Fatal intestinal inflammatory lesions in equids in California: 710 cases (1990–2013)

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OBJECTIVE

To determine incidences and underlying causes of fatal intestinal inflammatory lesions (FIILs) and demographic characteristics of affected equids necropsied at any of the California Animal Health and Food Safety Laboratory facilities between January 1, 1990, and April 16, 2013.

ANIMALS

710 equids with FIILs, including colitis, duodenitis, enteritis, enterocolitis, enteropathy, enterotyphlitis, gastritis, gastroenteritis, ileitis, jejunitis, typhlitis, or typhlocolitis, alone or in combination.

PROCEDURES

The medical records were reviewed, and data collected included animal age, sex, geographic origin, necropsy submission date, and breed, purpose, or characteristic of use. Descriptive statistics were compiled and reported as numbers and percentages.

RESULTS

Colitis (323/710 [45.5%]), enteritis (146/710 [20.6%]), and typhlocolitis (138/710 [19.4%]) were the most common FIILs, and the underlying cause of most FIILs was categorized as either undetermined (465/710 [65.5%]) or bacterial (167/710 [23.5%]). The most common bacteria responsible for FIILs were *Clostridium* spp and *Salmonella* spp.

CONCLUSIONS AND CLINICAL RELEVANCE

Results indicated that the underlying cause for most FIILs could not be identified; however, when it was identified, it was most commonly bacterial and typically *Clostridium* spp or *Salmonella* spp, which could be useful information for practitioners when evaluating and managing horses and other equids with intestinal distress. In addition, results underscored the need for improved diagnostic procedures and strategies to determine underlying causes of FIILs in equids. Knowledge of the most common FIILs and their underlying causes may help in diagnosing and mitigating intestinal disease in equids. (*J Am Vet Med Assoc* 2020;256:455–462)

Primary inflammatory alimentary diseases in equids can be categorized mainly by the anatomic location affected (eg, upper alimentary canal, stomach, and small and large intestines) or by the underlying cause (eg, mechanical, parasitic, toxic, and immune-mediated causes).[1–5] Previous studies[5–8] show that *Salmonella* spp and *Clostridium difficile* are the most important infectious causes of inflammation in the alimentary tract of equids, and such infections are mainly characterized clinically by colic and diarrhea and pathologically by enteritis, typhlitis, or colitis, alone or in combination. Other infectious agents (eg, *Rhodococcus equi*, *Clostridium perfringens,* rotavirus, and coronavirus) and parasites (eg, *Strongylus* spp) can also affect the digestive system of equids and cause enterocolitis, typhlitis, or both.[8] In addition, toxicoses from toxins (eg, oleandrin [the toxic principle of *Nerium oleander*][4,9]) or drugs (eg, NSAIDs[8]) can affect the digestive tract and result in ulcerative to severe inflammatory lesions.

ABBREVIATIONS

CAHFS	California Animal Health and Food Safety Laboratory
FIIL	Fatal intestinal inflammatory lesion

Although the ability to determine the underlying cause of enteric diseases in equids has increased over time, mainly because of the implementation of more specific and sensitive diagnostic tools, the diagnosis of these conditions is still challenging.[8] The difficulty is associated with the facts that different underlying causes, including etiologic agents, can result in similar clinical signs and lesions and that some of the etiologic agents can also be found in the intestines of clinically normal equids. Relatedly, the most common clinical sign of digestive disorders in horses is colic, which is defined as a gastrointestinal disease that causes signs of abdominal pain.[10,11] The incidence of colic in horses in the United States has been reported[12] as 4.2 events/100 horses/y, and colic is the second most common cause of death after old age. However, to our knowledge, neither the incidences of the inflammatory intestinal disturbances producing colic nor the main underlying causes of inflammatory gastrointestinal lesions are known for horses and other equids in California. Such knowledge would be useful to improve diagnostic and surveillance strategies for gastrointestinal diseases in horses and other equids. Therefore, the purpose of the study presented here was to determine the incidences and underlying causes of FIILs and the demographic characteristics of affected equids necropsied at any of the CAHFS facilities between January 1, 1990, and April 16, 2013.

Materials and Methods

Case selection

The medical records databases of the 4 CAHFS facilities that received carcasses of horses and other equids for necropsy between January 1, 1990, and April 16, 2013, were searched for records of those with colitis, duodenitis, enteritis, enterocolitis, enteropathy, enterotyphlitis, gastritis, gastroenteritis, ileitis, jejunitis, typhlitis, or typhlocolitis, alone or in combination, listed in the diagnosis field. When this report was written, the CAHFS was the reference veterinary diagnostic laboratory system for the state of California and was comprised of 4 laboratories (1 laboratory each in Davis, San Bernardino, Tulare, and Turlock), 3 of which (Davis, San Bernardino, and Tulare) received equid carcasses for necropsy. In addition, between 1990 and 2009, the CAHFS also had a laboratory in Fresno that received equid carcasses for necropsy, and records from this facility were included in the search.

