

Questionnaire assessment of airway disease symptoms in equine barn personnel

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Background	People working in cattle, swine and poultry barns have a higher prevalence of respiratory symptoms and decreased lung function. There is scant evidence regarding the respiratory health of humans working in horse barns, although it is well documented that stabled horses have a high prevalence of airway disease.
Aim	To determine whether people spending time in horse barns have a higher prevalence of self-reported respiratory symptoms than non-exposed controls.
Methods	A cross-sectional questionnaire study was conducted from May 2005 to January 2006 to investigate the prevalence of self-reported respiratory symptoms in 82 barn-exposed subjects and 74 control subjects. Logistic regression and the chi-square test were used to analyse the data.
Results	There was a significantly higher prevalence of self-reported respiratory symptoms in the barn-exposed group (50%) versus the control group (15%). Exposure to horse barns, smoking and family history of asthma or allergies was independent risk factors for respiratory symptoms. High exposure to the horse barn yielded a higher odds ratio for self-reported respiratory symptoms (8.9).
Conclusions	Exposure to the equine barn is a risk factor for respiratory symptoms. Investigation of organic dust exposures, lung function and horse dander allergies in the barn-exposed group will be necessary to determine how best to protect the health of this group.
Key words	Airway disease; asthma; barn; horse; IAD; organic dust.

Introduction

The equine industry contributes over \$39 billion annually to the US economy, and an estimated 4.6 million Americans are directly involved in the US equine industry—many of these people are exposed to the equine barn environment on a daily basis [1]. There has been little attention paid to the effect of the barn environment on the human respiratory system; however, recent evidence has begun to show that the equine environment may have an adverse effect on human respiratory health [2–4]. In addition

to this emerging risk, it is well established that the equine barn environment is hostile to the respiratory health of horses. An estimated 33% [5] to 80% [6] of stabled horses develop non-septic lower airway inflammation with variable exercise intolerance. This inflammatory airway disease (IAD) has been attributed to high levels of organic dust and endotoxin in the typical equine barn [7,8]. We have previously suggested that characteristics of clinical presentation, physiological changes and pathology of equine IAD are comparable to the human response to particulate matter [9]. Moreover, pig, dairy and poultry farmers, in environments similarly high in organic dust, are at a high risk for airway diseases [10–13]. These data prompted us to hypothesize that humans sharing the barn environment with horses would likewise be at risk for respiratory disease. Therefore, our aim in this cross-sectional questionnaire study was to determine the prevalence of self-reported respiratory symptoms in people exposed to the barn environment versus a control population.

Methods

We created a sampling frame from an existing list of equine barns in New England. We telephoned the barn

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managers on this list until we had a sufficient number agree to participate (a total of 35 barns). Participants between the ages of 18 and 75 were approached individually by a student volunteer. Our control population was chosen by recruiting random adults (18–75 years of age) at grocery stores, banks and other public venues in the same towns as the equine barns by the same student volunteers. For both the barn-exposed and control populations, the questionnaires were completed while the interviewer was on the premises and returned to the interviewer for analysis.

Exclusion criteria for the control population included any exposure to other livestock barns or cohabitation with a person exposed to horses or other livestock. Exclusion criteria for both the exposed and the control populations included employment in a dusty trade, such as wood-working and construction. The Tufts University Institutional Review Board approved the study protocol and informed consent was obtained from all participants.

The 'Organic Dust Exposure Questionnaire' [14] was modified to include questions regarding barn exposure, pet ownership, home exposures to mould or combustion particulates, occupation and family history of allergies or asthma. Participants were asked whether, in the last 12 months, they had experienced dry or productive cough, wheezing, chest tightness, shortness of breath, difficulty breathing or awakening at night due to respiratory problems or nasal irritation.

If participants had experienced dry or productive cough, wheezing, chest tightness, shortness of breath, difficulty breathing or awakening at night due to respiratory problems, they were designated as having respiratory symptoms. If participants reported experiencing nasal irritation, this was separately categorized as 'nasal symptoms'.

