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Demographic Characteristics and Prevalence of Elevated Temperature Among Horses Quarantined at the Three Air/Ocean Animal Import Facilities in the United States

USDA-APHIS-VS-CEAH
NRRC Building B, M.S. 2E7
2150 Centre Avenue
Fort Collins, CO 80526-8117
970.494.7000
Email: NAHMS@aphis.usda.gov
http://nahms.aphis.usda.gov
#615.0311

Cover photo courtesy New York Animal Import Center

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Executive Summary

The importation of horses[1] into the United States is regulated by USDA Animal and Plant Health Inspection Service (APHIS) Veterinary Services (VS). Other than those arriving for special events such as the World Equestrian Games (WEG), horses arriving by air or ocean are quarantined at one of three animal import centers: the New York Animal Import Center (NYAIC) in Newburgh, NY; the Miami Animal Import Center (MAIC) in Miami, FL; or the Los Angeles Animal Import Center (LA-AIC)[2] in Los Angeles, CA.

Fever is important in the diagnosis of disease in domestic animals; thus the body temperature of quarantined horses is monitored in order to facilitate prompt treatment interventions if appropriate. Above-normal body temperature can be the result of a true fever (most often due to an infection), inflammation, hyperthermia due to heat stress, drug reactions, allergies, tumors, or other causes. Horse characteristics such as age, breed, and previous experience with air travel, disposition, location in the jet stall, and location of the jet stall in the cargo area also might explain an increased risk for occurrence of elevated body temperature.

Records for 4,720 horses were analyzed for this study[3], which analyzed the demographic characteristics and prevalence of elevated temperature among horses arriving at U.S. animal import centers over a 12-month period. Elevated temperature was defined as at least one occurrence of a temperature greater than 101.5°F. The possible risk factors for having an elevated temperature evaluated in this study were breed, age, gender, quarter of year for arrival, purpose, and region of origin.

Upon arrival to the United States, horses are examined by VS personnel to check documentation and evaluate health status which includes collecting a rectal temperature and blood samples for official testing. Serologic samples are submitted to VS' National Veterinary Services Laboratories to be screened for antibodies to agents that cause four diseases: equine infectious anemia, equine piroplasmosis, dourine, and glanders. Horses must remain in USDA quarantine for a minimum of 42 hours, and must have three nonelevated temperatures recorded for the 24-hour period immediately prior to release in order to complete USDA quarantine. During quarantine, horses are observed for clinical signs of disease and a physical examination is generally performed every 12 hours.

The prevalence of elevated temperatures varied by quarantine center: 12.0 percent for LA-AIC, 11.4 percent for NYAIC, and 6.6 percent for MAIC. Across all centers, young age (less than 4 years) was a risk factor for elevated temperature. It is possible that younger age is a surrogate for lack of experience with air transport and/or susceptibility to transport stress or that normal body temperature for some of these younger animals is above 101.5°F.

The Friesian breed was more likely to have an elevated temperature than the other breed categories. The effect of breed on prevalence of elevated temperatures varied across centers for breed categories other than Friesians. No Friesians were imported through MAIC.

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[1] For this report, the term "horse" will be used to refer to horses and other equids.
[2] LA-AIC import quarantine is a privately owned facility (Jet Pets, Inc.) with oversight by USDA–APHIS–VS.
[3] Calendar year (CY) 2008 records for NYAIC and MAIC; CY 2009 records for LA-AIC.

The majority of elevated temperatures occurred within 12 hours of arrival to an import center, typically as a single occurrence, and usually as a low-grade elevation (i.e., greater than 101.5°F but less than 102.5°F).

NYAIC*:* The NYAIC received horses via one of three airports: JFK in Jamaica, NY, Newark in Newark, NJ, and Stewart at Newburgh/New Windsor, NY. A majority of the horses received at the NYAIC embarked from the Netherlands. Of the 2,062 horses that arrived in 2008, 236 (11.4 percent) had at least 1 elevated temperature from the time of arrival at NYAIC until release. Of the horses with an elevated temperature, 26.3 percent had more than one elevated temperature and 34.3 percent had a temperature greater than 102.5°F. Of the breed categories, the Friesian group had the highest prevalence of elevated temperature, and the Thoroughbred/other hot-blooded group had the lowest prevalence.

MAIC: 1,600 horses were imported through MAIC in 2008, nearly three-fourths of which came from Argentina or the Netherlands. There were 106 horses (6.6 percent) that had 1 or more elevated temperatures from the time of arrival until release from quarantine; a vast majority of these elevated temperatures occurred on day 1 of quarantine. Of the horses with an elevated temperature, 13.2 percent had a temperature of 102.5°F or higher. Warmbloods had a significantly lower prevalence of elevated temperature than did Thoroughbred/other hot-blooded breed and the "other breed" category. The risk factors for elevation in temperature for horses at MAIC were age, as seen across all centers, and gender. Intact males were more likely to have one or more elevated temperatures than were females or castrated males.

LA-AIC: Records of the 1,058 horses imported through LA-AIC in 2009 were used to generate this report. Horses originated from 21 countries, with a majority coming from Europe and the next largest group originating from Australia/New Zealand. There were 127 horses (12 percent) that had at least 1 elevated temperature; of those, 15 percent had a temperature of 102.5°F or higher. The highest percentage of horses arrived between October and December; this quarter of year also had a significantly higher prevalence of elevated temperature. The effect of breed on prevalence on elevated temperature varied by region of origin; a Friesian from Europe was 3.8 times more likely to have an elevated temperature than a Thoroughbred/other hot-blooded breed from Europe.

This study evaluating prevalence of an elevated body temperature appears to represent the largest analysis of records for horses shipped by air. Analysis of these data identified several factors associated with risk of an elevation in temperature. However, factors beyond those available in the existing data, such as conditions prior to embarkation, space in the jet stalls, location in the plane, and duration of transit, likely also influenced the occurrence of elevated temperature of shipped horses. Further work is necessary to determine more definitively the cause of elevated temperatures among imported horses.

Introduction

The importation of horses into the United States is regulated by USDA Animal and Plant Health Inspection Service (APHIS) Veterinary Services (VS). Three animal import centers are used to quarantine horses arriving by air or ocean. These centers are the New York Animal Import Center (NYAIC) in Newburgh, NY; the Miami Animal Import Center (MAIC) in Miami, FL; and the Los Angeles Animal Import Center (LA-AIC) in Los Angeles, CA. This report describes the characteristics of equine imports coming through the air/ocean ports and quarantined in one of these three animal import centers over a 12-month period. The report also describes the prevalence of and potential risk factors for elevation of body temperature (greater than 101.5°F[4]) among these horses.

Canadian horses imported for temporary stay (less than 30 days) in the United States are not required to be quarantined. Horses from Mexico are typically quarantined in Mexico prior to arrival in the United States. Other horses from countries that have screwworm or Venezuelan equine encephalitis are quarantined for a minimum of 7 days, and those from countries with African horse sickness are quarantined for a minimum of 60 days. Horses not falling into the 7- or 60-day categories are required to remain under USDA–APHIS–VS quarantine for at least 42 hours from time of arrival at the quarantine facility, and until the test results are determined to be negative, these horses have been termed "3-day horses" because historically it took 3 days for the import test results to be obtained. Certain horses arriving to the United States from regions with contagious equine metritis (CEM) are also required to undergo further quarantine and testing at State-operated quarantine facilities after completing import requirements at Federal facilities.

Upon arrival at a U.S. port, each horse is examined to ensure that the characteristics of that horse match those on the permit issued by USDA–APHIS–VS and the documents from the exporting country. As part of the quarantine process each horse is examined for ticks and treated with an acaricide. The horse's rectal temperature is obtained as part of the initial inspection at each quarantine center.

Horses arriving at a Federal quarantine center undergo regulatory testing for specified disease agents through collection of blood that is shipped for official testing to the National Veterinary Services Laboratories (NVSL) in Ames, IA. Serologic tests are performed to screen for antibodies to the agents that cause four diseases: equine infectious anemia (EIA), equine piroplasmosis (EP*)*, dourine, and glanders. In addition to serologic testing, horses are observed during quarantine for clinical signs of disease. To be eligible for release from USDA quarantine, horses must be clinically healthy and have three nonelevated temperatures recorded for the 24-hour period immediately prior to release. If anti-inflammatory or fever-reducing drugs, such as phenylbutazone or flunixin meglumine, are administered, a 24-hour washout period must elapse from the time of the last given dose before the first of the three required nonelevated temperatures can be established.

The objective of this study was to determine the annual prevalence of elevated temperatures for horses at each import center, determine risk factors for elevated temperatures, and compare prevalence of elevated temperatures across centers.

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[4] This temperature cutoff was chosen because USDA considers temperatures over 101.5°F to be abnormal according to a letter distributed to brokers on December 24, 2008, from the Chief Veterinary Officer, Dr. John Clifford.

A. Data Retrieval Methods

Individual records for horses imported during a 12-month period were retrieved from each center. The retrieval process varied among centers depending on the type and availability of source documents (e.g., electronic or paper) in each center.