Medical records review

Medical records of equids identified through the search of the CAHFS databases were reviewed. Animals were included in the study if enteritis, typhlitis, colitis, gastroenteritis, enterotyphlitis, enterocolitis, typhlocolitis, or enterotyphlocolitis, alone or in combination, was diagnosed and considered by the pathologist in charge of the case to have been either a severe clinical disease (in animals euthanized) or the cause of death. Jejunitis, duodenitis, and ileitis collectively were categorized as enteritis. Required diagnostic criteria included gross and microscopic descriptions of lesions; isolation, serotyping, immunohistochemical staining, or PCR assay (alone or in combination) to detect etiologic agents; and ELISA testing to detect toxins of *C perfringens* and *C difficile.*

FIILs—A lesion was defined as any pathological change in an organ or tissue produced by bacterial, viral, parasitic, toxic, allergic, immune-mediated, mechanical (eg, mesenteric or intestinal strangulation, colonic impaction, or mesenteric thrombosis of undetermined cause), or undetermined causes and could be gross, microscopic, or both. A lesion was considered a primary cause of death if the lesion was neither secondary to another process nor categorized as incidental. For instance, in a foal with gross and microscopic lesions of enteritis and with a clinical history of diarrhea, the enteritis was considered the primary cause of death and, therefore, a FIIL. Lesions were categorized as enteritis, typhlitis, colitis, gastroenteritis, enterotyphlitis, enterocolitis, typhlocolitis, enterotyphlocolitis, or enteropathy. The enteropathy category was used for FIILs in which the specific affected segment of intestine was not documented in the necropsy report.

Underlying causes of FIILs were grouped into 7 categories: bacterial, viral, parasitic, toxic or metabolic, mechanical (visceral displacement, impaction, or rupture or vascular compromise), allergic or immune mediated, or undetermined. Each cause of an infectious nature was further subcategorized by species or subspecies of the etiologic agent as determined with diagnostic procedures.

Animals were excluded from the study if they had > 1 FIIL attributed to different underlying causes or in nonadjacent portions of the intestinal tract (eg, an animal with enteritis caused by *C difficile* and colitis caused by *Strongylus* spp). Also excluded were animals in which the primary cause of death or euthanasia was not related to the gastrointestinal tract (eg, an animal that died because of a limb fracture yet also had gastritis).

Demographic data—For each animal in the study, demographic data pertaining to age, sex, geographic origin, necropsy submission date, and breed, purpose, or characteristic of use were obtained from the necropsy submission forms and medical records. Age of the animal at the time of death or euthanasia was categorized under 1 of the 5 age ranges established for the study: neonates (≤ 7 days), foals and weanlings (8 days to 1 year), juveniles (1.1 to 4 years), adults (≥ 4.1 years), or age unknown. The 4 categories for the sex of animals as listed in their records were female, sexually intact male, castrated male, or unknown or not reported.

The geographic origin of animals was based on the county of residence noted on the necropsy submission form and was categorized as northern, central, or southern California or as unknown or not from California. Counties included in the southern California category included Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Imperial, and Ventura. Those in the central California category included Fresno, Kings, Madera, Monterey, San Benito, Stanislaus, Tulare, and Tuolumne counties. The counties in the northern California category included Alameda, Butte, Calaveras, Contra Costa, El Dorado, Humboldt, Lassen, Marin, Mendocino, Mono, Napa, Nevada, Placer, Plumas, Sacramento, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Shasta, Siskiyou, Solano, Sonoma, Sutter, Tehama, Yolo, and Yuba. The dates of submissions for necropsy were grouped on the basis of the year submitted and categorized as those submitted during the first submission period (1990 through 1997), second submission period (1998 through 2005), or third submission period (2006 through 2013).

Lastly, the animals were grouped on the basis of breed (if known) or by purpose or characteristics of use, as documented in the medical record or necropsy submission form. The 9 categories of breed or use were stock horses (composed of Pinto Horse, Appaloosa, and American Quarter Horse), draft or harness horses (included Belgian, Clydesdale, Friesian, Haflinger, Hackney, Oldenburg, and Standardbred), Thoroughbreds, American Miniature Horses, Arabian horses, ponies (composed of Shetland Pony and Pony of the Americas), other purebred horses (including Andalusian, Dutch Warmblood, Swedish Warmblood, Holsteiner, Icelandic, Lipizzaner, Lusitanian, Missouri Fox Trotting Horse, Morgan, Mustang, National Show Horse, Paso Fino, Peruvian Paso, Tennessee Walking Horse, Azteca, and Bashkir), other equids (composed of donkey, miniature donkey, mule, and zebra), or unknown or not reported (including animals reported simply as equine, buckskin, mixed, or crossbred).