The control population was designated as having no exposure. Participants who spent <10 h/week at an equine barn were designated as having low exposure.

Participants who spent ≥10 h/week at an equine barn were designated as having high exposure. We chose these exposure categories because of anecdotal evidence suggesting that the casual rider who is unlikely to perform barn-related tasks resulting in greater exposure to the barn environment such as putting out hay or cleaning stalls is likely to spend 1–2 h/day, 2–5 days/week at the barn, whereas those routinely performing barn tasks resulting in greater exposure to the barn environment are likely to spend much more time at the barn.

Statistical analysis was performed using the epidemiologic software EGRET (Cytel, Seattle, WA, USA). Possible confounders were smoking, family history of asthma/atopy, allergies, pet ownership, presence of mould or combustion particulates in the home, sleeping with feather products, age and sex. All confounder and risk factor variables were first compared to outcome (self-reported respiratory symptoms) using multivariate anal-

ysis with logistic regression. Smoking was adjusted for as a dichotomous variable (current versus never- or ex-smokers), as was family history of asthma or allergies, and age was adjusted for as a continuous variable to yield adjusted odds ratios (ORs). The association between two categorical variables was determined using a chi-square test.

Results

In all, 102 people were approached and 82 accepted (response rate of ~80%) and 212 controls were approached and 74 accepted (34% response rate).

The barn-exposed group had a significantly greater percentage of females, current and ex-smokers and family history of allergies and asthma (Table 1).

Using the modified questionnaire, barn-exposed participants were compared to controls to determine whether barn exposure was associated with a higher occurrence of self-reported respiratory symptoms. There was significantly higher self-reporting of each of the respiratory symptoms in the barn-exposed group (Table 2).

Fifty per cent of the barn-exposed group reported experiencing at least one of the respiratory symptoms in the past 12 months, whereas only 15% of the control group reported the same; this difference was significant ($P < 0.05$) (Table 3).

None of the control group had any exposure to horse barns or other livestock. The majority (77%) of barn-exposed people were in the high-exposure group, with only 23% in the low-exposure group. Of the high-exposure group, 59% reported at least one of the respiratory symptoms, compared to 26% of the low-exposure, and 15% of the control group. These groups differed significantly from each other using chi-square analysis. A significantly higher percentage of the high-exposure group reported each of the possible respiratory symptoms than the low-exposure or control groups (Table 2). Similarly, only

Table 1. Descriptive data for barn-exposed and control groups

Descriptive data	Number (%)	Number (%)
	Barn exposed	Control
Age (years), mean (SD)	41 (13)	38 (15)
Number	82	74
Female gender <i>n</i> (%)	65 (80)*	58 (59)
Current smokers <i>n</i> (%)	10 (12)*	3.7 (5)
Ex-smokers <i>n</i> (%)	34 (41)*	20 (27)
Pack years, mean (SD)	2.1 (3.3)	2.6 (7.9)
Exposed >10 h/week <i>n</i> (%)	59 (72)	0
Family history of asthma or atopy <i>n</i> (%)	37 (45)*	22 (30)

* $P < 0.05$.

Table 2. Number and percent of control, all barn-exposed, low-exposure and high-exposure groups reporting specific respiratory symptoms

Self-reported respiratory symptoms	Control	Total barn exposed	Low exposure	High exposure
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Productive cough	2 (2)	8 (10)*	1 (5)	7 (12)*
Dry cough	6 (8)	28 (34)*	4 (18)	24 (41)*
Wheeze	3 (4)	12 (14)*	1 (4)	11 (19)*
Chest tightness	2 (2)	16 (20)*	1 (4)	15 (25)*
Shortness of breath	6 (8)	12 (15)*	0	12 (19)*
Difficulty breathing	3 (4)	11 (13)*	1 (4)	12 (20)*
Awaken at night with symptoms	4 (5)	15 (18)*	3 (14)	12 (20)*

P* < 0.05.Table 3.** Number and percent of control, all barn-exposed, low-exposure and high-exposure groups reporting at least one of the respiratory symptoms in Table 2

At least one respiratory symptom (not nasal)	No exposure (control)	Total barn exposed	Low exposure (<10 h/week)	High exposure (≥10 h/week)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Total in group	74	82	23	59
Affected (percentage)	11 (15)	41 (50)	6 (26)*	35 (59)*

**P* < 0.05.

12% of the control group experienced nasal irritation, whereas 17% of the low-exposure group and 39% of the high-exposure group experienced nasal irritation (Table 4).

