Estimate of the national incidence of and operation-level risk factors for colic among horses in the United States, spring 1998 to spring 1999

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The term colic refers to abdominal pain that may be caused by many different problems. In horses, most of these problems involve the gastrointestinal tract, but diseases of other structures within or associated with the abdomen such as the kidneys, liver, uterus, and peritoneum may also result in signs of colic. Diseases that cause colic are often placed in functional categories such as ileus, obstruction, strangulation, enteritis, and ulceration. However, risk for colic and cause of colic are often unknown.

Colic incidence, risk factors, cause, and case fatality rate have been reported for local populations of horses, using case-control and longitudinal studies. Suggested predisposing factors include geographic location, breed, use, diet, and other health management practices such as anthelmintic use and dental care. As a group, diseases that cause colic may be the first or second leading cause of death in horses. To the authors’ knowledge, a large study that accurately estimates the incidence of equine colic in the continental United States has not been performed. Furthermore, there are no reports of the cost of colic to the US horse industry.

In 1998, the National Animal Health Monitoring System (NAHMS) initiated a study of the US equine population and associated health management practices, and a portion of the results of that study are reported here. Objectives of the study were to estimate the national incidence, operation-level risk factors, and annual economic impact of colic in horses in the United States during 1998 and 1999.

Materials and Methods

As part of the NAHMS Equine '98 Study, data reported here were gathered directly from equine operations. In phase 1 of the study, the National Agricultural Statistics Service (NASS) selected operations with 1 or more horses (or ponies) from a stratified random sample based on their estimate of the number of equids and equine operations in the United States on Jan 1, 1998. The 28 target states included in the study were selected on the basis of the Census of Agriculture 1992 data so that at least 75% of operations with horses and ponies and 75% of horses and ponies in the United States were represented. The 28 states were divided into 4 regions for reporting purposes. The western region included California, Colorado, Montana, New Mexico, Oregon, Washington, and Wyoming; the southern region included Alabama, Florida, Georgia, Kentucky, Louisiana, Maryland, Oklahoma, Tennessee, Texas, and Virginia; the northeastern region included New Jersey, New York, Ohio, and Pennsylvania; and the central region included Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, and Wisconsin. Twenty-one of the states that were selected each accounted for 2% or more of US horses and ponies. Seven additional states were selected to improve geographic representation or because of interest from their equine industry (Georgia, Maryland, New Jersey, Alabama, Louisiana, New Mexico, and Wyoming).

To select premises within states, NASS developed 2 components from which to sample. One component (list) was a list of larger equine operations such as boarding stables, riding and training operations, and racetracks. The second component (area) was intended to capture small equine operations such as residences with equids for personal use, because these operations would not have appeared on the list frame. The area component was compiled by selecting geographic areas and taking inventory of all operations within the area. The 2 components were then combined, and duplicates were eliminated. Operations were randomly chosen from within-state and size-of-operation strata.


Design—Epidemiologic survey.

Animals—21,820 horses on 1,026 horse operations in 28 states.

Procedures—Horses were monitored for colic for 1 year, and results were recorded in a log that was collected quarterly. Operation-level data were collected via 4 on-site personal interviews. Associations between colic and independent variables adjusted for size of operation were determined.

Results—Annual national incidence of colic in the US horse population was estimated to be 4.2 colic events/100 horses per year. Case fatality rate was 11%, and 1.4% of colic events resulted in surgery. Annual cost of colic in the United States was estimated to be $115,300,000.

Conclusions and Clinical Relevance—The national impact of equine colic is substantial because of the high case fatality rate. (J Am Vet Med Assoc 2001; 219:67–71)
Operations that completed phase 1 of the study and had 3 or more horses on Jan 1, 1998 were eligible to participate in phase 2 of the study. Operations with 3 or more horses on Jan 1, 1998 accounted for 55.1% of operations and represented 85.3% of horses in the United States; therefore, we were able to optimize our resources (personnel time for site visits) by only including operations with 3 or more horses. Horses housed at racetracks were included for estimation of horse numbers only and did not contribute to the estimates of health events or management practices. We excluded horses housed at racetracks for the health and management aspect of the study, because it was our goal to collect 1 year of health and management data on horses included in phase 2 of the study. Because of the mobile nature of horses at racetracks, it was our opinion that data collection for 1 full year was not feasible for horses housed at racetracks.