The study period for NYAIC and MAIC was calendar year (CY) 2008. NYAIC and MAIC data included at least four temperatures taken from each horse prior to release from quarantine. Data for CY 2009 were used for LA-AIC because prior to that time the records included only entry and release body temperature recordings. Starting in January 2009, the LA-AIC records included at least four temperatures taken prior to release from quarantine.

NYAIC and MAIC are operated by USDA–APHIS–VS. The LA-AIC import quarantine is a privately operated facility (Jet Pets, Inc.) with oversight by USDA–APHIS–VS; official records are maintained in the Los Angeles USDA–APHIS–VS office. Use of the term “LA-AIC” in this report refers to both Jet Pets and to the USDA–APHIS–VS Los Angeles office that oversees import and quarantine of horses through Los Angeles.

Data about horses quarantined at NYAIC were available only from hard-copy records. Data about horses quarantined at MAIC were available primarily from the Animal Quarantine and Examination System (AQES) electronic database; hard-copy records were reviewed for horses that had elevated temperatures to determine the treatment and diagnostic tests performed on these horses. Data (age, breed, gender, country of origin, date of arrival, and date of release) about horses quarantined at LA-AIC were available from a USDA–APHIS–VS electronic database (Import Tracking System); temperature and treatment information were retrieved from hard-copy records.

B. Analytical Methods

Horses that had a temperature greater than 101.5°F any time from arrival to release from quarantine were categorized as having had an elevated temperature. Univariable logistic models were constructed to evaluate the effect of risk factors on prevalence of elevated temperatures within each center. A p-value of less than 0.05 was considered significant.

Within each center, multivariable logistic models were constructed with risk factors as independent factors. Backward elimination was used to eliminate factors with a p-value greater than 0.05. Interactions between the factors were examined and, if significant, were included in the final models.

A univariable logistic model was used to initially compare the prevalence of elevated temperatures between centers with p-value of less than 0.05 considered significant. A multivariable model was constructed with center, breed, age, and gender categories; region of origin and interaction with center and the other factors were included. The initial results of the multivariable model were used to determine the significance of the interactions. Separate models were to be constructed for each center if there was an interaction by center.

An initial three-center, multivariable logistic model with center, breed, age, gender; region of origin, and the four interactions between center and the other factors showed that all interactions with center were significant, meaning that the effect of all

of these factors varies by center. Separate models were therefore constructed for each center.

C. New York Animal Import Center (NYAIC), Newburgh, NY

Demographic and temperature data were analyzed from 2,062 records (1 record per horse) available from NYAIC for CY 2008.

Horses quarantined at NYAIC arrive through one of three airports: John F Kennedy (JFK), Newark (EWR), or Stewart (SWF). Upon arrival at the airport, the horses are examined and blood is collected for shipment to NVSL for regulatory testing. The horses are then taken by various forms of ground transportation (trailer, horse box, semitrailer) to NYAIC.

The standard operating procedure at NYAIC is to re-examine horses upon arrival at the center and determine initial rectal temperatures. The majority of horses arrive at NYAIC in late evening so the initial rectal temperature recording for most horses in this center was taken after 11:00 p.m. on day 1; per the director of this center, even if it was after midnight when the first temperature reading was obtained, the temperature would be recorded as PM for day 1. Horses are examined twice daily until released and temperatures are recorded from these examinations. Temperatures are determined using a glass rectal thermometer.

1. Country of origin, embarkation, and arrival airport

The country of origin was recorded in each horse's file on VS form 17-29 (declaration of importation). The most common countries of origin of horses being imported through NYAIC were Germany (32.4 percent), the Netherlands (22.2 percent), England (17.8 percent), Ireland (5.8 percent), Belgium (4.1 percent), France (3.7 percent), Sweden (2.6 percent), Spain (2.3 percent), and Denmark (1.8 percent). The following countries cumulatively accounted for 7.3 percent of all horses imported through NYAIC in 2008 (each accounting for 1.1 percent or less): Australia, Austria, Bermuda, the Czech Republic, Finland, Hong Kong, Iceland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Poland, Portugal, Saudi Arabia, Slovakia, Switzerland, Thailand, and the United Arab Emirates. Country of origin was categorized into one of four regions of origin (the Americas, Asia/Australia, Europe, and the Middle East) for further analysis. Region of origin was not significantly associated with an elevated temperature ($p=0.21$).

The port of embarkation (the country from which horses departed prior to arriving in the United States) also was recorded on VS form 17-29. The country where the horses depart can be different than the country of origin as horses are grouped from multiple locations to fill a load for a flight. The most common countries of embarkation for horses quarantined at NYAIC were the Netherlands (69.5 percent), England (13.7 percent), Ireland (5.1 percent), France (2.4 percent), and Belgium (2.4 percent). The remaining countries of embarkation (Australia, Bermuda, Germany, Hong Kong, Iceland, Israel, Japan, Korea, Mexico, Saudi Arabia, Spain, Thailand, and the United Arab Emirates) each accounted for less than 2 percent of all horses.

The percentage of horses that had an elevated temperature ranged from 12 percent at JFK to 7 percent at EWR (table 1); however, the difference in prevalence of elevated temperatures by arrival airport was not statistically significant ($p=0.11$). Approximately 80 percent of horses arrived at JFK with the remainder being split roughly between the other two airports. Horses being transported from JFK to NYAIC had to pass through New York City traffic and had the longest and farthest ground

transport. The shortest ground transport was from SWF (located within a few miles of NYAIC).

Table 1. NYAIC arrival airport demographics and prevalence of elevated temperature in horses at NYAIC

	Airport		
	JFK	**EWR**	**SWF**
Distance and approximate driving time* (airport to center)	82.4 mi 1.8 hr	76.1 mi 1.5 hr	2.7 mi 6 min
Number and percentage of horses arriving at this airport	1,676 (81.3%)	209 (10.1%)	177 (8.6%)
Prevalence of elevated temperature at least once	12%	7%	9%

*Depending on traffic.

2. Duration of stay in quarantine

The majority of NYAIC horses (98.8 percent) were in quarantine for 3 days or less. Nine horses (0.4 percent) were in the import center for 7 days. Fifteen horses (0.7 percent) from 1 shipment were in the center for approximately 3 weeks due to a positive test for one of the horses for *Babesia equi*. The 14 horses in contact with the *B. equi*-positive horse were held for retest (all of which were negative) and were released after 21 days in the center; the *B. equi*-positive horse was refused entry into the United States and was in the center for 23 days prior to being returned to the country of origin. One horse (0.1 percent) was in the center for 60 days.

3. Frequency and temporal occurrence of temperature elevation and association with selected risk factors

Rectal temperatures are routinely recorded on the stall card for horses quarantined at NYAIC. Temperature and treatment given, if any, are recorded in an area on the stall card designated with the date and an AM or PM entry. For some horses, more than one rectal temperature was recorded on the stall card for a given evaluation period. For example, if a horse had an elevated temperature during its initial examination, the temperature might have been retaken 1 hour later to determine if it had changed; both entries would be recorded during the same time period on the stall card. When multiple temperatures were recorded within the same time period, a treatment was often given that would have lowered the body temperature between the multiple readings. If more than one rectal temperature was recorded during the same evaluation period, the higher temperature was used for analysis.

Of 2,062 horses, 236 (11.4 percent) had at least 1 elevated temperature from the time of arrival at NYAIC until release. The majority of elevated temperatures occurred during the first 12 hours in the center, with 39 percent of the 236 horses (n=92) having the first occurrence of elevated temperature on day 1 in the PM and 43 percent (n=101) having the first occurrence of elevated temperature on day 2 in the AM (figure 1). Only 15.2 percent of the 236 horses had an elevated temperature that first occurred on the afternoon of day 2 or later. Nearly three-fourths of the 236 horses with an elevated temperature had a single occurrence; 62 horses had more than 1 occurrence (table 2).

