The Pennsylvania State University

The Graduate School

Department of Veterinary and Biomedical Sciences

A COMPREHENSIVE SURVEY OF OCCUPATIONAL HEALTH ISSUES OF WOMEN WORKING ON DAIRY FARMS IN PENNSYLVANIA

A Dissertation in

Pathobiology

by

Ginger D. Fenton

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

August 2009

The dissertation of Ginger D. Fenton was reviewed and approved* by the following:

Bhushan M. Jayarao
Professor of Veterinary and Biomedical Sciences/Extension Veterinarian
Dissertation Advisor
Chair of Committee

Subhashinie Kariyawasam
Assistant Professor/Veterinary Microbiologist

Robert J. Van Saun
Professor of Veterinary and Biomedical Sciences/Extension Veterinarian

Kathryn J. Brasier
Assistant Professor of Rural Sociology

Rama B. Radhakrishna
Professor of Agricultural and Extension Education

David R. Wolfgang
Field Studies Director/Extension Veterinarian

George F. Henning III
Associate Professor of Family and Community Medicine

Vivek Kapur
Professor of Veterinary and Biomedical Sciences
Head of the Department of Veterinary and Biomedical Sciences

*Signatures are on file in the Graduate School

ABSTRACT

Women play a significant role in Pennsylvania production agriculture, thereby potentially exposing them to occupational health risks. This cross-sectional study sought to assess the incidence of health conditions with a possible zoonotic origin in this underserved population. A written survey was sent to a stratified, random sample of dairy farms in Pennsylvania (n = 3709). In addition to providing demographic data, the survey respondents (n = 624) reported a low incidence of gastrointestinal illnesses, while respiratory problems which were reported by about 10%, were associated with lack of use of a breathing mask, and dermatoses, the most commonly reported conditions, were associated with growing fruits and/or vegetables, raising swine, and not wearing gloves. The use of personal protective equipment was infrequent. Most respondents, 89.7%, indicated that they felt they had minimal to no risk of contracting a disease from the animals with which they worked. The findings of the study suggest that many of the illnesses and conditions could have been acquired by working with dairy animals and their environment. Based on the findings of this study, additional investigations on the causes and prevention of these illnesses are warranted.

Environmental bio-aerosol and personal air samples were collected on dairy farms with milking parlors in Pennsylvania (n = 40). The average final total bacterial count ranged from 2.551 to 4.435 $\log_{10}$ CFU/m^3. The final total bacterial counts, Staphylococcal counts, presumptive *Staphylococcus aureus* counts, and *Enterobacteriaceae* counts were significantly different from the baseline counts. No correlations were observed between selected parlor variables including temperature and relative humidity and bacterial counts, however correlations were observed between the rate of cows milked per minute and Staphylococcal counts using the personal air sampler. *Escherichia coli* O157, *Listeria monocytogenes*, and *Salmonella* spp. were not recovered from air, therefore the occupational hazard resulting from airborne exposure to

these bacteria is uncertain. Species of Staphylococci including *S. warneri*, *S. hominis*, *S. xylosus*, *S. capitis*, *S. sciuri*, *S. lentus*, *S. cohnii ssp. cohnii*, *S. auricularis*, and *S. chromogenes* that were resistant to oxacillin and/or clarithromycin were recovered from the air.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I want to sincerely thank my advisor, Dr. Jayarao, for taking in "the refugee" and giving me the opportunity to work in his laboratory. It has been a pleasure to work in an environment where the emphasis is on learning and where everyone gets along and cooperates. Dr. Jayarao sets a great example of how to be a successful scientist and yet still maintain a balance in other areas of your life which I hope to be able to emulate some day.

Thank you to Beth and Marty for their advice, help, and friendship. They have been great coworkers and I will truly miss them. Thank you to Mandeep, Abhijit, Sailaja, Dr. Jason Brooks, Jason Baney, and Dr. Hegde for their assistance and advice on the project and for helping to make my transition to the department a smooth one. And to my dear friend Sarah… I miss you every day and I am so glad that I was able to work and learn from you with you even though the time was too short.

Thank you very much to Louise Byler who provided invaluable assistance in helping me find willing participants for both phases of the project. I also want to thank Carol, Kim and Hannah for their help with finding farms and equipment. Thank you to Amy for answering what seems like my endless amount of questions.