More detailed information regarding study design and implementation is available in the NAHMS tabular summary reports.11-12 Briefly, the first visit to equine operations was made by NASS personnel, and 3 subsequent on-site visits were made by field staff that included USDA:Veterinary Services veterinary medical officers, animal health technicians, and district state veterinarians. The visits began in the spring of 1998 and continued through the winter of 1998/1999, with a follow-up telephone call made to the participants in the spring of 1999.

Because the purpose of the study was to arrive at national estimates of health variables and management practices, data were weighted to account for the multistage stratified sampling design. In addition, weights were adjusted for nonresponse to allow the estimated number of horses to approximate estimates made by NASS.13 Personnel at each operation that participated in phase 2 of the study were asked to maintain a colic log. The person considered to be most knowledgeable regarding equine health was interviewed by the NAHMS data collector; this person was the primary contact (operator) for completion of the questionnaire and monitoring of horses for colic. On operations where horses had more than 1 owner, the operator may not have been the horse owner; however, the operator potentially had more day-to-day contact with the horses. All colics were operator-reported and were not necessarily confirmed by a veterinarian. Personnel were encouraged to monitor all horses on the premises for colic. If operators could not monitor all horses, they monitored a subpopulation.

Colic was defined as the occurrence of signs of abdominal pain such as pawing or kicking at the abdomen, bloating, rolling over, sweating, lying down slowly or violently, lying on the back, crouching, and straining to defecate. To optimize uniformity in data collection, the NAHMS field staff received training regarding questionnaire and biologic sampling forms and were instructed to inform participants about the case definition for colic and record keeping. Field staff collected the colic log during each of their quarterly visits. Analysis was limited to participants who provided data for all 4 of the colic event records in order to estimate colic events for an entire year and by season. Individual horse and event data collected via the colic log included identification of the horse, age, sex, breed, use of horse, date of colic, duration of colic, treatment, cause of colic if known, outcome (lived or died), whether evaluated by a veterinarian, whether treated by use of surgery, veterinary cost, days of lost use, and whether the horse had colic prior to the present colic. Field staff collected operation-level data via questionnaires during the 4 on-site visits. Information regarding management practices implemented for most horses on the operation, such as feed type, water source, method of watering, stocking density, dental care, and anthelmintic use were collected. In addition, field staff collected biological samples during the summer (50% of operations) or winter (50% of operations) visit. Horse feces were collected on the basis of a sliding scale according to the number of horses on the operation (as many as 20 samples/operation for operations with ≥ 50 horses).14-15 Samples were tested for parasite ova by use of a flotation method with Sheather solution at the USDA National Veterinary Services Laboratories Parasitology Laboratory, and results were reported as eggs per gram for strongyles and ascarids.16

Incidence and associated standard error (SE) were estimated by use of software,7 which accounted for the complex survey design. This program computed the variance by substituting the Taylor-series linearization of the statistic into the variance formula. An operation was considered a colic operation if colic was diagnosed on 1 or more occasions in any of the monitored horses during the study period. Population estimates were based on weighting the data for likelihood of an operation’s selection and adjusted for nonresponse. Horse-level incidence estimates were defined as the number of colics per 100 horses monitored per year. Recurrent colics in the same horse were treated as separate events in the analysis, because the goal of the study was to estimate incidence of colic events, not the number horses with colic or colics per horse. Births were not added, and deaths were not explicitly dropped from the denominator, because these would have been reflected in the quarterly estimation of horse numbers.

Before analysis, we defined operations as small, medium, and large, because we believed management would vary by size of operation. In order to have an adequate sample of large operations, we included a higher proportion of operations with 20 or more horses than those operations with < 20 horses. Size was estimated on the basis of the number of horses on each operation during the spring, summer, and winter visits. The Cochran-Mantel-Haenszel test was used to test for association between size (by number of horses) and independent variables adjusted for size of the operation, because it was assumed that colic events were more likely on large operations, compared with small operations, because there were more horses at risk of developing colic. Horse breeds were categorized as Thoroughbred, stock breed (Quarter Horse, Paint, Appaloosa, or other).