Figure 1. Number of horses by day and time (AM or PM) of first occurrence of elevated temperature at NYAIC

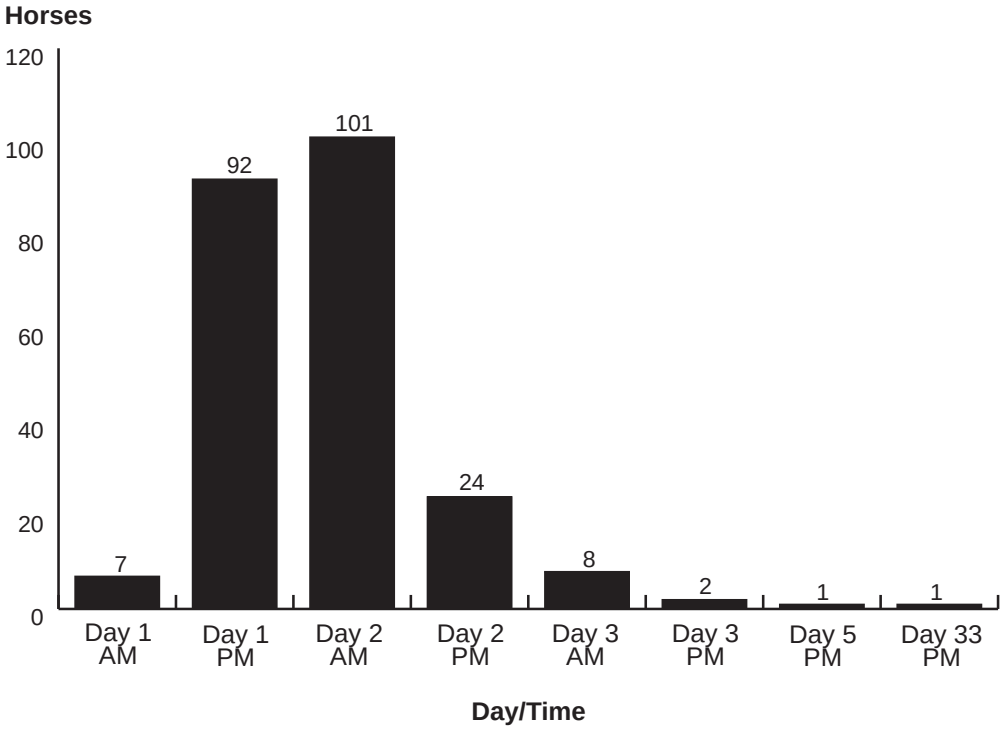
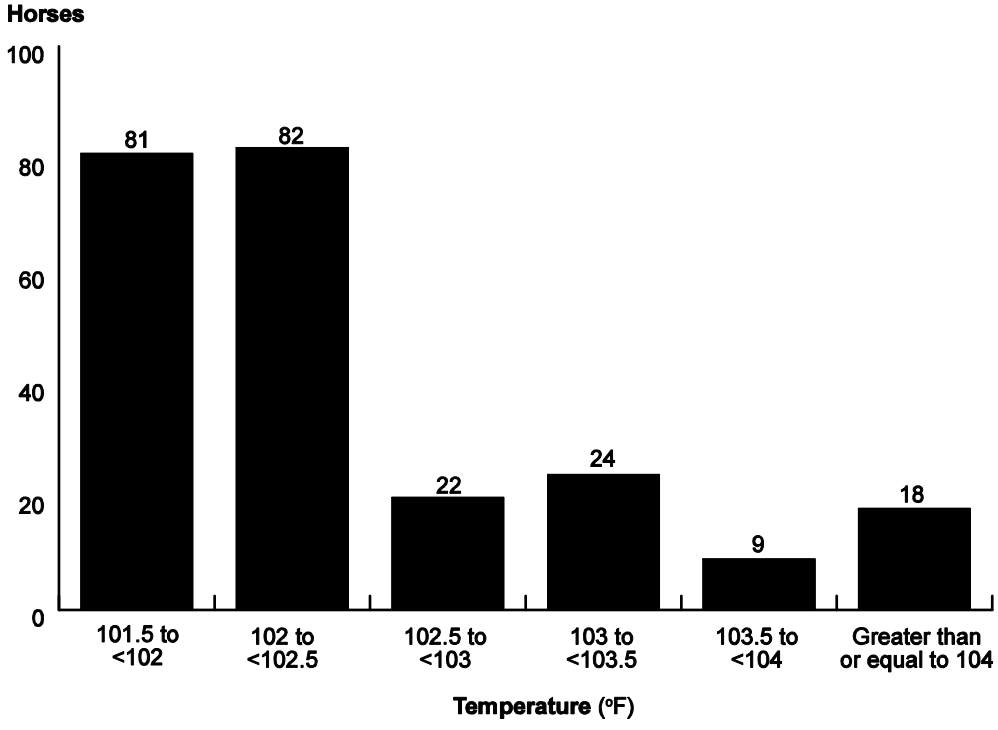


Table 2. Number of horses by frequency of occurrence of an elevated temperature at NYAIC

Number of Occurrences of Temperature Greater than 101.5°F	Number of Horses
1	174
2	48
3	11
4	1
5	2
Any occurrence of greater than 101.5°F rectal temperature	236

Of the 236 horses with an elevated temperature, 81 had elevated temperatures greater than 101.5°F but less than 102°F; 82 had their highest elevated temperature greater than 102°F but less than 102.5°F, 22 had elevated temperatures from 102.5°F to less than 103°F; 24 had a highest temperature 103°F to less than 103.5°F, while 9 had their highest temperature from 103.5°F to less than 104°F and 18 had elevated temperatures equal to or higher than 104°F (figure 2).

Figure 2. Number of horses by category for elevation of rectal temperature at NYAIC



4. Age of horses

Horses 1 year of age or less had the highest prevalence (26.1 percent) of elevated temperatures. Prevalence of elevated temperatures in other age categories was between 10 and 11 percent (table 3). There is a statistical difference between prevalence of an elevated temperature by age category ($p<0.0001$).

Table 3. Number and percentage of horses*at NYAIC by age and percentage with elevated temperature by age

	Age (years)				
	1 or Younger	**2–4**	**5–9**	**10 or Older**	**Total**
Number and percentage of imported horses by age	130 (6.3%)	612 (29.7%)	1,041 (50.6%)	275 (13.4%)	2,058* (100%)
Percentage of elevated temperature by age	26.1%	10.0%	10.9%	10.2%	11.5%

*Ages of four horses were unknown.

5. Gender
Intact males had a 15.9 percent prevalence of elevated temperature, higher than that for females or castrated males (10.3 and 11.3 percent, respectively); however, this difference was not statistically significant. Of the 2,060 horses for which gender data were available (gender not specified for 2 horses), 36.3 percent were females, 11.0 percent were intact males, and 52.7 percent were castrated males. Fourteen horses were noted on the stall cards as having been recently castrated.

6. Purpose of horses
On the VS form 17-30 (quarantine release), the purpose of the horse was recorded as competition, breeding, commercial use, or pleasure or other use. Competition was the purpose listed for the majority of horses (68.7 percent). The remaining horses were imported for breeding (28.6 percent), commercial use (2 percent), and pleasure or other use (less than 1 percent). Some records listed pleasure or other use as a purpose on one form in the record while competition was listed on another form in the record. When this occurred, competition was the purpose used for analysis.

The highest prevalence (24 percent) of elevated temperature was in horses for commercial use. Approximately 12 percent of competition horses and 10 percent of breeding horses had elevated temperatures. No horses with a reported use of pleasure or other had an elevated temperature. There was a significant difference in occurrence of elevated temperature by use ($p<0.04$).

7. Time of year
The highest percentage of horses were imported from October through December (31.4 percent) and the lowest percentage from January through March (19.2 percent). There was no significant difference in the prevalence of horses with an elevated temperature associated with quarter of the year (January–March, April–June, July–September, October–December).

8. Breed
The 41 recorded breeds were collapsed into 4 categories for analysis (table 4). The prevalence of an elevated temperature was significantly different by breed. Friesians had the highest prevalence of elevated temperatures; Thoroughbred and other hot-blooded breeds had the lowest prevalence.

Table 4. Number and percentage of horses at NYAIC by breed, and percentage with an elevated temperature by breed

	Breed				
	Friesians	Thorough-bred and Other Hot-blooded Breeds[1]	Warm-bloods[2]	Other[3]	Total
Number and percentage of all imports	51 (2.5%)	464 (22.5%)	1,335 (64.7%)	212 (10.3%)	2,062 (100%)
Percentage of horses with elevated temperature	19.6%	6.7%	12.4%	13.7%	11.4%

[1]Thoroughbred and other hot-blooded breeds included Thoroughbreds, Thoroughbred cross, Arabian, Arabian cross, American Saddlebred, and Morgan.
[2]Warmbloods included Warmblood, Trakehner, Westphalian, Oldenburg, Newforest, Lusitano, Holsteiner, Hanovarian, Haflinger, Dutch Warmblood, and Anglo/EU).
[3]Other breeds included Shetland, New Fjord, Welsh, Paso Fino, Hackney, Cleveland pony, Icelandic, Andalusian, Gypsy Cob, Pure Spanish, Selle Francais, Standardbred, Shire, Clydesdale, Quarter Horse, Paint, Appaloosa, other known and nondesignated breeds.

9. Occurrence of elevated temperature by arrival group at NYAIC

Horses that arrive on the same flight are considered a group or lot and are housed in the same barn at NYAIC. There was a total of 332 arrival groups based on arrival date and barn number data. Of these 332 arrival groups, 140 groups had 1 or more horses with an elevated temperature. Fifty-nine groups had 2 or more horses with an elevated temperature at some point during the quarantine. The size of the groups ranged from 1 to 44 horses and the number of horses with elevated temperature within a group ranged from 1 to 6. Of the shipments without young horses (horses 1 year or less), 36.2 percent had one or more horses with an elevated temperature; however, 67.2 percent of shipments with young horses had one or more horses with an elevated temperature. A significant difference also was observed if Friesians were in a shipment; 39.5 percent of shipments without Friesians had one horse or more with an elevated temperature, whereas 71.4 percent of shipments with Friesians had one horse or more with an elevated temperature.