The high- and low-exposure groups differed from the control group and to each other using chi-square analysis (*P* < 0.05).

Using multivariate analysis, after adjusting for confounders, we found that only smoking and family history of allergies and asthma were associated with the outcome; thus, these were retained in our final adjusted model. Although age and gender were not associated with the outcome, because other similar studies have found these confounders to be significant, these were also retained [15]. When barn-exposed people are stratified into low- and high-exposure groups, we find that being exposed to the barn environment for >10 h/week is a significant predictor of self-reporting respiratory symptoms in the past 12 months. Being exposed to the barn environment is likewise a significant predictor of having experienced nasal irritation in the past 12 months, although the association is not as strong. Being a current, but not a past

Table 4. Number and per cent of control, all barn-exposed, low-exposure and high-exposure groups reporting nasal irritation

Nasal irritation symptoms	No exposure (control)	Total barn exposed	Low exposure (<10 h/week)	High exposure (≥10 h/week)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Total in group	74	82	23	59
Affected (percentage)	10 (12)	27 (33)*	4 (17)	23 (39)*

**P* < 0.05.

smoker and having a family history of allergies or asthma was also a significant predictor of reporting respiratory symptoms. Family history of asthma or allergy, but neither current nor past smoking, was a significant predictor of self-reporting nasal irritation (Table 5).

Discussion

This cross-sectional study demonstrated a strong association between exposure to the horse barn environment and self-reporting respiratory symptoms. Among our high-exposure cohort, 59% reported respiratory symptoms and 19% reported wheeze. Self-reported nasal irritation was likewise more prevalent in both low- and high-exposure groups (Table 4). Moreover, self-reporting of respiratory symptoms was greater in the high-exposure group (Table 3). High exposure (≥10 h/week) was associated with a significantly higher OR (8.9, CI: 3.1–26.2) for self-reporting respiratory symptoms. A study of self-reported symptoms in European animal farmers revealed prevalences of shortness of breath of 10–15%, dry cough of 10–20%, productive cough of 9–18%, wheeze of 7–11% and nasal irritation of 21–29%, which were similar to our study [16]. Both the European study and our questionnaire study revealed a prevalence of respiratory symptoms which is considerably higher than our control group and that reported for the general north-eastern population of the USA [17].

Employees working with horses tended to smoke more than the sampled control population, and smoking was an independent risk factor for self-reported respiratory symptoms in the barn-exposed population, but did not explain the magnitude of the response (Table 5). Family history of asthma or allergies was an independent predictor of reporting respiratory symptoms (Table 5). This is concordant with previous questionnaire studies establishing the link between smoking, respiratory symptoms and asthma [18], as well as family history of atopy or asthma and respiratory symptoms. The suspected confounders that were independent predictors of nasal irritation were

Table 5. Final adjusted model for multivariate analysis of exposure to horse barns as a risk factor for self-reporting respiratory symptoms, with age, gender, family history of asthma, family history of allergies and smoking retained in the model