Statistical analysis

Descriptive statistics were reported as numbers and percentages. When reported for percentages, 95% confidence intervals were determined with available software.[a] For the 3 most commonly identified FIILs, underlying causes were described. In addition, lesions and underlying causes for common FIILs (eg, affecting ≥ 1% of the animals in the study) were reported by animal age, sex, necropsy submission date, geographic origin, and breed or use.

Results

Animals

A search of the medical record databases identified 1,503 equids, of which 710 animals satisfied the inclusion criteria. Most (504/710 [71.0%]) of these animals had died spontaneously as a consequence of an FIIL, whereas the remaining animals (206 [29.0%]) had been euthanized because of welfare concerns with their signs of severe pain and rapid clinical deterioration caused by gastrointestinal disease. Of the 710 animals included in the study, 248 (34.9%) were adults, 185 (26.1%) were juveniles, 121 (17.0%) were foals or weanlings, and 66 (9.3%) were neonates **(Table 1)**. Age was not reported in the records for the re-

Table 1—Summary descriptive characteristics of 710 horses and other equids with FIILs necropsied at any of the CAHFS facilities between January 1, 1990, and April 16, 2013.

Characteristic	No. of equids	Percentage (95% CI)
Age		
Not reported	90	12.7 (10.4–15.3)
Neonate (≤ 7 d)	66	9.3 (7.4–11.7)
Foal or weanling (8 d to 1 y)	121	17.0 (14.5–20.0)
Juvenile (1.1–4 y)	185	26.1 (23.0–29.4)
Adult (≥ 4.1 y)	248	34.9 (31.5–38.5)
Sex		
Not reported	43	6.1 (4.5–8.1)
Female	308	43.4 (39.8–47.0)
Sexually intact male	204	28.7 (30.4–37.4)
Castrated male	155	21.8 (13.7–19.1)
Origin		
Not reported or not from California	7	1.0 (0.5–2.0)
Northern California	262	36.9 (33.4–40.5)
Central California	48	6.8 (5.1–8.9)
Southern California	393	55.4 (51.7–59.0)
Date of submission		
1990–1997	204	28.7 (25.5–32.2)
1998–2005	273	38.5 (34.9–42.1)
2006–2013	233	32.8 (29.5–36.4)
Breed or use		
Not reported	100	14.1 (11.7–16.8)
Stock horse	188	26.5 (23.4–29.8)
Draft or harness horse	34	4.8 (3.4–6.6)
Thoroughbred	230	32.4 (29.1–35.9)
American Miniature Horse	30	4.2 (3.0–6.0)
Arabian	48	6.8 (5.1–8.9)
Other purebred horse	48	6.8 (5.1–8.9)
Pony	17	2.4 (1.5–3.8)
Other equid	15	2.1 (1.3–3.5)
FIIL		
Colitis	323	45.5 (41.9–49.2)
Enteritis	146	20.6 (17.8–23.7)
Typhlocolitis	138	19.4 (16.7–22.5)
Enterocolitis	61	8.6 (6.8–10.9)
Enteropathy	23	3.2 (2.2–4.8)
Enterotyphlocolitis	12	1.7 (1.0–2.9)
Typhlitis	5	0.7 (0.3–1.6)
Enterotyphlitis	1	0.1 (0.0–0.8)
Gastroenteritis	1	0.1 (0.0–0.8)

CI = Confidence interval.

maining 90 (12.7%) animals. There were 308 (43.4%) females, 204 (28.7%) sexually intact males, and 155 (21.8%) castrated males; however, sex was not reported for the remaining 43 (6.1%) animals. Thoroughbreds (230/710 [32.4%]) and stock horses (188/710 [26.5%]) were the most commonly represented. Most (393/710 [55.4%]) of the animals originated from southern California, followed by northern (262/710 [36.9%]) and central (48/710 [6.8%]) California. The county of origin was not reported for 7 animals, and not all counties were represented. The proportion of neonatal animals from northern California (262/710 [37.0%]) was lower than those from southern (393/710 [55.4%]) or central (48/710 [6.8%]) California. When considered by date of submission for necropsy, the number of animals with FIIL increased