10. Determination of association of elevated temperature with potential risk factors

A multiple logistic (multivariable) analysis was performed utilizing data from 2,025 records. Records with data missing for any of the variables were eliminated from this analysis. Variables included in the initial model were breed, age, gender, arrival airport, quarter of the year, purpose, and region of origin. A backward stepwise elimination of variables with $p>0.05$ was performed and the only variables remaining in the model were age and breed.

Because an age and breed interaction was detected, we examined the effect of breed within age category (table 5). In the 2-to-4-year age group, there was a significant difference between Warmbloods and Friesians, with Friesians being three times more likely to have an elevated temperature than Warmbloods. In contrast, Thoroughbreds and other hot-blooded breeds in the 2-to-4-year age group were less likely to have a temperature elevation than were Warmbloods. In the 5-to-9-year age group, significantly more Warmbloods had an elevated temperature than did horses of other breeds and Thoroughbred/other hot-blooded breed horses.

Table 5. Odds ratios and 95-percent confidence intervals for elevation in temperature for comparison of breed within age categories at NYAIC

	Age (years)			
Comparison	**1 or Younger**	**2–4**	**5–9**	**10 or Older**
WB[1] vs Friesian	2.3 (0.3, 15.5)	3.0 (1.1, 8.1)	0.7 (0.2, 3.0)	—[4]
WB vs TB/HB[2]	1.1 (0.4, 3.3)	0.4 (0.2, 0.9)	0.4 (0.2, 0.8)	0.5 (0.1, 1.7)
WB vs other[3]	1.4 (0.5, 3.5)	1.5 (0.7, 3.5)	0.3 (0.1, 0.9)	1.0 (0.3, 3.5)
Overall p-value	0.82	0.003	0.014	0.72

[1]Warmbloods (WB) included Warmblood, Trakehner, Westphalian, Oldenburg, Newforest, Lusitano, Holsteiner, Hanovarian, Haflinger, Dutch Warmblood, and Anglo/EU).
[2]Thoroughbred and other hot-blooded breeds (TB/HB) included Thoroughbreds, Thoroughbred cross, Arabian, Arabian cross, American Saddlebred, and Morgan.
[3]Other breeds included Shetland, New Fjord, Welsh, Paso Fino, Hackney, Cleveland pony, Icelandic, Andalusian, Gypsy Cob, Pure Spanish, Selle Francais, Standardbred, Shire, Clydesdale, Quarter horse, Paint, Appaloosa, other known and nondesignated breeds.
[4]This cell was not estimable because there were only two horses.

An analysis of variance model for time at first occurrence of an elevated temperature was created to investigate associations of potential risk factors with the time when horses first developed an elevated temperature during quarantine. Variables in this model included age, breed, gender, region of origin, quarter of the year, arrival airport, and reported purpose. Only age remained in the final model when a stepwise elimination of variables with $p>0.05$ was used. The oldest horses (>10 years) developed their first elevated temperatures later than did younger horses.

11. Complete blood cell counts, treatment, and trembling/shaking

A complete blood count (CBC) was performed in the NYAIC in-house laboratory on samples from 143 of 2,062 horses (6.9 percent). Of the horses for which one or more CBCs were performed, nearly 95 percent had elevated temperatures. Of the 2,062 horses, 139 (6.7 percent) were treated at least once with a nonsteroidal anti-inflammatory drug (NSAID), most commonly phenylbutazone. Nearly 92 percent of horses treated with an NSAID had elevated temperatures.

Twenty-two horses (1.1 percent) received an antimicrobial drug (AMD) at least once; 18 of these 22 horses (81.8 percent) were horses that had elevated temperatures. The most commonly administered AMD was trimethoprim sulfa, followed by ceftiofur.

Because the NSAIDs and/or AMDs were being given to treat a horse that had an elevated temperature rather than being causally associated with induction of an elevated temperature, these variables were not included in any of the models used to describe risk factors for elevation in body temperature.

Trembling or shaking was noted on the stall cards for 14 horses, 9 of which had increased temperatures. The veterinarians at NYAIC indicated that this appeared to be a transport-associated myositis or stress response. Trembling also could be due to impending fever, cold ambient temperature, or fear.

D. Miami Animal Import Center (MAIC)

Data analysis was performed on 1,600 records (1 record per horse) contained in the AQES electronic database used by MAIC to record specific animal information and examination findings during quarantine. Horses arriving at the Miami airport are transported a short distance to the quarantine facility which is colocated on the airport grounds. The horse's initial temperature is taken when the horse is in its stall in the quarantine facility. As of January 2008, all rectal temperatures were taken using digital thermometers. In this facility, each horse is separated from other horses by residing in its own dedicated stall with a separate handling and air exchange system.

1. Country of origin and arrival airport
Nearly three-fourths of the horses (73.8 percent) imported through MAIC in 2008 came from Argentina or the Netherlands (40.1 and 33.7 percent, respectively). All horses arrived at the Miami International Airport.

2. Duration of stay in quarantine
The duration of stay (in days) was calculated based on the actual arrival date and date of release from MAIC. Slightly more than 37 percent of horses were in MAIC for 3 days or less and 60 percent were in MAIC for 4 to 7 days (table 6). No horses were at MAIC longer than 14 days in 2008.

Table 6. Number and percentage of horses, by number of days in MAIC

Number of Days	Number of Horses	Percent Horses
2	19	1.2
3	576	36.0
4	10	0.6
5	3	0.2
6	205	12.8
7	743	46.4
8	24	1.5
10	3	0.2
13	1	0.1
14	16	1.0
Total	1,600	100

3. Frequency and temporal occurrence of temperature elevation and association with selected risk factors
For analysis, country of origin was collapsed into two regional categories: Mexico/Central America/South America and Europe. Eleven horses from Australia and Malaysia, none of which had elevated temperatures, were excluded from the analysis as there were not enough animals to justify creating a third region (table 7). Prevalence of an elevated temperature was more than twice as high for horses originating in the Mexico/Central America/South America region as those originating from Europe (p=0.0003).

Table 7. Number and percentage of horses at MAIC by region of origin and number and percentage of horses with elevated temperature by region of origin

Region of Origin	Number of Horses (percent)	Number of Horses with Elevated Temperature (percent)
Mexico/Central America/South America[1]	993 (62.5)	83 (8.4)
Europe[2]	596 (37.5)	23 (3.9)
Total[3]	1,589 (100.0)	

[1]Argentina, Brazil, Colombia, Chile, Peru, Venezuela, Dominican Republic, Ecuador, Cayman Islands, Uruguay, Costa Rica, Mexico, Panama, El Salvador, Guatemala, Turks and Caicos Islands, Bahamas.
[2]The Netherlands, Belgium, United Kingdom, Denmark, France, Germany.
[3]Australia and Malaysia had 11 horses not included in the 2 defined regions—too few to create a separate category.

Of the 1,600 horses in quarantine at MAIC in 2008, 106 (6.6 percent) had 1 or more elevated temperatures from the time of arrival until release from quarantine. The vast majority of elevated temperatures (94.3 percent) occurred on day 1 of quarantine (table 8).

Table 8. Time and day of first occurrence of first temperature elevation at MAIC

Period	Frequency	Percent
Day 1 AM	56	52.9
Day 1 PM	44	41.6
Day 2 AM	1	0.9
Day 2 PM	2	1.9
Day 3 AM	1	0.9
Day 4 AM	1	0.9
Day 6 PM	1	0.9
Total	106	100.0

When more than one temperature was recorded for the same time period (AM or PM) the highest recorded temperature was retained for analysis (table 9). The observation period in table 9 reflects 12-hour observation intervals; observation 1 includes arrival. The majority of horses (93.4 percent) had the first occurrence of an elevated temperature at arrival. The majority of horses (88.7 percent) had only one occurrence of an elevated temperature (table 10).

Table 9. Time of occurrence (observation period) of first occurrence of elevated temperature at MAIC

Observation Period*	Number of Horses	Percent Horses
1	99	93.5
2	3	2.9
3	1	0.9
4	1	0.9
7	1	0.9
12	1	0.9
Total	106	100.0

***** Observation period 1 is at arrival and each observation period thereafter represents a subsequent 12-hour period.

Table 10. Number and percentage of horses by number of occurrences of elevated temperatures at MAIC

Number of Times Temperature Greater than 101.5°F per Horse	Number of Horses	Percent Horses
1	94	88.7
2	10	9.4
3	2	1.9
Total	106	100.0

Of the 106 horses with elevated temperatures, 64 (60.4 percent) had their highest temperatures greater than 101.5 to less than 102.0°F. Twenty-eight horses had a highest temperature of 102.0°F to less than 102.5°F; 3 had a highest temperature of 102.5°F to less than 103.0°F; 7 had a highest temperature of 103.0°F to less than 103.5°F; and 4 had a highest temperature of 103.5°F or greater.