To determine economic estimates for colic, the NAHMS Equine ’98 Study results and population and value estimates from the NASS data17 were used. Components of the economic calculation of colic in the US horse population included: 1) the NASS estimate of US equine inventory as of Jan 1, 1998 was 5.3 million head; 2) the NAHMS Equine ’98 Study estimate of the Jan 1, 1998 equine population for percentage of horses > 6 months old was 98.7; 3) the NAHMS Equine ’98 Study estimate of colic events per horse monitored was 0.042; 4) the NAHMS Equine ’98 Study estimate of percentage of colic events survived was 89.0; 5) the NASS estimate of the mean sales price of horses as of Jan 1, 1998 was $3,146/horse; and 6) the American Horse Council estimate of the weighted annual mean maintenance cost of horses was $2,978/horse. Questions in the NAHMS survey were structured such that 3 components of costs associated with colic could be estimated, including death loss; veterinary services, drugs, and additional care costs; and loss of use of the affected horse. Death loss was calculated by multiplying the number of colic events that ended in death by the mean sale value of a horse in the United States in 1998. The weighted mean cost of veterinary services, drugs, and additional care as reported in the NAHMS survey was multiplied by the estimated total number of colics in the US horse population to obtain a national estimate of these costs. Lost revenue attributable to loss of use of each horse was calculated on the basis of the mean number of days of lost use and an estimate of the

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value of this lost use.\textsuperscript{15,19} The value of lost use was calculated, using the mean sale value of a horse divided by the number of days of life expectancy adjusted to current dollars and the weighted mean cost of maintaining a horse during the period of lost use. For this analysis, life expectancy of a horse was assumed to be 20 years.

Results

In the first phase of the study, 2,904 equine operations participated; 2,238 operations qualified for phase 2 of the study, and of those, 1,178 (52.6\%) agreed to participate in phase 2. Among operations that agreed to maintain a colic log, 1,026 (87.8\%) monitored their horses for all 4 quarters, and only data from these operations were included in estimates of colic. Ninety-six percent of these operations monitored all horses on the operation; therefore, potential for bias was considered to be minimal. Overall, 21,820 horses were monitored for colic throughout the study period.

Incidence of colic was 4.2 events/100 horses per year (SE, 0.7). There were no differences in colic rates among geographic regions. A larger percentage of the colics occurred in spring (37.7\%; SE, 4.7), compared with summer (20.7\%; SE, 4.6) or fall (16.1\%; SE, 2.8).

The overall case fatality rate for horses with colic was 11% (SE, 2.8). In 90\% (SE, 6.9) of colics, the affected horse was evaluated by a veterinarian; this percentage did not vary by size of operation. Colic events in horses evaluated by a veterinarian lasted longer than did colic events in which the horses were not evaluated by a veterinarian (23.0 vs 11.1 hours; \(P = 0.003\)). Whereas 15.9\% (SE, 4.3) of colic events in which the affected horse was evaluated by a veterinarian resulted in death, 6.2\% (SE, 3.2) of colic events in which the affected horse was not evaluated by a veterinarian ended in death; this difference was not significant (\(P = 0.09\)). Overall, 1.4\% (SE, 0.6) of colic events resulted in surgical intervention. The percentage of colic events that resulted in surgery did not vary by size of operation. Among horses with colic during the study, 43.5\% (SE, 7.4) were reported to have had colic previously (not necessarily during the study period). Eleven percent of study horses had a recurrent colic during the one year monitoring period.

The most common cause of colic reported by owners was in the unknown category followed by gas colic and feed-related factors. Other less commonly listed causes included impaction, twisted intestine, weather-related, dehydration, pregnancy-related, sand, parasites, stress, associated with cribbing, exercise-related, adhesions, old age, gastric or intestinal ulceration, colitis, drug reaction, tumor, transport-related, associated with ovulation, secondary to a viral infection, enterolithiasis, and secondary to limb trauma.