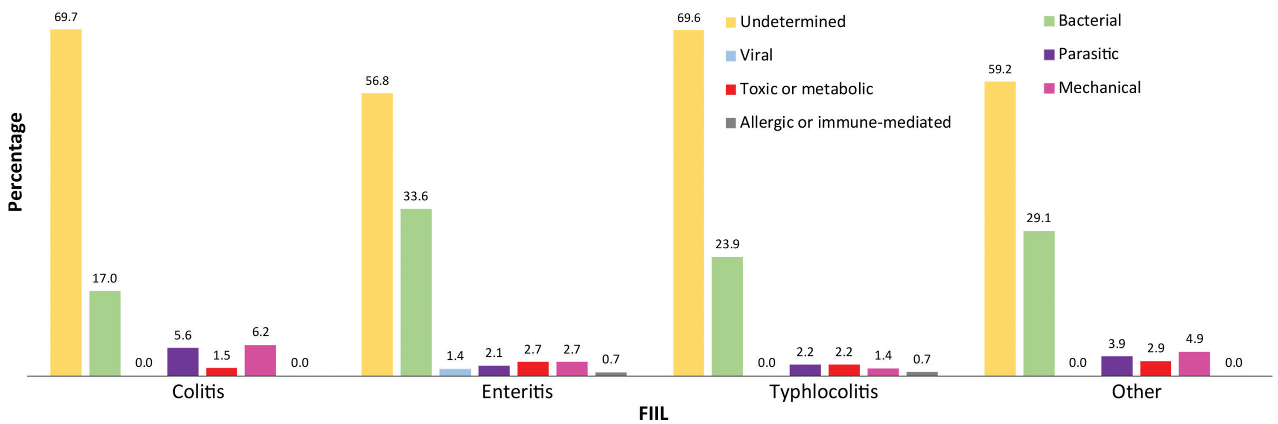

Figure 1—Categories of underlying causes of the 3 most common FIILs (colitis [n = 323], enteritis [146], and typhlocolitis [138]) and all other FIILs (enterocolitis, enteropathy [collective category for intestinal inflammatory lesions without specific affected segment documented in the necropsy report], enterotyphlitis, enterotyphlocolitis, gastroenteritis, and typhlitis; 103) diagnosed in 710 horses and other equids necropsied at any of the CAHFS facilities between January 1, 1990, and April 16, 2013.

Table 2—Number (%) of common FIILs diagnosed in ≥ 1% (703/710) of the animals in Table 1, stratified by animal sex, age, geographic origin, date of submission for necropsy, and breed or use. The excluded categories were typhlitis (n = 5), gastroenteritis (1), and enterotyphlitis (1)

		FIIL					
Characteristic	**No. (%) of equids (n = 703)**	**Enteropathy (n = 23)**	**Enteritis (n = 146)**	**Colitis (n = 323)**	**Enterocolitis (n = 61)**	**Typhlocolitis (n = 138)**	**Enterotyphlocolitis (n = 12)**
Age							
Not reported	89 (12.7)	3 (13.0)	24 (16.4)	36 (11.2)	9 (14.8)	15 (10.9)	2 (16.7)
Neonate (≤ 7 d)	65 (9.3)	3 (13.0)	37 (25.4)	9 (2.8)	11 (18.0)	4 (2.9)	1 (8.3)
Foal or weanling (8 d to 1 y)	121 (17.2)	3 (13.0)	26 (17.8)	57 (17.6)	13 (21.3)	20 (14.5)	2 (16.7)
Juvenile (1.1–4 y)	184 (26.2)	2 (8.8)	24 (16.4)	102 (31.6)	8 (13.1)	48 (34.8)	0
Adult (≥ 4.1 y)	244 (34.7)	12 (52.2)	35 (24.0)	119 (36.8)	20 (32.8)	51 (36.9)	7 (58.3)
Sex							
Not reported	43 (6.1)	3 (13.0)	10 (6.8)	20 (6.2)	2 (3.3)	7 (5.1)	1 (8.3)
Female	304 (43.2)	9 (39.2)	60 (41.1)	154 (47.7)	29 (47.5)	47 (34.1)	5 (41.7)
Sexually intact male	201 (28.6)	8 (34.8)	56 (38.4)	77 (23.8)	18 (29.5)	40 (29.0)	2 (16.7)
Castrated male	155 (22.1)	3 (13.0)	20 (13.7)	72 (22.3)	12 (19.7)	44 (31.9)	4 (33.3)
Origin							
Not reported or not from California	7 (1.0)	0	3 (2.1)	2 (0.6)	0	1 (0.7)	1 (8.3)
Northern California	260 (37.0)	10 (43.5)	60 (41.1)	132 (40.9)	20 (32.8)	33 (23.9)	5 (41.7)
Central California	47 (6.7)	3 (13.0)	12 (8.2)	21 (6.5)	6 (9.8)	5 (3.6)	0
Southern California	389 (55.3)	10 (43.5)	71 (48.6)	168 (52.0)	35 (57.4)	99 (71.8)	6 (50.0)
Date of submission							
1990–1997	203 (28.9)	9 (39.1)	35 (24.0)	108 (33.4)	17 (27.9)	32 (23.2)	2 (16.7)
1998–2005	271 (38.5)	12 (52.2)	44 (30.1)	119 (36.9)	20 (32.8)	71 (51.4)	5 (41.7)
2006–2013	229 (32.6)	2 (8.7)	67 (45.9)	96 (29.7)	24 (39.3)	35 (25.4)	5 (41.7)
Breed or use							
Not reported	99 (14.1)	5 (21.8)	26 (17.8)	42 (13.0)	10 (16.4)	15 (10.9)	1 (8.3)
Stock horse	187 (26.6)	5 (21.8)	33 (22.6)	89 (27.5)	22 (36.1)	34 (24.6)	4 (33.3)
Draft or harness horse	34 (4.9)	1 (4.3)	5 (3.4)	19 (5.9)	3 (4.9)	6 (4.3)	0
Thoroughbred	228 (32.4)	6 (26.1)	46 (31.5)	105 (32.5)	13 (21.3)	56 (40.6)	2 (16.7)
American Miniature Horse	28 (4.0)	0	6 (4.1)	16 (5.0)	1 (1.6)	3 (2.2)	2 (16.7)
Arabian	48 (6.8)	3 (13.1)	11 (7.5)	20 (6.2)	5 (8.2)	8 (5.8)	1 (8.3)
Other purebred horse	47 (6.7)	1 (4.3)	12 (8.2)	21 (6.5)	4 (6.6)	9 (6.5)	0
Pony	17 (2.4)	1 (4.3)	2 (1.4)	6 (1.9)	3 (4.9)	4 (2.9)	1 (8.3)
Other equid	15 (2.1)	1 (4.3)	5 (3.4)	5 (1.5)	0	3 (2.2)	1 (8.3)