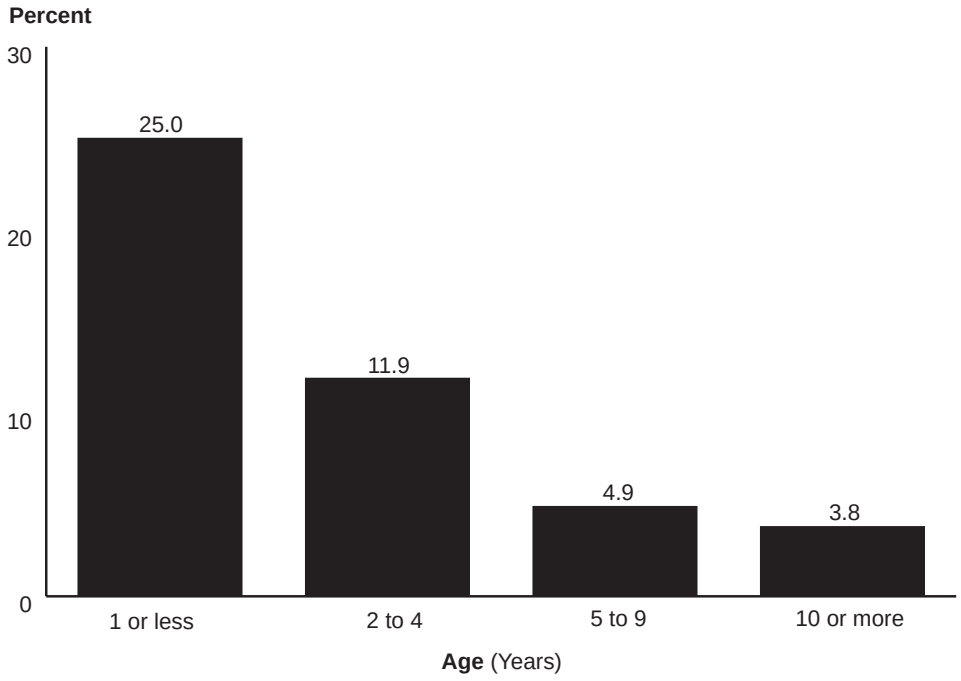
4. Age of horses

To determine risk factors for elevated temperature, four age categories were created (table 11, figure 3). The majority of horses (62.6 percent) were 5 to 9 years of age. There was a significant difference in prevalence of an elevated temperature by age group ($p<0.0001$). The highest prevalence of elevated temperature was in the 1-year-or-less age group (25.0 percent), followed by the 2-to-4-year age group (11.9 percent).

Table 11. Number and percentage of horses at MAIC by age and number and percentage with elevated temperature by age

Age* (years)	**Number of Horses** (percent)	**Number of Horses with Elevated Temperature** (percent)
1 or less	36 (2.3)	9 (25.0)
2 to 4	328 (20.5)	39 (11.9)
5 to 9	1,002 (62.6)	49 (4.9)
10 or more	234 (14.6)	9 (3.8)
Total	1,600 (100.0)	106 (6.6)

Figure 3. Percentage of equids with one or more occurrences of elevated temperature, by age



5. Gender

The highest percentage of horses imported through MAIC were females, followed by castrated males. There was a significant difference by gender for occurrence of elevated temperature, with the highest prevalence in the intact male group ($p<0.0001$) [table 12].

Table 12. Number and percentage of horses at MAIC by gender and number and percentage of horses with elevated temperatures by gender

Gender	Number of Horses (percent)	Number of Horses with Elevated Temperature (percent)
Castrated male (gelding)	555 (34.7)	20 (3.6)
Female	727 (45.4)	46 (6.3)
Intact male	318 (19.9)	40 (12.6)
Total	1,600 (100.0)	106 (6.6)

6. Purpose of horses

Four horse use purpose categories were created for analysis: breeding, commercial, competition, and other use. Nearly 82 percent of horses were imported for competition. There was no significant difference in prevalence of an elevated temperature by purpose of importation (p=0.15) [table 13].

Table 13. Number and percentage of horses at MAIC by purpose and number and percentage of horses with elevated temperatures by purpose

Purpose	Number of Horses (percent)	Number of Horses with Elevated Temperature (percent)
Breeding	80 (5.0)	8 (10.0)
Commercial	38 (2.4)	1 (2.6)
Competition	1,301 (81.3)	90 (6.9)
Other*	181 (11.3)	7 (3.9)
Total	1,600 (100.0)	106 (6.6)

*Other included pet, purebred, and transient.

7. Time of year

Arrival dates were categorized into quarter of the year for analysis. The highest percentage of horses (37.2 percent) arrived in the first quarter (January–March) and the lowest percentage (10.7 percent) arrived in the third quarter (July–September) [table 14]. There was no significant difference in prevalence of horses with elevated temperature by quarter of the year (p=0.43).

Table 14. Number and percentage of horses at MAIC by quarter of the year and number and percentage of horses with an elevated temperature by quarter of the year

Quarter	Number of Horses (percent)	Number of Horses with Elevated Temperature (percent)
1 (January–March)	596 (37.2)	37 (6.2)
2 (April–June)	398 (24.9)	33 (8.3)
3 (July–September)	171 (10.7)	12 (7.0)
4 (October–December)	435 (27.2)	24 (5.5)
Total	1,600 (100.0)	106 (6.6)

8. Breed

Horses were grouped into one of three breed categories for analysis: Thoroughbred and other hot-blooded breeds, Warmbloods, and "other." There was a significant difference in prevalence of horses with elevated temperature by breed (p=0.004); Warmbloods had the lowest prevalence (table 15).

Table 15. Number and percentage of horses at MAIC by breed and number and percentage of horses with an elevated temperature by breed

Breed*	Number of Horses (percent)	Number of Horses with Elevated Temperature (percent)
Thoroughbred or other hot-blood	593 (37.1)	47 (7.9)
Warmblood	586 (36.6)	21 (3.6)
Other	421 (26.3)	38 (9.0)
Total	1,600 (100.0)	106 (6.6)

*Thoroughbred or other hot-blooded breeds: Thoroughbred, American Saddlebred, Arabian, polo pony.
Warmblood: Warmblood, Hanoverian, Holsteiner, Westphalian.
Other: Andalusian, Appaloosa, French Saddle Horse, mule, not specified, other, Paint, Paso Fino, pony, Quarter Horse.

9. Determination of association of elevated temperature with potential risk factors

A multiple logistic regression model included the categories for breed, age, gender, quarter of year, purpose, and region of origin. After a backward elimination (p=0.05), two variables remained in the final model: age (p<0.0001) and gender (p=0.0016). There was no interaction between age and gender. Based on the logistic model, horses 1 year or less were more likely than horses of any other age to have one or more occurrences of an elevated temperature; intact males were more likely than females or castrated males (geldings) to have one or more occurrences of an elevated temperature (table 16).

Table 16. Odds ratio and 95-percent confidence interval by age and gender, for a horse at MAIC having an elevated temperature

	Odds Ratio	95-percent Confidence Interval
Age (years)		
1 or less	Reference	
2 to 4	0.47	0.21–1.09
5 to 9	0.21	0.09–0.48
10 or more	0.18	0.06–0.49
Gender		
Castrated male (gelding)	0.35	0.20–0.63
Female	0.59	0.37–0.94
Intact male	Reference	

Analysis of variance model for time of first occurrence of an elevated temperature showed that none of the risk factors was significantly associated with time at which the first elevation in temperature occurred, probably because the vast majority of horses (99/106, 93.4 percent) had their first high temperatures at arrival.

10. Complete blood cell counts (CBCs) and treatment
Some information was not recorded in the electronic database so hard-copy records of horses with elevated temperatures were requested to obtain information about treatments given and diagnostic tests performed for these horses. Stall cards were not available for 13 of the 106 horses with elevated temperatures. The following description of treatments and diagnostic tests refers to the 93 horses with elevated temperatures for which the stall card and other hard-copy records were provided.

Three of the 93 horses had 1 or more CBCs performed. Ten horses were treated at least once with an NSAID—4 with flunixin meglumine, 5 with phenylbutazone, and 1 with dipyrone. Six horses were treated at least once with an AMD or a combination of AMDs—four received oxytetracycline, one received sulfadimethoxine, two received gentamicin/penicillin (one of these received metronidazole as well), and one horse received gentamicin, ceftiofur, and metronidazole. Other treatments given (albeit infrequently) included application of ointment to wounds, bandaging of limbs, a diuretic drug, sedation, an immunostimulant, gastrointestinal motility drug, and electrolytes. One horse died and necropsy photographs were included in the record. The cause of death, based on lesions visible in the photographs, appeared to be an intestinal problem resulting in peritonitis.

E. Los Angeles, CA, Animal Import Center (LA-AIC)

1. Country of origin
The 1,058 horses imported through the Los Angeles airport (LAX) in CY 2009 originated from 21 countries. The largest number of imported horses were from Germany (n=236), the Netherlands (n=208), and the United Kingdom (n=122). A total of 198 imported horses came from Australia (n=101) and New Zealand (n=97). For analysis, the country of origin was collapsed into four regions of origin: Australia/New Zealand, United Arab Emirates [UAE], Europe, and other. Seventy-six percent of

horses originated from Europe; 19 percent originated from Australia/New Zealand. The highest prevalence of elevated temperatures (13.9 percent) occurred among horses originating from Europe, and the lowest prevalence of elevated temperatures (4 percent) occurred in horses originating from Australia/New Zealand.

