Economic Considerations of Aggressively Treating the Influenza Virus in Equines

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Chapter I: Introduction

The equine influenza virus is a significant cause of respiratory disease in horses. Even though horses generally recover from this virus, it is highly contagious horse to horse and can cause physical distress (Thomas, 2006). There is no treatment for this virus; while symptoms can be managed, the virus must be allowed to run its course. However, sometimes horses with equine influenza develop secondary bacterial infections which can cause severe pneumonia and increases recovery times. Because of this, owners and managers are faced with the decision in whether to delay preventative treatment in hopes of the horse not getting a secondary bacterial infection or aggressively treat the horse before an infection becomes an issue.

The purpose of this study is to address the economic considerations of the "wait and see" versus "treat now" alternatives of treating a horse diagnosed with equine influenza. These considerations include the possibility of treatment costs as well as the extent to which the owner/manager prefers to avoid seeing the horse feeling poorly and potentially losing training days. To this end, a conjoint analysis is performed on equine influenza virus treatment strategies to estimate the willingness to pay of owners and managers for different attributes of treatment strategies.

The structure of the paper is as follows: Chapter 2 outlines the horse industry in Kentucky and provides information about equine influenza and secondary bacterial infections. Chapter 3 describes the survey design used in the conjoint analysis experiment. Chapter 4 presents the descriptive statistics of the demographic portion of the survey. Chapter 5 introduces the empirical model used in this research. Chapter 6 presents the preliminary results of logit model (and will eventually include results from the mixed logit). Finally, in Chapter 7, the conclusions and implications of the study are addressed.

Chapter II: Background

The state of Kentucky is known as the horse capital of the world for good reason. It is a major breeding center for the Thoroughbred horse industry, is a home to Thoroughbred racing, and generates more revenue in the sale of horses than any other place in the world (VisitLex). Horse enthusiasts come to Kentucky to bask in the breathtaking beauty of Kentucky horse farms laid on the beautiful bluegrass, as well as bring their passion of horses to the state whether just visiting, working for the equine industry, or living amongst other horse enthusiasts while taking care of their own horse.

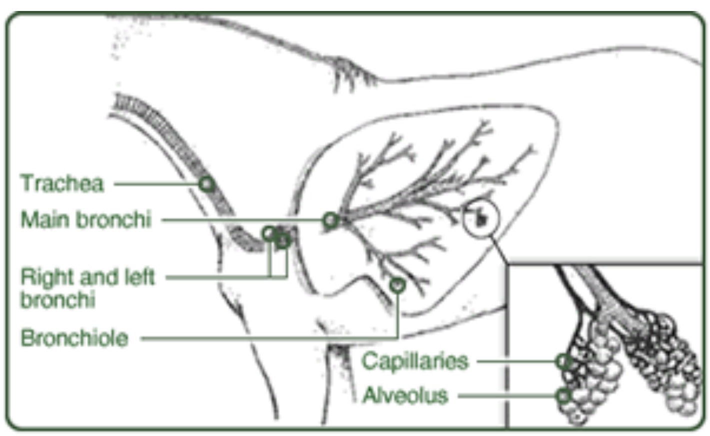
Kentucky's horse industry has a 3 billion dollar impact to its economy. An estimated 40,665 individuals are employed because of the presence of the Equine industry in Kentucky. There are about 242,400 horses in this state, and while Kentucky is known for Thoroughbreds and horse racing, over fifty percent of the state's horses are not involved in horse racing, but rather in showing and recreation (2012 Kentucky Equine Survey). According to the 2012 Kentucky Equine Survey, there were 54,000 Thoroughbred horses in Kentucky, which can be attributed to breeding, racing, and even people owning a Thoroughbred for recreational purposes. Quarter Horses are the next most populous breed in Kentucky with 42,000 horses, followed by Walking Horse Breeds (36,000), American Saddlebreds (14,000), donkeys and mules (14,000), and Mountain Horse Breeds (12,500). According to this survey, recreational riding (trail and pleasure riding) is the primary use of most horses at 32.8%, followed by breeding (stallions, broodmares, foals, yearlings, and weanlings) at 26.8%. 10% of the horses are primarily used for competition (non-racing). Equine use for horse racing is at 6%.