I want to thank each of my committee members for their help. You all have made valuable contributions and this wouldn't have been possible without you all.

Finally, I want to thank Matt. He provided that extra little push to get me here to begin with and has made many sacrifices on my behalf. Thank you to parents and my brother for always encouraging me, for raising me on a farm, and for fostering and nurturing my interest in science.

Chapter 1

Introduction

The agricultural industry employs a significant portion of the workforce in Pennsylvania. The sale of agricultural products is a major contributor to the economy in Pennsylvania as the Pennsylvania Department of Agriculture cites that nearly $45 billion comes from agriculture and agribusiness. According to the 2000 US Census Labor Force data for Pennsylvania, a total of 29,160 women were identified as farm managers or supervisors, agricultural product inspectors or graders, and miscellaneous agricultural workers; this accounts for nearly one-third of the total agricultural work force. The number of women with a primary role in agriculture in Pennsylvania as principal operators has increased from 6,079 in 2002 to 8,550 in 2007 according to the 2007 Census of Agriculture. The true contribution of women to agriculture in Pennsylvania is not reflected in these numbers as many more are involved in capacities that are not reported. Other changes in the demographics of the agricultural workforce such as the true portion of Hispanic workers including Hispanic women may not be accurately reflected in the employment statistics.

Even though women comprise a significant and vital part of the agricultural workforce in Pennsylvania, a void exists in studies on which they are the focus. Women's health has been deemed an area of special interest by the National Institutes for Health. The focus of this study is on health issues of women working in the agricultural industry in Pennsylvania. This study was undertaken to add to the relatively shallow breadth of knowledge regarding this topic and to provide insight and direction for future studies with regards to health status, demographic characteristics of the population, tasks that are performed by these women, and preventative measures that are practiced. This information also can be used to develop educational programs and short and long term preventative measures.

The objectives of the study were to create a valid survey instrument for use in assessing the exposure of diseases with possible zoonotic origin experienced by women working on dairy farms in Pennsylvania. We also sought to determine what tasks women perform, behaviors that could result in exposure to zoonotic disease, and preventative measures practiced by women on dairy farms. The results from the survey were applied in the second phase of the research. Respiratory problems were indicated by 9.8% of the survey respondents. The respondents also indicated that 70% milked cows on a daily basis, therefore data pertaining to exposures to bio-aerosols in milking parlors was examined. The focus of this study was to determine the number and type of bacteria in air samples collected in milking parlors, thereby gauging the likelihood of coming in contact with bacterial pathogens and determining whether this route of exposure constituted an occupational health risk. The final objective involved determining if the gram-positive, catalase positive bacteria from air samples that were collected in milking parlors demonstrated antibiotic resistance to oxacillin, amoxicillin/clavulanic acid, and clarithromycin.

Chapter 2

Review of Literature

2.1 Statistics and Trends

Many women in the United States are actively involved in farming. While little data exist as to the numbers of women involved with farming, data are available on women with primary roles on farms. A principal operator dedicates 50% or more of their work time to farming. The number of women with primary roles in farming, denoted as principal operator or operator, is increasing. According to the 2007 Census of Agriculture, the number of female principal farm operators in the United States has risen by 28.8% to a total of 306,209 since the previous Ag Census in 2002 was conducted.[1] The number of female operators who are not reported as principal operators, but are still considered as farm operators, increased by nearly 20% to a total of 985,192.[1] Pennsylvania is following this national trend as the number of female principal operators has increased from 6,079 in 2002 to 8,550 in 2007.[1] Of the farms in Pennsylvania that have female operators, 34.1% report that a woman is the principal operator. The number of female operators (as opposed to principal operators) in Pennsylvania also has increased but is slightly below the national percentage at 16.3% in Pennsylvania compared to 19.8% nationally.[1] The number of farm operators in Pennsylvania who are female is 26, 405.[1] It should be noted that these numbers reflect only women that are considered farm operators or principal operators, however, many more women are involved in farming in Pennsylvania in other capacities such as employees or in helping with their family farms.

The survey procedures used by the United States Department of Agriculture National Agriculture Statistics Service may introduce a bias. The surveys target women who are managers or owners of agricultural operations and therefore may be more likely to be white women who work on farms. The number of Hispanic and minority farm workers and operators may not be captured by these surveys if the respondent does not read English. Future surveys should be bi-lingual to ensure inclusion of all farming groups.