2. Duration of stay in quarantine
The majority of horses (98.7 percent) were in the quarantine facility for 42 hours to 3 days.

3. Arrival and housing protocol
Horses imported through LAX are met at the airplane by a USDA–APHIS–VS veterinary medical officer (VMO) and personnel from Jet Pets, the private APHIS-approved import quarantine facility located adjacent to LAX. The horses are unloaded from the cargo plane while still in jet stalls and transported to Jet Pets by private transporters contracted to perform this service by the importer or Jet Pets. The horses are unloaded from the air-transport-stable containers at Jet Pets and are inspected at that time by the VMO. The horses are housed together by lot (the group they arrived with) in a given barn. The VMO oversees all rectal temperature recordings upon arrival that are then entered into the horse's official record. Temperatures are taken with a glass thermometer.

4. Frequency and temporal occurrence of temperature elevation; association with potential risk factors

Temperature recording times were coded as 1, 2, 3, or 4: temperature 1 was the arrival temperature recording; numbers 2, 3, and 4 represented subsequent temperatures typically taken at 12-hour intervals while horses were in quarantine. Of the 1,058 horses whose records were used to generate this report, 127 horses (12 percent) had at least 1 elevated temperature. Of the 127 horses with elevated temperatures at Jet Pets, 96 percent had the first occurrence of an elevated temperature at arrival. The majority of horses (92.9 percent) with an elevated temperature had a single occurrence of an elevated temperature. Only nine horses had more than one elevated temperature; six had two elevated temperatures, one had three elevated temperatures, and two had four elevated temperatures.

Of the 127 horses with elevated temperatures, 64 (50.4 percent) had a highest temperature of greater than 101.5°F and less than 102.0°F; 44 had a highest temperature of 102.0°F to less than 102.5°F; 6 had a highest temperature of 102.5°F to less than 103.0°F; 6 had a highest temperature of 103.0°F to less than 103.5°F; and 7 had a highest temperature of 103.5°F or more.

5. Age of horses

The majority of horses at LA-AIC (47.1 percent) were 5 through 9 years old. The highest prevalence of elevated temperatures occurred in horses that were 1 year of age or less (table 17), with a statistical difference between prevalence of an elevated temperature by age ($p<0.0001$). Prevalence of elevated temperatures declined with increasing age.

Table 17. Number and percentage of horses at LA-AIC by age and number and percentage with elevated temperature by age

	Age (years)				
	1 or Younger	**2–4**	**5–9**	**10 or Older**	**Total**
Number and percentage of imported horses by age	64 (6.0%)	267 (25.3%)	497 (47.1%)	228 (21.6%)	1056* (100.0%)
Percentage with elevated temperature	61.0%	17.6%	6.4%	3.9%	12.0%

*Ages of two horses were unknown.

6. Gender

Of the 1,058 horses at LA-AIC, 29.9 percent were females, 25.2 percent were intact males, and 44.9 percent were castrated males. The prevalence of elevated temperatures among females and intact males (17.7 and 16.1 percent, respectively) was higher than that for geldings (6.0 percent); this difference was statistically significant ($p<0.0001$).

7. Purpose of horses

On the VS form 17-29 (declaration of importation), the designation of the purpose of the horse was provided by the importer as either competition, breeding, commercial use, pleasure, or other. The listed purpose for the majority of horses was competition (52.2 percent). The remaining were 4.4 percent for breeding, 27.1 percent for pleasure, and 16.3 percent for other.

The highest prevalence of elevated temperature was in the competition (13.8 percent) and other use (13.4 percent) categories. Prevalence of an elevated temperature in the pleasure horse category was 9.8 percent. None of the horses in the breeding category had an elevated temperature. There was a significant difference in occurrence of elevated temperature by use ($p<0.002$).

8. Time of year

The quarter October–December had the highest percentage of horses (30.4 percent) going through this import center. The percentages of horses in quarantine during the other three quarters were similar, ranging from 21.1 percent in July–September to 26 percent in January–March.

There was a significant difference ($p=0.006$) in the prevalence of horses with elevated temperatures associated with quarter of the year. The highest prevalence of elevated temperatures was October–December (17.1 percent); the lowest prevalence occurred in July–September (8 percent). The higher prevalence of elevated temperatures did not occur during the hottest environmental temperature period.

9. Breed

Four breed categories were created for analysis (table 18). The prevalence of an elevated temperature was significantly different by breed ($p<0.0001$). Friesians had the highest prevalence of elevated temperatures (40.0 percent) and Warmbloods had the lowest prevalence (6.2 percent).

Table 18. Number and percentage of all horses at LA-AIC by breed and percentage with elevated temperature by breed

	Breed				
	Friesian	Thorough-bred and Other Hot-blooded Breeds[1]	Warm-bloods[2]	Other[3]	Total
Number and percentage of all imports	45 (4.2%)	255 (24.1%)	502 (47.5%)	256 (24.2%)	1,058 (100.0%)
Percentage and number of horses with elevated temperature	40.0% (18)	16.9% (43)	6.2% (31)	13.7% (35)	12.0% (127)

[1]Thoroughbred and other hot-blooded breeds included Thoroughbreds, Thoroughbred cross, Arabian, Polo pony, and American Saddlebred.
[2]Warmbloods included Warmblood, Trakehner, Westphalian, Oldenburg, Holsteiner, Hanovarian, Haflinger, and Royal Warmblood Studbook of the Netherlands (KWPN).
[3]Other breeds included Pony, Belgian, Quarter Horse, Hackney, Appaloosa, Palomino, Mule, Welsh, other known and nondesignated breeds.

10. Determination of association of elevated temperature with potential risk factors

Variables included in the initial multivariable logistic model were breed, age, gender, region of origin, quarter of the year, and purpose. A backward stepwise elimination of variables with p>0.05 was performed. Four variables remained in the model: breed (p<0.0001), age (p<0.0001), region of origin (p=0.004), and gender (p=0.03).

The UAE and "other" regions were combined in subsequent analyses because UAE represented only one breed and the other region had two cells with no horses with elevated temperatures (so the models would not converge).

The only interaction included in the final model was between breed and region of origin. This means the effect of breed on elevated temperature varies by region of origin in this center; therefore, we looked at the effect of breed separately within each of the regions of origin. The only breed category represented in all four regions of origin was Thoroughbred and other hot-blooded breeds, so that breed combination was assigned to be the reference group. Friesians from Europe were 3.8 times more likely to have an elevated temperature than were Thoroughbred or other hot-blooded breeds from Europe (table 19). The odds of horses from Australia and New Zealand in the other breed category having an elevated temperature was less than for Thoroughbreds and other hot-blooded breeds.

Table 19. Odds ratios and 95-percent confidence intervals for elevation in temperature for comparison of breed within region of origin for horses at LA-AIC

	Region of Origin		
Breed	**Australia/ New Zealand**	**UAE and Other**	**Europe**
Friesian			3.8 (1.5, 9.1)
Other[1]	0.08 (0.01, 0.65)	4.6 (0.7, 31.6)	1.9 (0.9, 4.0)
Thoroughbred and other hot-blooded breeds[2]	Reference	Reference	Reference
Warmblood[3]	Not estimatable[4]	Not estimatable[4]	0.6 (0.3, 1.1)

[1]Other breeds included Pony, Belgian, Quarter Horse, Hackney, Appaloosa, Palomino, Mule, Welsh, other known and nondesignated breeds.
[2]Thoroughbred and other hot-blooded breeds included Thoroughbreds, Thoroughbred cross, Arabian, Polo pony, and American Saddlebred.
[3]Warmbloods included Warmblood, Trakehner, Westphalian, Oldenburg, Holsteiner, Hanovarian, Haflinger, and Royal Warmblood Studbook of the Netherlands (KWPN).
[4]Not estimatable because none of the Warmbloods from these regions had an elevated temperature.

The effects of age and gender did not vary by region of origin (i.e., there was no interaction); thus the main effects of age and gender were estimated across region of origin. Horses greater than 1 year of age were at reduced risk of an elevated temperature when compared with horses 1 year of age or less (table 20).

The odds of an elevated temperature for females were higher than that for castrated males (table 21). The odds of an elevated temperature for intact males were not significantly higher than for castrated males.

Table 20. Odd ratios (and 95% CI) for an elevation of temperature for horses at LA-AIC, by age

Age (years)	**Odds Ratio** (95% confidence interval)
1 or less	Reference
2 to 4	0.22 (0.11, 0.45)
5 to 9	0.09 (0.04, 0.18)
10 and older	0.05 (0.02, 0.13)

Table 21. Odd ratios (and 95% CI) of an elevated temperature for horses at LA-AIC, by gender

Gender	**Odds Ratio** (95% confidence interval)
Castrated male	Reference
Female	2.05 (1.2–3.6)
Intact male	1.3 (0.7–2.4)

11. Treatments
While in quarantine at LA-AIC, 107 of the 1,058 horses (10.1 percent) received an AMD. Of the horses treated with an AMD, 43 had an elevated temperature. Fifty-six of the 1,058 horses (5.3 percent) received an NSAID while in quarantine. Thirty-five of these 56 horses had an elevated temperature.