At the horse level, neither sex nor use of horse was significantly associated with colic; however, breed of horse was associated with colic. Thoroughbreds were more likely to develop colic (10.9 colics/100 horses per year; SE, 3.6) than were stock horse breeds (Quarter Horses, Paints, Appaloosas [3.5 colics/100 horses per year; SE, 0.6; \(P = 0.04\)]) or all other types of horses (2.9 colics/100 horses per year; SE, 0.5; \(P = 0.03\)). Incidence of colic events by age categories of horses per year was 0.2 events/100 horses (SE, 0.1) for foals < 6 months old (reference category), 4.5 events/100 horses (SE, 1.5; \(P = 0.005\)) for horses 6 to < 18 months old, 5.9 events/100 horses (SE, 2.2; \(P = 0.009\)) for horses 18 months to < 5 years old, 3.7 events/100 horses (SE, 0.6; \(P < 0.001\)) for horses 5 to < 20 years old, and 4.2 events/100 horses (SE, 1.3; \(P = 0.002\)) for horses ≥ 20 years old. Foals < 6 months old were significantly less likely to develop colic than were horses in all other age categories.

The number of colics that resulted in death in 1998 was estimated to be 24,167. When combined with a mean sales value of $1346/horse,\textsuperscript{18,19} losses from deaths attributable to colic were estimated at $76 million.

The weighted mean cost of veterinary services, drugs, and additional care was $160/colic event. In contrast to this relatively low cost of veterinary services, drugs, and additional care for all horses with colic, estimated weighted mean cost for those horses that had surgery was $3,872/colic event. The national cost for veterinary services, drugs, and additional care was $35.2 million in 1998.

The mean number of lost days of use attributable to colic was 2.2 days/colic event. The mean life expectancy of colic survivors was estimated to be 12.5 years on the basis of a mean age of 7.5 years for those surviving colic. Revenue lost by the horse owner was $8.83/\textsuperscript{18,19}d,\textsuperscript{18,19} annual national loss for horses that survived was $4.1 million. Thus, the total economic impact of equine colic in the United States in 1998 was $115.3 million, with death loss accounting for 66\% of the cost.

Overall percentage of operations with 1 or more colic events was 16.3 (SE, 2.2). The only operation-level factors that were significantly associated with the outcome of colic irrespective of size of operation were the practice of rotating anthelmintics and testing practices for parasites (Table 1). Variables evaluated at the

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<tr>
<th>Table 1—Percentages (mean ± SE) of equine operations of various sizes in which horses developed colic, in relation to use of anthelmintics and testing for parasites.</th>
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<tbody>
<tr>
<td><strong>Factor</strong></td>
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<td>--------------------------</td>
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<tr>
<td>Rotate anthelmintics</td>
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<tr>
<td>Yes</td>
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<tr>
<td>No</td>
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<tr>
<td>Parasite testing policy</td>
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<td>Never tested</td>
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<td>Routinely tested</td>
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<td>Test in response to a problem</td>
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\*Within each column, values with different superscripts are significantly (\(P < 0.05\)) different.
operation level and found not to be significantly related to colic included geographic region, primary water sources in the summer, type of dried forage fed, type grain-concentrate fed, type of pasture, pasture quality (as evaluated by the field staff), percentage of pasture with edible vegetation (as evaluated by the field staff), access to dirt while eating, frequency of feeding forage, access to salt, health care implementation, gender of the person making health care decisions on the operation, relationship of the person implementing the equine health care on the operation to the owner of the operation, stacking density; frequency of use of anthelmintics, mean strongyle egg count in feces, primary use of the horse, and type of flooring in the stalls.

**Discussion**

It is important to realize that the population of horses being observed and the type of monitoring for colic could potentially influence the conclusions of an epidemiologic study of colic and its associated risk factors. This study was designed to generate national estimates of the incidence of colic among different types of operations and different types of horses. In the stratified design used in this study, each unit in the population did not have the same probability of inclusion in the sample. Weighting was required to account for the varying probability of operations being selected for the sample. If weighting had not been performed, the national estimates would have been biased.1 In a probability-based survey, substantial bias may be introduced into estimates if nonrespondents differ substantially from respondents. In this study, weighting of data adjusted for nonresponse was based on matching of available information.