More than 50% of the nation's farms are operated by persons over the age of 55[1]. Female farm operators also appear older when comparing age categories in the data from the 2007 Census of Agriculture. Nationally, each of three age categories for operators over the age of 45 demonstrated increases greater than 45%, while in the three age categories for operators under 45 years one demonstrated a loss, one a gain of 20% and one held steady. Several possible scenarios exist to explain why the age of female farmers is increasing. Older women may be seeking to supplement their income by farming. These women may have inherited the farm or been left as sole owner and subsequently, assumed principal operation of the farm. Female farmers, like their male counterparts, may not retire from farming or may retire at later ages than observed in other industries. Further, the average age of all female operators in the United States has increased from 51.9 years to 54.0 years between 2002 and 2007 and from 56.7 to 58.8 years for principal operators.[1] This observation was similar for Pennsylvania except the average age of female operators increased from 48.3 to 51.4 years while principal operators in increased from 52.5 years to 55.9 years between 2002 and 2007.[1] Very large increases, with totals almost doubling, were noted by age category for the three categories of age 45 and over from the 2007 Census of Agriculture.

Age is an important consideration when examining health status because susceptibility to certain diseases increases with age as the body's immune system declines in function.[2,3,4,5] Foodborne illnesses such as campylobacteriosis, gastroenteritis due to *Escherichia coli* O157, salmonellosis, and listeriosis can be of special concern as older members of the population may take certain medications that can cause a shift in the pH of the digestive system or cause a shift in the microflora of the digestive system, thereby allowing pathogens to be more competitive.[2]

Research has indicated that the contribution to agriculture by women tends to be under-reported. Less documentation exists that describes the demographic characteristics and the work performed by women who work on farms who are not considered as principal operators. Despite their substantial contribution, many women do not consider themselves as primary operators, but rather they consider themselves as "agricultural helpers".[6] Some farmers do not consider voluntary farm work as work. A similar observation that a woman may refer to herself as a "farm wife" to indicate involvement in both the home and the farm, while not considering herself as a farmer was noted by another researcher.[7] Another reason that the role of women in agriculture may be under-reported is that women working on family farms may not be paid wages, therefore there is little governmental documentation of the contribution of these women.[8] Some farm women may downplay the work that they do, and therefore, do not report that work. Other researchers noted that women perceived their risks from injury on the farm were less because they did not view their farmwork as active involvement in production.[9]

The number of women who are considered as principal farm operators is increasing in the United States and in Pennsylvania, however Ag Census data do not reflect the total involvement of women in farming. The number of women who are involved with farming is underreported. This is due to women's perception of their involvement and because the work is frequently unpaid and subsequently not documented in government records. According to the Ag Census data, the overall age of women in farming is increasing, thereby increasing the susceptibility of this population to certain diseases.

2.2 Nature of Farm Work

Women are involved in farm work to varying degrees. In many cases, the type of farm operation dictates the role that women take in the farm work. Operations including dairy and livestock that required constant labor were more likely to utilize women for work.[7] Previous documentation indicated that women were more frequently involved with raising small animals.[10]

In the 2007 Census of Agriculture, higher numbers of female principal operators were reported as raising certain commodities including fruits, vegetables, and melons, some crops including sugarcane and hay, and animals including beef cattle and hogs. However, the largest increases were noted in the number of women raising small animals such as sheep, goats, poultry and eggs.[1] A recent trend in agriculture that may affect the role that a woman plays on a farm is the shift to smaller, more specialized farms.[10] The production practices on these farms may be tailored to operation by women.

When recounting their farm tasks, many farm women included taking care of animals among their responsibilities. Rosenfeld[7] reported that at least 50% of the women surveyed indicated that they took care of animals on the farm at least occasionally. Results from a survey of farm women in Louisiana (n = 657) indicated that 56.6% of the respondents worked with farm animals.[11] Other responsibilities reported in the study that could have health-related implications included hauling animals to market, applying pesticides, and driving a tractor.