When people think of Kentucky, they think of horse racing. Horse racing every year is in the limelight, as money is poured in the hope of producing a Kentucky Derby winner or even a

Triple Crown. However, as the statistics show, the majority of people and horses are recreational owners and non-racing breeds. This is the target group for this study. While there is a lot of money invested into breeding and making a racehorse, the "backyard horse owners" constitute the majority of horse owners in Kentucky and therefore represent an important segment of the equine health care industry.

The function of breathing is to carry oxygen that is inhaled through the horse's nostrils to the lungs, blood, and eventually the muscles. The oxygen that is breathed through the nose enters a series of tubes. The first tube is the pharynx, which leads to the trachea. From the trachea to the bronchi each dividing into bronchioles. At the end of the bronchioles are the capillaries and alveoli, which look like grapes. This is where gas exchange occurs passing the oxygen into the bloodstream to fuel the muscles the horses need (Oke, 2010; *Equestrian and Horse*).

Figure 1. Horse Respiratory System (Source: Equine Kingdom)



Respiratory diseases can be caused by dust, allergy, parasites, bacteria and viruses. A common sequel to an equine respiratory viral infection is a secondary bacterial infection caused by Streptococcus equi zooepidemicus. Equine influenza is a highly contagious virus and is the most common equine respiratory disease in many countries (Timoney, 1996). It has a low mortality rate and horses usually recover, but due to the physical distress brought on by the virus, a horse may be kept out of training and competition for weeks or months (Thomas, 2006). The virus itself is not treatable, but symptoms of the virus can be alleviated by over-the-counter and prescription drugs. Even though there are extensive vaccination programs, transmission and outbreaks still occur causing major economic losses and threatening equine welfare (Ault, et. al, 2012).

Outbreaks of equine influenza generally occur in the late fall, winter or spring. This is when young horses are weaned and are put into training, putting them in contact with other horses. The close proximity of horses at race tracks, sales, show, and training centers can also facilitate the spread of the virus (Timoney, 1996). After an incubation period of 1-2 days, the virus starts by a rise in temperature greater than 102 degrees and can reach 106 F° (Timoney, 1996) and last as long as 4 to 5 days (Paillot, 2006), along with a loss of appetite, followed by a dry cough and discharge that carries a mucus-pus like substance (Sarasola, et al, 1992). There is also the presence of tender lymphatic glands, heart rate, swelling of the limbs, and muscle stiffness or soreness (Timoney, 1996).

Laboratory procedures confirm a flu case. This is done by taking a nasopharyngeal swab, usually at the onset of the fever to increase chances of a proper diagnosis. The treatment for equine influenza is symptomatic. The most important treatment for a horse with influenza is a clean stall with proper ventilation and rest (Merck Veterinary Manual). Complete recovery of the respiratory tract takes up to a month or maybe even longer after the symptoms go away. Horses typically need one week of rest for every day they have a fever. An inadequate rest period will prevent the horse from returning to its full training potential; however, some horses never return to their performance capabilities pre-exposure to influenza (Timoney, 1996).

Vaccines are an option for horse owners who want to protect against the possibility of their horse getting the equine flu. Yong horses under the age of four and senior horses over 16 years of age are more susceptible to the virus (Thomas, 2006). It is important that the vaccines are periodically updated to the virus strains that are currently circulating at the time (Timoney, 1996).

Unfortunately, horses can develop secondary bacterial infections after the onset of the influenza virus. This can lead to pneumonia, and/or, pleuritis (Paillot, 2006), especially in horses that are not vaccinated; these infections can be fatal (Timoney, 1996). The nature and severity of a horse coming down with an infection depends on several factors including age, history of past exposure (which can lead to a weaker immune system), past vaccinations against the influenza virus, and environmental factors (Timoney, 1996).