from the first submission period (1990 through 1997; 204/710 [28.7%]) to the second (1998 through 2005; 273/710 [38.5%]), but then decreased in the third (from 2006 through 2013; 233/710 [32.8%]). Similarly, the overall equid necropsy caseload increased from the first submission period (2,755) to the second (5,956), then decreased in the third (4,206). Thus, the incidence of FIIL was 7.4% (204 cases/2,755 necropsies) during the first submission period, 4.6% (273 cases/5,956 necropsies) during the second submission period, and 5.5% (233 cases/4,206 necropsies) during the third submission period.

FIIL categories

On the basis of clinical, gross, and microscopic findings, gastrointestinal disease was considered to have been severe in all animals. Microscopic changes in all animals included lesions affecting ≥ 1 layer of the intestine or stomach with combinations of necrosis (with or without pseudomembrane formation); infiltration with neutrophils, lymphocytes, plasma cells, or macrophages (alone or in combination); thrombosis; hemorrhage; edema; and presence of intralesional bacteria, parasites, or both. The lesions were similarly recorded, regardless of the gastrointestinal segment affected. In addition, villus blunting and fusion were reported for lesions in the small intestines, and full-thickness segmental infarction was recorded in the small or large intestines (alone or in combination) in animals with an underlying mechanically caused FIIL.

Colitis (323/710 [45.5%]), enteritis (146/710 [20.6%]), and typhlocolitis (138/710 [19.4%]) were the 3 most common primary FIILs, affecting 85.5% (607/710) of animals (**Figure 1**; Table 1) and accounting for 86.3% (607/703) of the common FIILs (ie, affecting ≥ 1% of the animals in the study; **Table 2)**. The least common primary FIILs affecting ≤ 1% of the animals in the study were typhlitis (n = 5), enterotyphlitis (1), and gastroenteritis (1). Neonatal animals had enteritis more commonly than other FIILs, whereas animals in all other age groups had colitis more commonly than other FIILs.

Underlying causes

Five of the 7 categories of underlying causes of FIILs affected 706 animals and included the categories of undetermined (n = 465/706 [65.9%]), bacterial (167 [23.7%]), mechanical (31 [4.4%]), parasitic (28 [4.0%]), or toxic or metabolic (15 [2.1%]) causes **(Table 3)**. The remaining animals had FIILs of less

Table 3—Number (%) of the top 5 of 7 categories of underlying causes of FIIL diagnosed in the animals in Table 1, stratified by animal sex, age, geographic origin, date of submission for necropsy, and breed or use. The excluded categories were viral (n = 2) and allergic or immune-mediated (2) causes.

