature (312 day's gestation). Both mares were asymptomatic. Overall, 17.6% deaths were related to septicaemia or an infectious incident: this is much lower than that reported by Cohen (1994) where deaths due to pneumonia, septicaemia and musculoskeletal infections accounted for 36.2% of all deaths; and, Sturgill and Carter (2008) where 36.3% of deaths were caused by septicaemia or pneumonia.

Although not a major cause of mortality in this population, the majority of foals (62.7%) had at least one infectious condition during the first 12 months of life. Respiratory tract infection was the most common cause of disease accounting for 27.8% of all disease incidences, affecting 42.3% of animals. While respiratory disease was the most common disease incident (22.1%) in the study by Cohen (1994), it affected only 6.1% of foals. The disparity may be due to the different age groups studied, farm management practices and the inclusion of mild cases in this study. In this population, 34.4% of all respiratory incidents occurred between six and 12 months of age.

Bacterial (non-*R. equi*) pneumonia accounted for 50% of all respiratory conditions. However, only 11% of these cases required longer than seven days of treatment suggesting disease was mild in the majority of cases.

R. equi is a frequently reported and well-recognised cause of pneumonia in foals. (Wilkins 2004; Sturgill and Carter 2008). Recently, a study based on endemic farms in Texas reported a 15% disease incidence with 13% of affected foals dying (Chaffin *et al.* 2003). While the disease morbidity in this study is similar (12.7%), the mortality rate is significantly less (2.3%). Leadon and Klay (2006) suggest that increased awareness and greater efforts at earlier diagnosis and treatment of foals has minimised the number of cases presenting with the classical signs of pyrexia and 'rattles'. In addition to daily temperature monitoring in all foals, a proportion of these foals (198) had scheduled haematological and ultrasonographic examinations resulting in recognition of the disease mainly in the subclinical form. Only one foal from the *R. equi* affected group presented with marked tachypnoea and pyrexia. There was one extra-pulmonary *R. equi* disorder (osteomyelitis) recorded which was the only death that occurred in this category. Hyperimmune plasma was not used on the farms in this study

Umbilical remnant infections are considered by some to be an important source from which bacteria could disseminate to other locations, and were reported in 13% of septic foals (Gayle *et al.* 1998). In this population, 16.6% of foals were examined for an infectious umbilical disorder and this is significantly higher than reported in other studies (Wohlfender *et al.* 2009). Contributing factors to this disparity may be different diagnostic criteria and the inclusion of cases where prophylactic therapy was utilised. There was an increased incidence of cases during the third year of the study on one farm: this was attributed to topical umbilical therapy, which resulted in localised irritation and subsequent inflammation of the umbilicus and surrounding body wall.

Diarrhoea affected 17.5% foals in this study, however, over 50% of these were categorised as mild enteritis. Rotavirus was detected in 35.6% of diarrhoeic foals, this concurs with the findings of Browning *et al.* (1991). The overall incidence of rotavirus was 6.2%: cases were sporadic and mild in nature, with foals remaining diarrhoeic for an average of 2.4 days. A rotavirus incidence of 3% was reported by Wohlfender *et al.* (2009) in foals up to 30 days of age. The use of an inactivated rotavirus vaccine during the eight, ninth and tenth month of pregnancy, in combination with a relatively low rate of FPT, good hygiene and farm management practices are likely contributing factors to the low morbidity in this population. Such factors have been suggested to control this disease (Dwyer 2007).

Incidences of gastric ulceration in asymptomatic foals in the UK and Ireland were reported to be 57% and 47% respectively (Murray *et al.* 1990). The lower incidence in this population reflects those that exhibited clinical signs. Gastrocopy was not used and, therefore, sub-clinical cases were not detected. Furthermore, anti-ulcer therapy was routinely used in foals which were considered to be at high risk of developing gastric ulceration, i.e., during periods of anorexia, diarrhoea or times of prolonged use of non steroidal anti-inflammatory drugs.

Meconium retention has been reported to be the most common cause of colic in the neonate (Ryan and Sanchez 2005). Wohlfender *et al.* (2009) reported a 1.97% incidence of meconium retention. The lower incidence (0.6%) in this population may be related to the routine administration of enemas to the newborn foal on each of the farms in this study.

Umbilical hernias occurred in 12.1% of foals. Surgical correction was performed in 29% of cases and rubber ring application carried out on the remainder. Although for the purpose of this study umbilical hernias were categorised as congenital, information was not available from the records as to whether these hernias were truly congenital or developed in the post partum period. In a study where the overall incidence of umbilical hernias was 29.5%, Enzerink *et al.* (2000) reports that 12 of 13 hernias developed between five to eight weeks of age.

Non-infectious musculoskeletal cases were a significant cause of morbidity in this study, (recorded in 40.1% of foals, accounting for 25% of all disease incidences). Primary flexural deformities may be present at birth but can develop during first two years of life (Greet 2000). Excluding the four foals that were euthanased due to arthrogryposis, 10.6% foals were noted on their newborn examination to have hyperextension or hyperflexion of one or more joints. This finding is similar to that of Wohlfender *et al.* (2009)(12.11%).

In conclusion, while the mortality rate from sepsis related diseases was lower than previously reported, infectious disease remains a major cause of morbidity in this population despite good farm management. The seemingly high disease incidence in this population may partially be a consequence of inclusion of very mild disease incidents. Preventative measures can not yet be suggested to minimise the incidence of mortality due to congenital abnormalities or accidental musculoskeletal traumas. However, one area of preventative medicine that is receiving a lot of interest is identification and early intervention in the high risk pregnancy (Vaala 1994; Wolfsdorf 2009). In our population, four deaths (23.5%) were due to either in-utero infection or in-utero/intra-partum asphyxia. The introduction of pregnancy monitoring for all mares in the last trimester could perhaps help to reduce the risk of deaths related to an abnormal in-utero environment.

One limitation of the study is that it was retrospective in nature. However, diligent records were kept meaning that, with the exception of birth weight, the data is believed to be complete. There is likely to be some bias in this study, due to the selection of participating studs. All of the studs were within a limited geographic area. Furthermore, these studs have daily veterinary visits and close attention to individual animals by a large staff. Relative to less intensively managed farms, this may mean that the morbidity rate is much higher, as more minor problems with the foals might be noticed and brought to the attending vets attention. However, this increased scrutiny of foals also means that the morbidity rate may be closer to reflecting all the problems experienced by foals in the first year of life, compared to a morbidity rate reported from less frequently scrutinised foals. This early and high level of intervention might also be expected to reduce the mortality rate. Indeed, a study on less intensively managed farms in Canada reported a lower morbidity (42%), but a higher mortality rate (11%) in the first year post partum (Morley and Townsend 1997). This bias may mean that the results could be difficult to extrapolate to other equine populations in the country due to variation in breed, management practices and pathogens. Despite these limitations, this study provides an epidemiological benchmark from which other clinicians and farm management can identify areas in need of further improvement or indeed identify areas in which successful intervention has already been accomplished.

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