The secondary bacterial infection will occur a few days after the equine influenza virus fever subsides. The infection will cause the horse to have a second fever that is higher and lasts longer than the first fever from the influenza. A horse's symptoms include mucopurulent nasal discharge, increased coughing, lack of appetite and signs of bronchial and lung involvement (P.J. Timoney, 1996). They also carry on other similar symptoms to the equine influenza. Secondary bacterial infections should be treated with appropriate antibiotics and other antimicrobial drugs.

There are monetary and nonmonetary costs associated with a horse that becomes ill with a respiratory virus. The expense of treatment includes veterinarian visits, medications, as well as an owner's time needed to treat the horse. Damage to the respiratory tract can take weeks to heal.

For many, there is a loss in training time for the horse, which may result in an economic loss for the owner. For example, a horse that missed competitions is missing valuable point shows (Giedt), and a horse that is racing is missing valuable training time and potentially even races. Even though there are fewer economic losses from a horse that is used for pleasure riding not being able to be ridden, the owner bears the nonmonetary costs of forgone pleasure from riding. In addition, a horse feeling poorly can place stress on an owner. A horse that is put back to work too soon can develop significant complications, and may never be able to reach its full performance potential again (Ball, 1998).

Chapter III: Survey Design

This study relied on the feedback from horse owners in the form of a survey. The first part of the survey was the demographic portion requesting respondents' individual background information. The second part of the demographic portion focused on respondents' horse background information. The second part of the survey was a dichotomous choice experiment, which allows the research team to estimate owner/manager willingness-to-pay of attributes associated with equine influenza treatment strategies (also called conjoint analysis). These strategies represent what the respondent would choose if their horse became ill with the equine influenza. In each question, respondents were presented with two treatment strategies, Strategy A and Strategy B; the respondent also had the option of choosing Strategy C which meant that neither "A" or "B" strategy was preferred, and is interpreted as the respondent choosing the status quo. Each treatment strategy is described by three attributes: the horse's appetite, how many days the horse is out of training, and the cost associated with the horse becoming ill. Figure 2 gives an example of one of the choice cards.

Figure 2. Choice Card

Card 2

Attribute	Strategy A	Strategy B	Strategy C
Appetite	Poor	Decreased	I would not choose A or B
Days Out Of Training	1-3 Days	4-6 Days	
Cost	$750	$250	

I would likely choose: ☐ ☐ ☐

Several intensive steps were taken in designing the questionnaire. The selection of attributes and levels are of high importance in choice experiments, and careful consideration was taken in selecting the attributes that would collectively represent a horse that became ill. When designing a choice experiment, too many attributes can leave the respondent feeling overwhelmed having to compare, but two few attributes can leave the respondent not being well-informed on the situation, as well as not enough choice variation amongst the four choice experiments. Several research experts from the Gluck Equine Research Center at the University of Kentucky, as well as veterinarians, were contacted to help define and refine the attributes and their levels. While many attributes were considered (high temperature, nasal discharge, heart rate, respiratory rate, lung sounds, attitude, appearance, and coughing), three attributes were ultimately chosen: Appetite, Days Out Of Training, and Cost.

The focus of the data collection was on Kentucky horse owners. The Kentucky Horse Council (KHC) database was used in contacting these owners since they have an active list of horse owners and mailing addresses, as part of their membership with the KHC. The survey was distributed using a modified Dillman method[1]. This Dillman method has been shown to optimize response rates for mail surveys.

Chapter V: Empirical Model (in progress)

Models in the logit family are typically associated with studying discrete choices (Hensher, et. al 2003), which is fitting for this study. We look at the basic logit model to analyze hypotheses about the demographic variables, and then utilize the mixed logit and conditional logit models for the dichotomous choice experiment.