		Underlying cause				
Characteristic	**No. (%) of equids (n = 706)**	**Undetermined (n = 465)**	**Bacterial (n = 167)**	**Parasitic (n = 28)**	**Toxic or metabolic (n = 15)**	**Mechanical (n = 31)***
Age						
Not reported	90 (12.7)	57 (12.3)	24 (14.4)	5 (17.9)	1 (6.7)	3 (9.7)
Neonate (≤ 7 d)	66 (9.3)	30 (6.5)	34 (20.4)	1 (3.6)	0	1 (3.2)
Foal or weanling (8 d to 1 y)	119 (16.9)	70 (15.1)	30 (18.0)	12 (42.9)	3 (20.0)	4 (12.9)
Juvenile (1.1–4 y)	183 (25.9)	134 (28.8)	37 (22.2)	3 (10.7)	4 (26.7)	5 (16.1)
Adult (≥ 4.1 y)	248 (35.1)	174 (37.4)	42 (25.2)	7 (25.0)	7 (46.7)	18 (58.1)
Sex						
Not reported	43 (6.1)	26 (5.6)	12 (7.2)	3 (10.7)	0	2 (6.4)
Female	307 (43.5)	195 (41.9)	74 (44.3)	15 (53.6)	8 (53.3)	15 (48.4)
Sexually intact male	201 (28.5)	129 (27.7)	56 (33.5)	7 (25.0)	3 (2.0)	6 (19.4)
Castrated male	155 (20.1)	115 (24.7)	25 (15.0)	3 (10.7)	4 (26.7)	8 (25.8)
Origin						
Not reported or not from California	7 (1.0)	5 (1.1)	0	0	1 (6.7)	1 (3.2)
Northern California	262 (37.1)	188 (40.4)	36 (21.6)	19 (67.9)	8 (53.3)	11 (35.5)
Central California	48 (6.8)	25 (5.4)	16 (9.6)	3 (10.7)	0	4 (12.9)
Southern California	389 (55.1)	247 (53.1)	115 (68.9)	6 (21.4)	6 (40.0)	15 (48.4)
Date of submission						
1990–1997	202 (28.6)	138 (29.7)	35 (21.0)	8 (28.6)	5 (33.3)	16 (51.6)
1998–2005	271 (38.4)	190 (40.8)	59 (35.3)	7 (25.0)	7 (46.7)	8 (25.8)
2006–2013	233 (33.0)	137 (29.5)	73 (43.7)	13 (46.4)	3 (20.0)	7 (22.6)
Breed or use						
Not reported	100 (14.2)	63 (13.6)	27 (16.2)	5 (17.9)	2 (13.3)	3 (9.7)
Stock horse	188 (26.6)	128 (27.5)	45 (26.9)	6 (21.5)	2 (13.3)	7 (22.6)
Draft or harness horse	34 (4.8)	22 (4.7)	8 (4.8)	2 (7.1)	0	2 (6.5)
Thoroughbred	228 (32.3)	156 (33.6)	57 (34.1)	5 (17.9)	1 (6.7)	9 (29.0)
American Miniature Horse	30 (4.2)	21 (4.5)	4 (2.4)	2 (7.1)	2 (13.3)	1 (3.2)
Arabian	47 (6.7)	27 (5.8)	9 (5.4)	3 (10.7)	3 (20.0)	5 (16.1)
Other purebred horse	47 (6.7)	26 (5.6)	13 (7.8)	3 (10.7)	4 (26.7)	1 (3.2)
Pony	17 (2.4)	13 (2.8)	1 (0.6)	0	1 (6.7)	2 (6.5)
Other equid	15 (2.1)	9 (1.9)	3 (1.8)	2 (7.1)	0	1 (3.2)

*Includes mesenteric or intestinal strangulation (n = 2), colonic impaction (3), and mesenteric thrombosis of undetermined cause (26).

Table 4—Number (%) of animals from Table 1 with bacterial colitis, enteritis, or typhlocolitis, stratified by etiologic agent.

FIIL	No. of equids	Percentage (95% CI)	*Clostridium* spp	*Salmonella* spp	*Escherichia coli*	*Actinobacillus equuli*	*Rhodococcus equi*	*Streptococcus zooepidemicus*	*Streptococcus equi*	*Fusobacterium equinum*	*Mycobacterium avium*
Colitis	323	45.5 (41.9–49.2)	200 (61.9)	94 (29.1)	10 (3.1)	13 (4.0)	6 (1.9)	0	0	0	0
Enteritis	146	20.6 (17.8–23.7)	98 (67.1)	30 (20.5)	6 (4.1)	3 (2.1)	0	3 (2.1)	3 (2.1)	3 (2.1)	0
Typhlocolitis	138	19.4 (16.7–22.5)	62 (44.9)	68 (49.3)	4 (2.9)	0	0	0	0	0	4 (2.9)

CI = Confidence interval.