F. Prevalence of Elevated Temperature among Imported Horses at APHIS or APHIS-supervised Animal Import Centers (Comparison Among Centers)

Analysis was conducted on 4,720 records from the 3 animal import centers: NYAIC=2,062, MAIC=1,600, and LA-AIC=1,058. The origin of imported horses varied by center. The majority of horses imported through MAIC originated from the Americas; no horses were imported through MAIC from Australia/New Zealand or the Middle East (table 18). The vast majority of horses imported through NYAIC and LA-AIC were from Europe, whereas only about one-third of the imports into MAIC came from this region.

The prevalence of elevated temperature varied by import center: 12.0 percent for LA-AIC, 11.4 percent for NYAIC, and 6.6 percent for MAIC. An initial univariable model with center as the only factor showed that the prevalence of elevated temperature was significantly lower for MAIC than for LA-AIC ($p<0.0001$) or NYAIC ($p<0.0001$) and was not different between LA-AIC and NYAIC ($p=0.6$).

There were clear differences in the types of horses imported into the three centers (table 22). For example, no Friesian horses and a lower percentage of horses 4 years of age or less (22.8 percent) were imported into MAIC compared to the other two centers (LA-AIC=31.4 percent; NYAIC=36.1 percent). Young age was a risk factor for elevated temperature across all three centers. Normal temperatures of yearlings and foals tend to be at the high end of the normal range for adult horses. This is in part thought to be due to the incompletely developed thermoregulatory center in these younger horses and it is thought their normal temperature range can extend to

102.2°F (Rose, 1999). Friesian breed was a risk factor for elevated temperature. The differences in types of horses imported into the centers potentially could explain some of the difference in overall prevalence of elevated temperatures between LA-AIC and NYAIC versus MAIC.

An initial three-center, multivariable model with center, breed, age, gender, region of origin, and the four interactions between center and the other factors showed that all interactions with center were significant, meaning that the effect of all of these factors varied by center. Separate models were therefore constructed for each center.

Several additional models were used to explore the effect of center on the outcome of interest, e.g., prevalence of an elevated temperature at least once at arrival or during quarantine. In one model, the data from NYAIC and LA-AIC were combined and compared to the data from MAIC. In a second model, Friesians and horses 1 year of age or less were excluded from the data across all three centers. In a third model, data for Friesians were omitted and four age categories were collapsed into two age categories (4 years of age or less and 5 years of age or more).

These models demonstrated a persistent interaction of risk factors by center. The prevalence for horses with elevated temperatures was similar for LA-AIC and NYAIC, but higher than that of MAIC (table 22). The higher prevalence of horses with an elevated temperature at LA-AIC than at MAIC was explained in part by the fact that there was a higher percentage of young horses (4 years of age or less) at LA-AIC and the prevalence of elevated temperature among young horses entering LA-AIC was high. The higher prevalence of elevated temperatures in horses at NYAIC than at MAIC was explained in large part by the fact that the prevalence of elevated temperatures among Warmbloods entering NYAIC was much higher than among Warmbloods entering MAIC (12.4 vs. 3.6 percent). The result of combining LA-AIC and NYAIC data was that the higher prevalence of elevated temperatures in Warmbloods in NYAIC was offset by the LA-AIC data, and the higher prevalence of elevated temperatures in young horses (4 years of age or less) in LA-AIC was offset by the lower prevalence of elevated temperatures in Warmbloods entering LA-AIC (6.2 percent). Because the reasons for a difference in prevalence of elevated temperatures varied between NYAIC and MAIC versus LA-AIC and MAIC, combining data from LA-AIC and NYAIC to make conclusions was not considered scientifically defensible.

Table 22. Percentage distribution of horses and prevalence of horses that had elevated temperatures by breed, age, and region of origin, and by center

	Center					
	LA-AIC		MAIC		NYAIC	
	Percent	Elevated Temp Prevalence	Percent	Elevated Temp Prevalence	Percent	Elevated Temp Prevalence
Breed						
Friesian	4.2	40.0	0.0		2.5	19.6
Other breeds	24.2	13.7	26.3	9.0	10.3	13.7
Thoroughbred/ other hot-bloods	24.1	16.9	37.1	7.9	22.5	6.7
Warmblood	47.5	6.2	36.6	3.6	64.7	12.4
Total	100.0		100.0		100.0	
Age (years)						
1 yr or less	6.0	60.9	2.3	25.0	6.3	26.2
2 to 4	25.3	17.6	20.5	11.9	29.8	10.0
5 to 9	47.1	6.4	62.6	5.0	46.1	11.4
10 or more	21.6	4.0	14.6	3.9	17.8	9.0
Total	100.0		100.0		100.0	
Region of Origin						
Australia/NZ	18.7	4.0	0.0		0.7	0.0
Middle East	1.7	11.1	0.0		1.3	11.1
Europe	76.6	13.9	37.5	3.9	95.1	11.8
Americas*	2.2	17.4	62.5	8.4	0.9	0.0
Asia	0.8	0.0	0.0		2.0	4.9
Total	100.0		100.0		100.0	

*Mexico, Central and South America (Argentina, Brazil, Cayman Islands, Chile, Costa Rica, Dominican Republic, Equador, El Salvador, Guatemala, Mexico, Panama, Peru, The Bahamas, Turks and Caicos Islands, Uruguay, and Venezuela).

Evaluation of the results of the three models showed that the difference in prevalence of elevated temperatures across centers could not be fully explained by the variables evaluated in this study. This conclusion comes from the observation that center consistently stays in all models in the presence of the other factors (age, breed, gender, and region of origin). The appropriate step when there is an interaction observed in the models for center is to look at the data from each center separately and not make further comparisons across centers. The reader is thus directed to the three individual center summaries in previous sections of this report.

Several potential factors exist that could alter the risk for horses developing an elevated temperature. Examples of potential factors for which data were not available

are number and duration of transportation episodes a horse experienced prior to and during exportation, space available in the jet stall, location of horse in the cargo transport section of the aircraft, the horse's previous experience with air travel, and compatibility of horses transported in the same lot.

G. Discussion

Horses are transported worldwide for various purposes such as competition, change of ownership, and breeding. Multiple factors can influence the outcome of transport. Transport has been recognized for a long time as being stressful to horses. Potential stressors include isolation from herd mates, forced proximity to unfamiliar or aggressive horses, novel or threatening surroundings, exposure to new pathogens, restraint of normal activity patterns, forced adoption of an abnormal posture, extremes in temperature and humidity, noise, and water and feed deprivation (Friend, 2000). Duration of transport also can affect the outcome of transport (Leadon, personal communication).

Factors that can affect the health of transported horses include the method of confinement, the degree of movement possible while in transit, lack of previous long-distance air travel experience, and environmental changes of temperature, relative humidity, and number of micro-organisms within the inhaled air. All of these factors can add to the transport stress experienced by horses shipped via air (Leadon, 1995). The air temperature and humidity in aircraft have been reported to be higher when the aircraft is stationary during loading, unloading, and refueling stops than when airborne. When an aircraft is airborne, the air flows from the front to the back of the aircraft and is cooler and dryer than air in the plane when it is on the ground (Leadon, 1995). Layouts of the aircraft used to transport horses vary in the amount of space and potential airflow in the area of the jet stalls. This difference could affect the stress and potentially predisposition to airway infection; a prospective study would be needed to objectively determine if this is a risk factor for elevation in body temperature or airway infection.

The practice of tying horses by their halters in transport has been shown to result in the spread of the normal nasopharyngeal flora into the lower respiratory tract, thereby facilitating the development of respiratory infections (Rackyleft and Love, 1989). Horses shipped by air are most frequently loaded into jet stalls for the flight (Leadon, personal communication). Jet stalls are configured to hold from one to three horses. The number of horses per jet stall is determined by the horse's owner and the person contracted to arrange shipment of the horse(s) (Leadon, personal communication). The number of horses in the jet stall (one, two, or three) and the positioning of a chest-high barrier that allows grooms to feed and water horses while in transit affect the degree to which horses can move. Clearance of the horses' airways during transport logically would reduce the risk of airway infection associated with long duration transport, but this cannot occur effectively if the horse cannot lower its head and neck. This lowering of the head allows for clearance of the airway that is impeded when the horses have their heads held in a high position throughout the flight (Leadon, personal communication).

The duration of transit varies based on multiple factors. Horses often arrive at the departure airport 1 to 2 hours before they are loaded into the jet stalls. Ideally, the horses are in the jet stalls waiting to be loaded onto the aircraft 1 to 2 hours prior to the flights scheduled departure time (Leadon, personal communication). After arrival at the airport of destination the horses are loaded onto various means of ground transport for the trip to the import center (Leadon, personal communication). The trip from the airport to the import center can take 3 to 4 hours if going to from JFK or

Newark to NYAIC; even when the ground transport distance from arrival to quarantine is short such as for Miami, LA , and Stewart arrivals, it may take an hour from aircraft arrival to arrival of the horses at the import center (Leadon, personal communication).