5.1 Logit Model

The logit model is useful for binary dependent variables, where the dependent variable takes on the value of 0 or 1. This type of modeling is used to predict whether someone purchases, adopts, participates, etc. In this study, the binary outcome of the logit model is whether or not a respondent has ever had a horse with a respiratory virus (the dependent variable). Independent variables from the first section of the survey are used to predict the likelihood that an owner will experience a respiratory virus case. Table 8 describes the independent variables used in the model.

[1] Due to technical difficulties with the Kentucky Horse Council Database only half of the initial recipients of the survey were able to receive a second mailing and a second postcard mailing could not be completed as a follow up to the second survey mailing.

Table 8. Variable Definitions of Logit Model

Variable	Definitions
dummy_1_horse	=1 if respondent owns one horse and 0 otherwise
dummy_2_10_horse	=1 if respondent owns 2 to 10 horses and 0 otherwise.
dummy_property	=1 if respondent who keep their horse(s) on their own property and 0 otherwise.
dummy_both	=1 if respondent who keep their horses on their own property and at a boarding facility and 0 otherwise.
dummy_young_1_4	=1 if a respondent horse is between 1 and 4 years of age and 0 otherwise.
dummy_senior_16_plus	=1 if a respondent horse is over the age of 16 and 0 otherwise.
riding	=1 if respondent primary discipline is riding and 0 otherwise.
breeding	=1 if respondent primary discipline is breeding and 0 otherwise.
driving	=1 if respondent primary discipline is driving and 0 otherwise.
halter	=1 if respondent primary discipline is halter and 0 otherwise.
work	=1 if respondent primary discipline is work and 0 otherwise.
idle	=1 if respondent primary discipline is idle and 0 otherwise.
dummy_comp_yes	=1 if respondent horse competed in the past year and 0 otherwise.
dummy_involv_6_10	=1 if respondent has 6 to 10 years of horse experience and 0 otherwise.
dummy_involv_10_plus	=1 if respondent has over 10 years of horse experience and 0 otherwise.

The logit model takes on the functional form

$$F\ (y_i = 1) = \frac{exp\ (x_i\beta)}{1+ex\ p(x_i\beta)}$$

where $F\ (y_i = 1)$ is *dummy_horsesick_y*, which is a respondent who answered "yes" to their horse having the equine influenza, and $x_i\beta$ = [dummy_1_horse, dummy_2_10_horse, dummy_property, dummy_both, dummy_young_1_4, dummy_senior_16_plus, riding, breeding, driving, halter, work, idle, dummy_comp_yes, dummy_involv_6_10, dummy_involv_10_plus].

5.2 Conditional and Mixed Logit Model (to be estimated)

In the dichotomous choice experiment, the data is analyzed using conditional and mixed logit models. Both these models are used in this study.

The conditional logit model, while widely used, cannot account for heterogeneity among respondents. This means that it does not take into account different consumer tastes. It also has the assumption that it holds a restrictive pattern when a consumer is deciding between two choices, their decision should not be based on whether a third choice is present. This is called the Independence of Irrelevant Alternatives (IIA assumption) and can lead to unrealistic predictions.

The conditional logit model takes on the functional form

$$p_{ij} = p(y_i = j) = \frac{\exp(\mathrm{x}'_{ij}\beta + \mathrm{w}'_i\gamma_{ij})}{\Sigma_{k=1}^{m}\exp(\mathrm{x}'_{ik}\beta + \mathrm{w}'_i\gamma_k}$$

The mixed logit is used because it relaxes the IIA assumption and introduces random parameters, assuming the coefficient β is random and not fixed. This model specifies the utility to the *i*th individual for the *j*th alternative. The foundation of the mixed logit comes from the random utility model which states that an individual's utility is based on an alternative that they choose. $f\ (\beta|\theta)$ is the density function of β. The functional form of the mixed logit is

$$p_{ij} = \int \frac{\exp\left(\mathrm{x}'_{ij}\beta\right)}{\Sigma_{j=1}^{J}\exp\left(\mathrm{x}'_{nj}\beta\right)} f\ (\beta|\theta)d\beta$$

Chapter VI: Results

To obtain the results of the model, Stata 13 was used. The model was used in estimating the likelihood of certain demographic attributes that would predict the likelihood that an owner had a horse experience a case of equine viral respiratory disease. The summary statistics from the model that is estimated are presented in Table 9.