common underlying causes categorized as viral (n = 2) or allergic or immune mediated (2). For the 3 FIILs diagnosed most often (colitis, enteritis, and typhlocolitis), the most common underlying cause was categorized as undetermined, followed by bacterial (Figure 1). When considered by the date of submission for necropsy, the proportion of FIILs with an undetermined underlying cause was 68.3% (138/202) and 70.1% (190/271) for animals submitted during the first and second submission periods, respectively, compared with 58.8% (137/233) during the third submission period. In addition, FIILs more commonly had bacterial causes in neonates, whereas the cause was more often undetermined in other age groups. One hundred fifteen of the 167 (68.9%) animals with a bacterial cause of FIIL were from southern California, compared with 36 (21.6%) from northern and 16 (9.6%) from central California. Further, the underlying cause of FIIL was bacterial in 35 of 202 (17.3%) animals during the first submission period, 59 of 271 (21.8%) animals during the second submission period, and 73 of 233 (31.3%) animals during the third submission period.

The bacteria most commonly identified in animals with FIILs of colitis, enteritis, or typhlocolitis were *Clostridium* spp and *Salmonella* spp **(Table 4)**. *Clostridium* spp were more commonly isolated from animals with colitis (200/323 [61.9%]) or enteritis (98/146 [67.1%]), whereas *Salmonella* spp were isolated more frequently from animals with typhlocolitis (68/138 [49.3%]).

Bacterial enteritis FIILs caused by *Salmonella* spp (diagnosed by bacterial isolation or PCR assay detection of *Salmonella* spp; n = 30) were further subcategorized into those caused by *S enterica* serotypes Typhimurium, Newport, Saint Paul, Krefeld, Arizonae, Enteritidis, and Anatum. There were 68 animals with bacterial typhlocolitis caused by *Salmonella* spp. Two hundred animals had bacterial colitis caused by *Clostridium* spp (*C difficile* [n = 112], *C perfringens* [58], *C sordellii* [6], *C piliforme* [6], *C tetani* [6], or *Clostridium* spp not typed [12]).

Discussion

Results indicated that the higher number of animals with FIIL submitted for necropsy during the second submission period (1998 through 2005), compared with the first (1990 through 1997) and third (2006 through 2013) submission periods, was mirrored by overall submissions of equids for necropsy during those same times. The fluctuations in caseload could have been attributed in part to rule changes at horse racetracks in California. For instance, during the first submission period the California Horse Racing Board Postmortem Program began (1990) and required that every horse that died on a California Horse Racing Board–sanctioned racetrack be necropsied at the CAHFS. The postmortem program was running at full capacity at the end of 1997, which could have accounted for the greater number of equid necropsy submissions in the second submission period. However, during the third submission period, a major race track in California closed, which may have been reflected in the decreased number of equid necropsy submissions. Another possible reason for the decrease in the equid necropsy submissions between the second and third submission periods could have been the general economic downturn after the Great Recession in 2008.

In most animals of the present study, the underlying cause of their FIIL was not determined (465/710 [65.5%]). This finding reflected knowledge gaps in available technology, diagnostic strategies, diagnosticians' diagnostic ability, or a combination of these. The proportion of animals with the underlying cause of FIIL categorized as undetermined was lowest in the third submission period (137/233 [58.8%]), whereas the proportion of animals with a bacterial cause of FIIL was highest in that same period (73/233 [31.3%]). These findings coincided with the implementation and use of new bacteriologic diagnostic assays at our laboratory. For instance, the use of ELISAs for the detection of *C perfringens* and *C difficile* toxins and the use of molecular techniques to detect and type bacterial isolates allowed the diagnosis of underlying causes of diseases that previously could not be identified. Thus, the occurrences of these diseases may not have changed, but rather new diagnostic tests may have helped to identify pathogens that were not detected before.[13]

Changes in pathogen dynamics, host responses, or both could have contributed to differences in numbers of FIILs over time, across age groups, among underlying causes, or among other characteristics evaluated during the study period; however, identifying such potential interactions was beyond the scope of the present study. For example, investigators report that excessive antimicrobial exposure is likely driving the establishment of *C difficile* in animals and humans.[14] To better determine whether a decrease in the proportion of animals with FIILs of undetermined cause was attributable to changes in either diagnostic methods or host-pathogen dynamics, further surveillance and monitoring strategies for infectious diseases in equids are needed.