Model	OR (95% CI)
Reported at least one respiratory symptom in past year	
Low exposure	2.3 (0.6–9.8)
High exposure	8.9 (3–32.3)
Family history of respiratory problems	5.3 (2.2–12.6)
History of allergies	2.7 (1.2–6.5)
Current smoker	2.3 (0.7–7.1)
Past smoker	1.4 (0.5–3.9)
Age	0.8 (0.3–1.9)
Gender	0.9 (0.3–2.6)
Nasal irritation in the last year	
Low exposure	0.4 (0.6–1.5)
High exposure	3.5 (1.1–10.6)
Family history of respiratory problems	8 (3.1–20.8)
History of allergies	3.6 (1.4–9.3)
Current smoker	1 (0.3–3.6)
Past smoker	1.2 (0.4–3.8)
Age	0.60 (0.2–1.6)
Gender	1 (0.30–3.6)

family history of asthma and allergies, but not smoking. Unlike prior reports of certain respiratory diseases, such as asthma, being more prevalent in females in New England (Asthma Regional Council Report 2006), we found no significant effect of gender in our study.

There are important potential weaknesses of this study. We had low numbers, thus we were constrained to concentrating on several key points in order to avoid lowering convergence and statistical power. Although we used a modified version of the Rylander Organic Dust survey, we did not estimate exposures beyond time spent in the barn. Further, the inability to truly randomize is an inherent weakness of a study such as this, as we are unable to guarantee the original comparability of the two populations, and it is impossible to completely rid such a study of residuals despite controlling for possible confounders. We did not attempt to determine the extent of the ‘healthy worker effect’ in this study [19]; however, people who work with horses tend to do so because they are passionate in their pursuit of horse sports, and may prefer to rely on medication to alleviate symptoms or live with symptoms, rather than abandon the horse environment. This may explain to a certain extent the extremely high prevalence of self-reported respiratory symptoms. Finally, we did not investigate the prevalence of horse dander allergy in either the exposed or non-exposed group. Recently, a cohort of horse grooms was shown to have a prevalence of allergy to horses of 12.8 versus 4.3% in the control group [3]. Although the prevalence of allergy to horses in the exposed group was higher, the relatively low level overall leads us to believe that horse dander allergy is un-

likely to be the sole cause of the respiratory symptoms described by the barn-exposed group in our questionnaire.

Evidence that the horse barn environment is associated with development of respiratory symptoms in exposed people is beginning to emerge. A study of work-related respiratory symptoms in New Zealand farmers demonstrated that working with horses was consistently associated with higher prevalence rates of chronic bronchitis, dyspnoea, organic dust toxic syndrome and farmer’s lung than were other types of farming [2]. Horse management has also been associated with a higher prevalence of asthma [3] and respiratory work-related symptoms [20]. Our findings are in strong support of the recently published study by Gallagher *et al.* [4] revealing that horse trainers in New Zealand are at increased risk for reporting chronic bronchitis. Our study demonstrates that even relatively low exposures (<10 h a week) are associated with a greater risk of reporting respiratory symptoms. Respiratory disease is a prevalent problem in stabled horses, with 50–80% of stabled horses experiencing non-septic lower airway inflammation [21]. A severe manifestation of this IAD, known as ‘heaves’, is characterized by varying degrees of both irreversible airway obstruction and reversible narrowing [22]. There is severe neutrophilic airway inflammation, goblet cell hyperplasia, bronchial epithelial cell hyperplasia, smooth muscle hypertrophy and collagen deposition [23]. The neutrophilic airway inflammation and airway obstruction are reminiscent of the human response to particles of biological origin, such as grain dust [24] and cotton dust [25]. This evidence, in combination with our data showing the high prevalence of respiratory symptoms in barn-exposed people, prompts us to hypothesize that the barn environment has a similar effect on the human respiratory system.

Particles at the breathing zone of the horse range from 0.41 to 20.0 mg/m³ [26] and are biological in composition, comprising animal waste, mould spores and other particles from hay and straw, wood dust and grain dust. There is a high endotoxin load at the breathing zone of horses, with airborne endotoxin ~1.52 mg/m³ in respirable dust [27]. It is reasonable to assume that the dust load presented to the human occupying the same environment will be similar. In comparison, significant pulmonary function decrements were shown in poultry workers when they were exposed to 2.4 mg/m³ of total dust, 0.16 mg/m³ of respirable dust and 614 endotoxin units/m³ of endotoxin [28].