Table 9. Summary Statistics of Logit Model Variables

Variable	Mean	St. Dev	Min	Max
dummy_1_horse	0.130	0.337	0	1
dummy_2_10_horse	0.665	0.472	0	1
dummy_property	0.647	0.479	0	1
dummy_both	0.041	0.198	0	1
dummy_young_1_4	0.063	0.244	0	1
dummy_senior_16_plus	0.230	0.422	0	1
riding	0.829	0.378	0	1
breeding	0.019	0.135	0	1
driving	0.026	0.159	0	1
halter	0.007	0.086	0	1
work	0.011	0.105	0	1
idle	0.026	0.160	0	1
dummy_comp_yes	0.320	0.467	0	1
dummy_involv_6_10	0.071	0.257	0	1
dummy_involv_10_plus	0.892	0.311	0	1

All independent variables are dummy variables. A total of 269 observations are used. The dependent variable is whether or not a respondent ever had a horse sick or not. Independent variables were chosen on factors that could influence a horse being sick. These variables were based on whether the owner has one horse or more than one horse, along with the primary discipline, horse's age, owner's involvement with horses, and location of the horse (whether on property, boarding facility, or both). Primary discipline is included because depending on the activity, the horse could become more stressed or be around more horses. The horse's age can affect the immune system of a horse, and the owner's experience with horses may suggest that someone with less experience might not know the signs of disease and therefore not catch it in time, or people that were experienced more with horses for a longer period may have had more opportunity to have a horse with a respiratory virus. The location of the horse also can be a factor in coming down with a respiratory virus due to environmental factors of those locations. The results of the logit model are shown in Table 10 and Table 11.

Table 10. Logit Model Results

Log liklihood=	-158.05
LR chi2(14)=	45.5
Prob>chi2 =	0.0000

dummy_horsesick_y	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
dummy_1_horse	-1.939	0.670	-2.89	0.004***	-3.253	-0.626
dummy_2_10_horse	-0.543	0.384	-1.41	0.157	-1.295	0.210
dummy_property	0.291	0.382	0.76	0.445	-0.457	1.040
dummy_both	1.960	0.878	2.23	0.026**	0.240	3.679
dummy_young_1_4	0.541	0.565	0.96	0.339	-0.567	1.648
dummy_senior_16_older	0.177	0.334	0.53	0.596	-0.478	0.832
riding	1.434	0.662	2.17	0.030**	0.136	2.731
breeding	1.600	1.194	1.34	0.181	-0.742	3.938
driving	-0.230	1.293	-0.18	0.859	-2.763	2.304
halter	1.283	1.657	0.77	0.439	-1.964	4.530
work	2.167	1.426	1.52	0.129	-0.628	4.962
dummy_comp_yes	0.541	0.299	1.82	0.070*	-0.043	1.126
dummy_involv_6_10	-0.533	1.044	-0.51	0.609	-2.579	1.513
dummy_involv_10_plus	0.501	0.854	0.59	0.557	-1.173	2.176
_cons	-2.074	0.935	-2.22	0.026	-3.906	-0.243

Notes: dummy_horse_sick_y is the dependent variable, and ***, **, and * represent significance at the 1, 5, and 10% levels, respectively.