The finding that FIILs with bacterial etiologic agents were detected at a higher proportion in animals from southern California (115/167 [68.9%]) than from central (16 [9.6%]) or northern (36 [21.6%]) California was unexpected. A possible reason for this difference could have been the differences in ages of animals submitted from each region. For instance, age is a risk factor for some bacterial diseases, such as necrotic enteritis caused by *C perfringens* type C that occurs almost exclusively in newborn animals.[15,16]

Results indicated that the proportion of neonatal animals submitted for necropsy was lower from northern California than from southern or central California. However, it is unclear whether northern California had fewer neonatal horses than did the other regions, whether the other regions had higher incidences of neonatal FIILs, or whether neonatal animals from the other regions were simply more likely to have been submitted for necropsy. In addition, our findings indicated that enteritis most commonly affected neonatal animals but less commonly affected older animals, consistent with a previous study.[16]

The duration of the present study was relatively long, and results indicated that the proportion of animals with undetermined causes of FIILs decreased between the second and third submission periods, coinciding with increasing availability of new diagnostic procedures. For example, during the last few years of the present study, use of an ELISA to detect toxins produced by 3 types of *C perfringens* was adopted, which allowed detection of β toxin in intestinal content, which is diagnostic for *C perfringens* type C enteritis.[16] During the same submission period, enteritis by *C perfringens* type C was diagnosed in higher proportions in the present study, suggesting that this apparent increase in occurrence of the disease was a consequence of more accurate diagnostic tests, rather than a true increase in number of cases. Similarly, an increase in diagnostic efficacy owing to the use of more accurate diagnostic tests has been observed with the implementation of the ELISA for detection of *C difficile* toxins A and B.[17]

The present study had several limitations. Equids in the study were likely not representative of the overall equid population of California because not all that died between 1990 and 2013 were submitted to the CAHFS for necropsy. In addition, racehorses may be overrepresented because owners were required to have them necropsied at the CAHFS if they died on a California Horse Racing Board–sanctioned racetrack. Another limitation was that animals with multiple lesions of different causes were excluded, which decreased our sample size.

In addition, our data collection relied on information contained in existing medical records that varied in quality and level of detail. For instance, animal age, sex, or breed was missing from the records of many animals. Further, the FIIL type could have been incorrectly diagnosed or reported, leading to potential misclassification of the FIIL in the present study. This may have contributed to the numbers of animals with undetermined causes of FIILs. However, the potential for misclassification in the present study was minimized with strict case definitions and exclusion criteria.

Results indicated that despite complete necropsies being performed in most cases by board-certified veterinary pathologists, the underlying cause for most lesions could not be identified. However, when it was identified, it was most commonly bacterial and typically *Clostridium* spp or *Salmonella* spp. These results may be useful for practitioners when evaluating and managing horses and other equids with intestinal distress. In addition, to our knowledge, the present study was the first to describe FIILs and underlying causes in a large number of horses and other equids necropsied. Our findings underscored the need for improved diagnostic procedures and strategies to determine the underlying causes of FIILs in equids. Studies like this are important for assessing and advancing diagnostic tools, preventions, and treatments of intestinal disease in horses and other equids.

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Footnotes

a. SPSS Statistics, version 20, IMB Corp, Armonk, NY.

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From this month's *AJVR*

Prognostic value of measuring heart rate variability at the time of hospital admission in horses with colic

Valentina Vitale et al

OBJECTIVE
To evaluate the prognostic value of measuring heart rate variability (HRV) in horses with colic at the time of admission to a referral hospital.

ANIMALS
51 horses > 1 year of age with colic (41 that survived [survivors] and 10 that died or were euthanized [nonsurvivors]).

PROCEDURES
HRV was recorded within 1 hour after admission by use of heart rate sensors with horses restrained in stocks. A 5-minute recording period was analyzed to obtain HRV measurements (eg, SD of R-R intervals [SDRR], root mean square of successive differences between R-R intervals [RMSSD], and geometric SDs determined from Poincaré plots [SD1 and SD2]). Variables associated with outcome (survival vs nonsurvival) were identified. Measurements were compared among diagnostic categories for colic (obstructive, inflammatory, or ischemic).

RESULTS
SDRR and RMSSD were significantly higher in survivors (median [25th to 75th percentile], 91.0 milliseconds [78.9 to 114.6 milliseconds] and 64.8 milliseconds [40.9 to 78.4 milliseconds], respectively) than in nonsurvivors (50.7 milliseconds [29.1 to 69.2 milliseconds] and 33.4 milliseconds [12.6 to 47.9 milliseconds], respectively). Similarly, SD1 and SD2 were significantly higher in survivors (48.3 milliseconds [28.9 to 60.9 milliseconds] and 111.3 milliseconds [93.0 to 146.6 milliseconds], respectively) than in nonsurvivors (23.7 milliseconds [8.9 to 33.9 milliseconds] and 65.1 milliseconds [33.7 to 91.9 milliseconds], respectively). The SDRR and SD2 were significantly higher for horses with obstructive colic than for horses with ischemic colic.

CONCLUSIONS AND CLINICAL RELEVANCE
Analysis of HRV in horses with colic may provide information on the underlying cause and be helpful in identifying horses less likely to survive. (*Am J Vet Res* 2020;81:147–152)

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