It is possible that the high level of airborne mould spores act not only as potential allergens but also as a particulate *per se*. The role of airborne moulds in respiratory disease remains debatable in human medicine; the remarkable levels found in the equine barn environment may allow us to better understand the role that these bio-aerosols play in human respiratory disease.

The results of this cross-sectional questionnaire demonstrate that exposure to the horse barn is strongly associated with reporting respiratory symptoms. These results

suggest that an environment shared by horse and human may result in development of similar airway inflammation and dysfunction. It will be important in future to establish human exposures to organic dust and determine what the components of that dust are, including endotoxin and moulds and other bioaerosols, as well as decomposition gases such as ammonia. It will also be important to determine task-specific exposures and farm characteristics, as well as longitudinal effects on lung function [29]. As there is evidence that allergy to horse dander is associated with development of asthma after childhood farming exposures [30] or extensive exposure to horses [3], the role of the immune response in the underlying pathology of respiratory symptoms in this group should also be an area for future research.

Key points

- Our questionnaire study showed a significantly higher prevalence of self-reported respiratory symptoms in a barn-exposed group (50%) versus the control group (15%).
- This study demonstrates the need for further investigation into organic dust exposures, lung function and horse dander allergies in order to determine how best to control respiratory symptoms in barn workers.

Funding

National Institutes of Health (T35 DK07635).

Conflicts of interest

None declared.

References

1. Directory HI. *Economic Impacts of US Horse Industry*. Washington, DC: American Horse Council Foundation, 2005.
2. Kimbell-Dunn MR, Fishwick RD, Bradshaw L, Erkinjuntti-Pekkanen R, Pearce N. Work-related respiratory symptoms in New Zealand farmers. *Am J Ind Med* 2001;**39**:292–300.
3. Tutluoglu B, Atis S, Anakkaya AN, Altug E, Tosun GA, Yaman M. Sensitization to horse hair, symptoms and lung function in grooms. *Clin Exp Allergy* 2002;**32**:1170–1173.
4. Gallagher LM, Crane J, Fitzharris P, Bates MN. Occupational respiratory health of New Zealand horse trainers. *Int Arch Occup Environ Health* 2007;**80**:335–341.
5. Burrell MH, Wood JL, Whitwell KE, Chanter N, Mackintosh ME, Mumford JA. Respiratory disease in thoroughbred horses in training: the relationships between disease and viruses, bacteria and environment. *Vet Rec* 1996;**139**:308–313.
6. Holcombe SJ, Jackson C, Gerber V *et al*. Stabling is associated with airway inflammation in young Arabian horses. *Equine Vet J* 2001;**33**:244–249.
7. Pirie RS, Dixon PM, Collie DD, McGorum BC. Pulmonary and systemic effects of inhaled endotoxin in control and heaves horses. *Equine Vet J* 2001;**33**:311–318.
8. Vandenput S, Istasse L, Nicks B, Lekeux P. Airborne dust and aeroallergen concentrations in different sources of feed and bedding for horses. *Vet Q* 1997;**19**:154–158.
9. Ghio AJ, Mazan MR, Hoffman AM, Robinson NE. Correlates between human lung injury after particle exposure and recurrent airway obstruction in the horse. *Equine Vet J* 2006;**38**:362–367.
10. Radon K, Winter C. Prevalence of respiratory symptoms in sheep breeders. *Occup Environ Med* 2003;**60**:770–773.
11. Baumgartner KB, Samet JM, Coultas DB *et al*. Occupational and environmental risk factors for idiopathic pulmonary fibrosis: a multicenter case-control study. Collaborating Centers. *Am J Epidemiol* 2000;**152**:307–315.
12. Schenker M, Christiani DC, Cormier Y. Respiratory health hazards in agriculture. *Am J Respir Crit Care Med* 1998;**158**:S1–S76.
13. Mastrangelo G, Tartari M, Fedeli U, Fadda E, Saia B. Ascertaining the risk of chronic obstructive pulmonary disease in relation to occupation using a case-control design. *Occup Med (Lond)* 2003;**53**:165–172.
14. Rylander R, Peterson Y, Donham KJ. Questionnaire evaluating organic dust exposure. *Am J Ind Med* 1990;**17**:121–126.
15. Bakirci N, Kalaca S, Francis H *et al*. Natural history and risk factors of early respiratory responses to exposure to cotton dust in newly exposed workers. *J Occup Environ Med* 2007;**49**:853–861.
16. Radon K, Danuser B, Iversen M *et al*. Respiratory symptoms in European animal farmers. *Eur Respir J* 2001;**17**:747–754.
17. Statistics NCfH: CDC. NCHS Public-Use Data Files and Documentation. Hyattsville, MD: US Department of Health and Human Services, CDC, National Center for Health Statistics, 1997. <http://www.cdc.gov/nchs/datawh/ftpserve/ftpdata/ftpdata.htm> (2 August 2006, date last accessed)
18. Frank PI, Morris JA, Hazell ML, Linehan MF, Frank TL. Smoking, respiratory symptoms and likely asthma in young people: evidence from postal questionnaire surveys in the Wythenshawe Community Asthma Project (WYCAP). *BMC Pulm Med* 2006;**6**:10.
19. Baillargeon J, Wilkinson G, Rudkin L, Baillargeon G, Ray L. Characteristics of the healthy worker effect: a comparison of male and female occupational cohorts. *J Occup Environ Med* 1998;**40**:368–373.
20. Mackiewicz B, Prazmo Z, Milanowski J, Dutkiewicz J, Fafrowicz B. Exposure to organic dust and microorganisms as a factor affecting respiratory function of workers of purebred horse farms. *Pneumonol Alergol Pol* 1996;**64**(Suppl. 1):19–24.
21. Gerber V, Robinson NE, Luethi S, Marti E, Wampfler B, Straub R. Airway inflammation and mucus in two age groups of asymptomatic well-performing sport horses. *Equine Vet J* 2003;**35**:491–495.