The reported incidence of colic from other studies varies from 3.5 to 26 colics/100 horses per year.1,4,6,8 Our estimate of the incidence of colic was 4.2 colics/100 horses per year, which was similar to that reported in another study8 that also included large and small equine operations. Studies that reported a higher incidence of colic (e.g., 10.6 colics/100 horses per year) included a limited number of farms and only farms with a large number of horses.1

Breed of horse has been identified as a risk factor for colic in some studies and not in others. If owners of certain breeds were more observant for colic or if some breeds were managed differently than others, a particular breed could appear more predisposed to colic than others. In 1 study,7 Standardbreds were significantly more numerous in a group of horses with colic than in the reference population; however, confounders such as feeding practices, use of horse, and preventative health care were not taken into account, and the difference was small. In 2 studies, Arabians were at higher risk for colic.1,7 In the NAHMS Equine '98 Study reported here, Thoroughbreds were more likely to develop colic, which was similar to results of the study by Tinker et al.1 Many Thoroughbreds reside at racetracks and may be different in some ways from those that reside off racetracks; therefore, Thoroughbreds in our colic study, which did not include horses at racetracks, may not have been representative of the breed as a whole in the United States. Although breed distribution was significantly different by region,11 region was not associated with incidence of colic in our study. It was not possible to analyze the data at the individual horse level for confounders such as diet or level of observation of the caretaker (more likely to observe and report colic), so it is possible that factors other than breed accounted for the finding that Thoroughbreds appeared to be more likely to develop colic. Because of the scope of our study, the increased incidence of colic in Thoroughbreds is likely an accurate observation but may potentially be attributable to factors other than breed.

Age of horse was also a risk factor for colic. Foals that were < 6 months old were at less risk for colic than horses that were 6 months old or older. This finding was similar to that of another study1 in which horses that were < 2 years old were at lower risk of colic than horses that were 2 to 10 years old. Similarly, older age was associated with increased risk for colic in a second study.1 Specific types of colic seem to be more prevalent in certain age groups, such as intussusception in foals, spasmodic colic in adult horses, and strangulating lipo- ma in aged horses.11 Again, it is important to consider that multiple factors such as diet, time exposed to parasites, or changes in intestinal function with aging may explain reduced colic risk in foals.

Sex has not been associated with risk of colic in general, although it is well recognized that specific causes of colic are sex-related, such as scrotal hernia in sexually intact males.4,6-10 In 1 study,8 mares that foaled during the study had increased incidence of colic. Sex was not found to be associated with the overall incidence of colic in our study.

The percentage of colics that resulted in surgery (1.4%) was lower in this study than in 2 previous studies.14 Cohen et al reported that 6.3% of 821 colics for which horses were evaluated by veterinarians in Texas resulted in surgery. Because all horses with colic in that study were evaluated by a veterinarian, it is reasonable to expect these events to be more serious and, therefore, more likely to require surgery. Tinker et al1 reported that 3.8% of 104 colics in horses on farms with ≥ 20 horses resulted in surgery. However, that study was based on data from a limited number of farms in 2 counties in Virginia and Maryland.

Case fatality rate in our study (11.0%) was similar to that of another study, whereas Tinker et al1 reported a case fatality rate of 6.7%. In a university hospital population, there was a 39.6% case fatality rate for horses with colic.12 University hospitals, as tertiary care facilities, likely treat a large proportion of horses with severe colic, which may result in a higher case fatality rate. In phase 1 of the NAHMS Equine '98 Study, causes of equine mortality in 1997 were determined, and colic was second only to old age as the cause of death in equids that were 30 days old or older.13 Case fatality rate, the high mean cost of care for horses that required surgery, and the number of horses that required surgery contributed to the high cost of colic, which was estimated at $115.3 million in 1998. In comparison, the economic cost of lameness as estimated by NAHMS was $678 million to $1.1 billion, and the cost of equine protozoal myeloencephalitis was $27 million.15
Risk factors for colic in other studies were determined from direct reports from veterinarians or by profiling individual horses. Operation-level management practices recorded in our study were applicable to most of the horses and may not have been applicable to a specific horse that had colic. For example, use of anthelmintics or diet of an individual horse on an operation may have been different than that for most of the horses on the operation. This may have contributed to the low number of operation-level risk factors for colic events that were identified in our study.

The practice of rotating anthelmintics and the parasite testing policy were counterintuitively associated with increased risk of colic; this finding may represent changes in management practices as a result of previous colics rather than factors that truly predispose horses to colic.

Available upon request.

Sudaan Software for the Statistical Analysis of Correlated Data, Research Triangle Institute, Research Triangle Park, NC.

References