Table 11. Logit Model Marginal Value Results

Variable	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
dummy_1_horse	-0.454	0.155	-2.93	0.003***	-0.758	-0.15
dummy_2_10_horse	-0.127	0.09	-1.41	0.158	-0.303	0.049
dummy_property	0.068	0.089	0.76	0.445	-0.107	0.243
dummy_both	0.459	0.207	2.21	0.027**	0.053	0.865
dummy_young_1_4	0.127	0.132	0.96	0.339	-0.133	0.386
dummy_senior_16_older	0.041	0.078	0.53	0.596	-0.112	0.195
riding	0.336	0.154	2.19	0.029**	0.035	0.637
breeding	0.374	0.279	1.34	0.18	-0.172	0.921
driving	-0.054	0.303	-0.18	0.859	-0.647	0.54
halter	0.300	0.388	0.78	0.438	-0.459	1.06
work	0.507	0.333	1.52	0.128	-0.146	1.16
dummy_comp_yes	0.127	0.07	1.82	0.069*	-0.01	0.264
dummy_involv_6_10	-0.125	0.244	-0.51	0.609	-0.604	0.354
dummy_involv_10_plus	0.117	0.2	0.59	0.557	-0.274	0.509

Notes: dy/dx is the marginal value of the independent variable. ***, **, and * represent significance at the 1, 5, and 10% levels, respectively.

The McFadden's pseudo-Rsquared for the logit model is 0.1258. The log likelihood is equal to -158.05.

6.1 *Interpretation of Results and Marginal Values*

Four independent variables were statistically significant at the 10% level or better. The variable controlling for owners who owned just one horse was significant at the 1% level with a P-value of .004. The estimate for the coefficient of *Dummy_1_Horse* suggests holding all variables constant owning only one horse decreases the chance of a horse becoming sick with a respiratory virus by 45% compared to owners who owned more than 10 horses. This is reasonable because there is less chance of transmission by an ill animal.

The variable controlling owners who kept some horses on their own property and boarded some were significant at the 5% level with a P-value of .026. The estimate for the coefficient of *Dummy_both* suggests holding all variables constant, that keeping horses in both location increases the chance of a horse becoming sick with a respiratory virus by 46% compared to owners who just boarded their horses.

The variable controlling for owners whose primary discipline was horseback riding was significant at the 5% level with a P-value of .03. The estimate for the coefficient of *Riding* suggests holding all variables constant, that riding horses increases the chance of a horse becoming sick with a respiratory virus by 34% compared to owners who were just idle.

The variable controlling for owners whose horse was active in competition over the last year were significant at the 10% level with a P-value of .07. The estimate for the coefficient of *Dummy_comp_yes* suggests holding all variables constant, that having a horse in competition over the past year increases the chance of a horse becoming sick with a respiratory virus by 13% compared to horses that were not in competition over the past year.

In summary, horses that were surrounded by other horses, were being ridden, were in a competition over the past year, and owners that had horses on both their property and at a boarding facility increases the likelihood of their horse becoming sick with a respiratory virus. Owners that solely had one horse were less likely to have their horse succumb to viral respiratory disease.

Chapter VII: Discussion and Conclusion

7.1 *Discussion of Logit Model Results*

The logit model was used to estimate the influence of different independent variables in increasing or decreasing the likelihood that an owner would experience a sick horse. The independent variables that were significant were respondents who owned one horse, respondents who kept their horses on their own property and at a boarding facility, respondents whose primary discipline was horseback riding, and horses that were in a competition over the past year.

An owner with one horse is less likely to have their horse succumb to viral respiratory disease . The virus is spread through the air and items that come in contact with the virus can become contaminated. If an owner just has one horse, the chances of the horse coming in contact with another horse can be diminished, and also reduces the likelihood that the surrounding environment would be contaminated.

An owner that has a horse at a boarding facility and another one kept on their own property are more likely to get a respiratory virus. It is not known which location the horse that had a respiratory virus is located, however, the owner, if moving between the property and boarding facility, can be a carrier between locations.

Owners that are actively involved in riding can put a horse in stressful conditions which can suppress the immune system. This can be done through transporting a horse to a trail or to a competition or training the horse vigorously, among other factors. A horse can be exposed to more horses if the owner is riding amongst other riders or placed in other environments where the horse will interact with other horses which can increase the chance of the horse becoming ill.