22. Robinson NE, Berney C, Eberhart S *et al.* Coughing, mucus accumulation, airway obstruction, and airway inflammation in control horses and horses affected with recurrent airway obstruction. *Am J Vet Res* 2003;**64**:550–557.
23. Kaup FJ, Drommer W, Damsch S, Deegen E. Ultrastructural findings in horses with chronic obstructive pulmonary disease (COPD). II: pathomorphological changes of the terminal airways and the alveolar region. *Equine Vet J* 1990;**22**:349–355.
24. Larsson BM, Larsson K, Malmberg P, Palmberg L. Airways inflammation after exposure in a swine confinement building during cleaning procedure. *Am J Ind Med* 2002;**41**:250–258.
25. Christiani DC, Ye TT, Wegman DH, Eisen EA, Dai HL, Lu PL. Cotton dust exposure, across-shift drop in FEV1, and five-year change in lung function. *Am J Respir Crit Care Med* 1994;**150**:1250–1255.
26. Crichlow EC, Yoshida K, Wallace K. Dust levels in a riding stable. *Equine Vet J* 1980;**12**:185–188.
27. McGorum BC, Ellison J, Cullen RT. Total and respirable airborne dust endotoxin concentrations in three equine management systems. *Equine Vet J* 1998;**30**:430–434.
28. Donham KJ, Cumro D, Reynolds SJ, Merchant JA. Dose-response relationships between occupational aerosol exposures and cross-shift declines of lung function in poultry workers: recommendations for exposure limits. *J Occup Environ Med* 2000;**42**:260–269.
29. Holness DL, O'Brien EL, Sass-Kortsak A, Pilger C, Nethercott JR. Respiratory effects and dust exposures in hog confinement farming. *Am J Ind Med* 1987;**11**:571–580.
30. Kilpelainen M, Terho EO, Helenius H, Koskenvuo M. Childhood farm environment and asthma and sensitization in young adulthood. *Allergy* 2002;**57**:1130–1135.