Fever is important in the diagnosis of disease in domestic animals; thus the body temperature of quarantined horses is monitored in order to facilitate initiation of prompt treatment interventions, if applicable. Above-normal body temperature can be the result of a true fever (most often due to an infection), inflammation, hyperthermia due to heat stress, drug reactions, allergies, tumors, or other causes. Becker and Wu (2010) described hyperthermia as passive, occurring as a result of heat gain from the environment or lack of heat loss following exercise, while fever is an active mechanism whereby the body raises the thermal set point through a deliberate thermoregulatory strategy. Fever can be in response to factors such as infection, inflammation, drug reactions, and allergies.. Multiple aspects of transportation could be related to an elevated body temperature. These aspects include the duration of air transport; the duration, environmental conditions, and type of ground transport; heat exposure due to elevated environmental temperature and humidity; and exposure to microbes or reactivation of latent infections during transport or while in quarantine. Horse characteristics such as age, breed, previous experience with air travel, disposition, location in the jet stall, and location of the jet stall in the cargo area might explain an increased risk for occurrence of elevated body temperature.

Body temperature is regulated by the hypothalamus. This area of the brain acts as a thermostat to maintain temperature as closely as possible to a normal set-point. The hypothalamus receives input from internal and external thermoreceptors, and it activates physiologic and behavioral activities that influence heat production, heat loss, and heat gain. Hyperthermia refers to any increase in body temperature above the normal range. Fever is a particular form of hyperthermia in which the heat loss and heat gain mechanisms are adjusted to maintain body temperature at a higher hypothalamic set-point; thus, fever is essentially a regulated hyperthermia. In nonfebrile cases of hyperthermia (e.g., heat stroke, exercise-induced hyperthermia, malignant hyperthermia, seizure) body temperature is elevated by abnormal and unregulated heat loss, heat gain, or heat production, and the hypothalamic set-point is not altered. Elevation of the hypothalamic set-point may be initiated by exogenous pyrogens, which include drugs, toxins, and viral or bacterial products (e.g., endotoxin). These pyrogenic stimuli lead to the release of cytokines, termed endogenous pyrogens, from inflammatory cells. Ultimately, locally synthesized prostaglandin E_2 in the hypothalamus is responsible for elevating the set-point, resulting in fever.

There are references in the literature to a psychological stress-induced rise in core temperature (PSRCT) in humans and animals. A review of the literature was conducted to describe the mechanisms and mediators of PSRCT (Oka, 2001). Oka concluded that PSRCT is a true fever with an associated rise in the thermoregulatory set-point. The PSRCT is responsive to NSAID treatment in some situations. Results of animal studies suggest the mechanism for PSRCT is mediated and modulated by classic neurotransmitters such as noradrenaline and 5-hydroxytryptamine, prostaglandins, and neuropeptides (corticotrophin-releasing factor). Further conclusions were that PSRCT is not due to increased locomotor activity during stress, and the magnitude of PSRCT is the same in warm and cold environments (Oka, 2001). Examples of stress-inducing experiments conducted on rats included open-field stress tests (rats are put in an open space in which they feel exposed and vulnerable), handling, and cage change. Cyclooxygenase inhibitors, which are considered to be NSAIDs, attenuate the rise in core body temperature experienced by rats exposed to these stressors. Cyclooxygenase inhibitors also attenuate the

increase in body temperature of pigs caused by physical restraint. It seems possible that some of the elevated temperatures experienced by imported horses upon arrival at the import center, particularly those that resolved without treatment or with a single dose of NSAID, represent a form of PSRCT. Further investigation to rule out other causes of elevated temperatures would be necessary to prove this hypothesis.

Studies to determine the prevalence of elevated body temperature and hyperthermia among horses transported long distances are rare (Kettle, 2007). Results of a 1990 survey of 112 horses transported from England to Australia showed that 7 horses (6.3 percent) had developed respiratory disease (shipping fever) upon arrival in Australia (Leadon, 1990). In a second study carried out for the Hong Kong Jockey Club, 1 of 18 horses shipped into Hong Kong for the International Bowl and Cup in December 1993 developed respiratory disease and all horses had a transient low grade fever at arrival (Leadon and Watkins, 1994).

To examine a large number of horses after long-distance shipment, Kettle (2007) studied horses imported into Dubai over a 12-month period. The Dubai Racing Club Quarantine handled 736 imported horses between October 1, 2005, and September 30, 2006. All these imports met the definition of a long-distance journey, a journey in excess of 5 hours. All journeys were measured stable to stable. After admission to the quarantine stable, temperatures were recorded morning and evening for 6 days with a minimum of 11 temperature readings required.

During the year-long Dubai study, 26 of the quarantined horses (3.5 percent) had at least 1 rectal temperature of 101.6°F or more. Twenty-two of these 26 horses had the first elevated temperature at arrival. Of these horses, five (19.2 percent) had more than a single episode of elevated temperature. None of the horses developed pleuropneumonia. Nearly 92 percent (674) of the horses transported to Dubai traveled by air; the balance (62; 8.4 percent) traveled by road. The prevalence of elevated temperature for horses traveling by road (9.7 percent) was more than three times greater than for those traveling by air (3.0 percent).

A report by Kettle (2007) and the results of our U.S. study showed that the majority of horses had the first episode of an elevated temperature at the first examination. Although the majority of imported horses at all three U.S. import centers had their first elevated temperatures at arrival or in the first 12 hours after arrival, the prevalence of elevated temperatures varied by center. There appeared to be an influence of center not described by the available data. Within each center there were some clear associations between the occurrence of elevation in body temperature and risk factors such as age and breed.

The data in this report clearly illustrate that age has an effect on the prevalence of elevated temperature among imported horses in all three centers. Horses 4 years of age or less in all three centers were at greater risk for an elevated temperature than were older horses. It is possible that younger age is a surrogate for lack of experience with air transport and/or susceptibility to transport stress. Friesians were at greater risk than other breeds for elevated temperature at both LA-AIC and NYAIC; no Friesians were imported through MAIC. The effect of breed on prevalence of elevated temperatures varied across centers for breed categories other than Friesians. Why certain breeds such as Friesians might be predisposed to a higher prevalence of elevated temperature in both LA-AIC and NYAIC was not determined by the existing data. The majority of elevated temperatures occurred within 12 hours of arrival to an import center, typically as a single event, and usually as a low-grade elevation (i.e., greater than 101.5°F but less than 102.5°F). These findings suggest that occurrences of an elevated temperature later in the quarantine period, high temperatures, or repeated elevations in temperature should be considered unusual

events. Such events should be taken more seriously than elevations observed at arrival and one-time, low-grade elevations, both for the sake of the animal's welfare and due to the potential risk these horses may pose for transmission of contagious diseases. The majority of horses in this report had self-limiting elevated temperatures or required minimal intervention to resolve a low-grade elevation in body temperature. However, the individual horse should be monitored for further increase in body temperature, recurrence of elevated temperature after the use of NSAIDs, and other signs of disease based on physical examination to most appropriately determine the need for treatment and diagnostic testing beyond a physical examination.

Factors beyond those available in the existing data could influence the occurrence of elevated temperature of shipped horses. Data were not available to determine the conditions the horses experienced prior to embarkation or to determine the location of the horses within the cargo area of the aircraft. Nor were data available regarding the horses' previous experiences with air transport, the number of horses, and location of the horse in the jet stall or the type of cargo that was on the shipment with the horses. Further studies would be necessary to determine if some of the elevated temperatures were due to infection caused by potential factors such as aspiration of pharyngeal secretions, head position during transport, air quality conditions during transport, or a contagious agent.

Diagnostic interventions during quarantine of horses are limited by the fact that all samples from quarantined horses must be under the supervision of regulatory officials until the horse is released from quarantine. The NYAIC has an in-house laboratory that allows them to perform some laboratory investigations such as a CBC. However, if diagnostic testing such as bacteriology and viral agent testing is to be pursued, then all handling and testing of samples would have to be under regulatory control. Thus, if further diagnostics on horses with elevated temperatures were to be pursued in a more rigorous manner, a protocol for how such samples would be handled and where they would be tested must be developed to assure that no exotic disease agent is released through the processing of such samples.

In conclusion, the data included in this report summarize records for 4,720 horses. This appears to represent the largest number of records for horses shipped by air to be evaluated for prevalence of an elevated body temperature. Analysis of the existing data identified several factors associated with risk of an elevation in temperature. Further work is necessary to determine more definitively the causes of and potential interventions for elevated temperatures among imported horses.

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Contacts for further information:

Questions or comments on data analysis:
Dr. Josie Traub-Dargatz or Dr. Barabara Bischoff (970) 494-7000

Email: NAHMS@aphis.usda.gov