Horses that are in competition are more likely to get sick. Horses can get stressed during competition time in which their immune system is suppressed making it easier for a virus to infect the horse. They are also around other horses in close quarters where viruses are most likely to spread, and stabling at competitions may not have adequate biosecurity.

7.2 *Research yet to be completed.*

Once the conditional and mixed logit models are completed, the willingness-to-pay of attributes can be completed, and there can be a more formal conclusion. It is expected that the results will be completed by the end of February 2016.

7.3 *Limitations*

The first limitation of this study is that there were technical difficulties with the Kentucky Horse Council (KHC) Database which did not allow the research team to properly obtain all of the remaining addresses of survey recipients for the second mailing. In addition to this, the team was not able to obtain any addresses for the second follow up postcard. Because of this, not all remaining recipients were contacted a second time with a second survey in the mail, nor did anyone get a second reminder postcard. Unfortunately there was nothing that could be done with the technical difficulties from the KHC database.

The second limitation was not everyone who filled out the survey understood what they were supposed to do. They either did not fill out the choice experiment portion, or they filled it out but wrote a note saying they did not understand, or were confused by the survey. For the respondents that did not understand the survey, they were left out of the study.

References

"2012 Kentucky Equine Survey", accessed June 6, 2015, http://equine.ca.uky.edu/kyequinesurvey

Ault, Alida, Alyse M. Zajac, Wing-Pui Kong, J. Patrick Gorres, Michael Royals, Chih-Jen Wei, Saran Bao et al. "Immunogenicity and clinical protection against equine influenza by DNA vaccination of ponies." *Vaccine* 30, no. 26 (2012): 3965-3974.

Ball, Michael, DVM, "Equine Respiratory Disease Part 2: The Lower Airway" theHorse, August 1, 1998.

Ball, Michael, DVM, "Transporting Horses" theHorse, April 1, 1998.

"Equine Respiratory System Vet, Horse First Aid." *Equestrian and Horse.* Accessed January 22, 2016. http://www.equestrianandhorse.com/care/veterinary/respitory.html

"Horse Capital of the World" VisitLex, accessed June 6, http://www.visitlex.com/about/horse-capital-of-the-world/

"Horse Respiratory System" Equine Kingdom, accessed June 6 http://www.equinekingdom.com/data/education/horse_anatomy/respiratory_system.html

Newton, J. R., J. M. Daly, L. Spencer, and J. A. Mumford. "Description of the outbreak of equine influenza (H3N8) in the United Kingdom in 2003, during which recently vaccinated horses in Newmarket developed respiratory disease." *The Veterinary Record* 158, no. 6 (2006): 185-192.

Oke, Stacey, DVM. “The Equine Respiratory System.” *The Horse*. February 1, 2010. http://www.thehorse.com/articles/24958/the-equine-respiratory-system

Paillot, R., D. Hannant, J. H. Kydd, and J. M. Daly. "Vaccination against equine influenza: quid novi?." *Vaccine* 24, no. 19 (2006): 4047-4061.

“Respiratory Diseases in Horses: What You Can Do to Prevent Them,” accessed June 6, 2015, http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2091/VTMD-9120web2014.pdf

Sarasola, P., D. J. Taylor, S. Love, and Q. A. McKellar. "Secondary bacterial infections following an outbreak of equine influenza." *Veterinary Record* 131, no. 19 (1992): 441-442.

Timoney, P. J. "Equine influenza." *Comparative immunology, microbiology and infectious diseases* 19, no. 3 (1996): 205-211.

Thomas, Heather Smith, “Equine Influenza” Bloodhorse, June 10, 2006, 3304.

Wall, Maryjean. *How Kentucky Became Southern: A Tale of Outlaws, Horse Thieves, Gamblers, and Breeders*. Kentucky Scholarship Online, 2011.