Several studies aid in creating a snapshot of the typical lifestyle and habits of women on farms. A purposive sample of farm women in Saskatchewan indicated that 60% described themselves as "homemakers" who performed work on the family farm.[12] Working long hours was common as 40% reported that they worked 13 or more hours in a work day. The most commonly performed tasks were looking after cattle and horses, operating farm machinery, hauling grain, and carrying out the marketing and bookkeeping.[12]

Patterns of tractor usage by women provide insight into the type and frequency of work that women were performing on farms. Farmwomen in Louisiana and Texas were surveyed regarding tractor usage.[13] Of the women surveyed, 43.6% (n = 577) indicated that they drove a tractor at least 1 day per year. Women that drive tractors typically learned to drive them in their 20's, got their information from their spouses, and most frequently engage in rotary cutting and plowing.

Self-described farm homemakers from Kentucky (n = 992) and Texas (n = 665) were interviewed by telephone to develop a description of the type of work that these women undertook.[8] Of the women surveyed, 46% identified themselves as farm homemakers. Most were married, white, and indicated that they had insurance. In Kentucky, 54% were 50-69 years old, while 44% fell into this age category in the Texas survey. In Kentucky, 43.2% indicated that they worked with animals while 38.8% reported the same in Texas. Work with animals was the leading cause of injury. The authors noted that farm women may serve as "reserve labor" and be called to help at busy times.

Women on farms indicated farm work becomes part of their culture, thereby lending to a lack of leisure time and a propensity to work even when ill.[14] Several studies have referenced the "third shift phenomenon" during which farm women become fatigued and stressed in an attempt to balance a job away from the farm, household work including family/child care, and farm work.[15] However, farm women have been viewed by some as a healthier than average population due to the physical demands of the work and dietary differences including farm-raised food and higher consumption of fresh fruits and vegetables. In one study, farm women had significantly lower rates of stroke, ischemic heart disease, lower total serum cholesterol levels, and lower smoking rates when compared to women who did not live on farms,[16] however farm women had significantly higher rates of hypertension and were more likely to be overweight.

The type of farming operation may dictate the amount of involvement by women. Animal care is a farm task that is frequently performed by women. In addition to farm work, women typically are responsible for running the household. Some may work outside the home as well which leads to very long work hours and fatigue. In some aspects, farm women appear to have better health than the general population.

2.3 Zoonotic Disease

Working with animals or in animal environments presents a risk of contracting zoonotic diseases. Several studies have examined various exposures and the possible routes by which they have occurred. Due to the role that they play in the household, women who live with or care for farmers may be exposed to pathogens by their spouses. For example, a woman who washed her husband's clothing was infected with cryptosporidiosis from handling the contaminated clothing from an outbreak at his workplace.[17]

The prevalence of antibodies to selected zoonotic organisms was surveyed in a random sample of farmers and their families in England (n = 606 with 157 women) and compared to samples from public workers.[18] The prevalence to antibodies to *Coxiella burnetii* was 29.2% while it was 50.2% to toxoplasma, however much lower prevalences were observed for other organisms including *Borrelia burgdorferi* and leptospira both at 0.2% and brucella was 0.7%. The odds ratio for *Coxiella burnetii* increased with exposure to dairy cattle (OR 1.48; CI 1.03-2.12). *Coxiella burnetii*, *Leptospira*, and *Brucella abortus* exposure are of particular interest to women as these organisms are associated with abortions. This study examined the presence of antibodies, however it did not reflect illness or temporality of exposure.

While some of the zoonotic diseases discussed are reportable, there is no active surveillance system to monitor the incidence of these diseases among the farm population, therefore the actual exposure to these diseases is unknown.

2.4 Skin Problems

Skin problems due to agricultural exposures including chemicals, animals, or biologicals have been documented as an occupational health issue for farm women. A cross-sectional survey of Iowa farmers and their wives was conducted to determine the prevalence of dermatoses. The results from this study indicated that dermatoses were more commonly reported among farm wives than their male counterparts.[19] Dermatoses were defined as dermatitis, eczema, or any other red, inflamed skin rash. The affected sites most frequently reported by the wives were the hands followed by the head, face, or neck. Exposures reported included soaps, detergents, cleaning or disinfecting solutions and glues, pastes, or adhesives. Significant associations with dermatitis included a level of education beyond high school and exposure to petroleum products. Interestingly, the use of gloves was not related to dermatitis in males or females. In another study of California farm operators, 15.8% of women and 8.9% of men experienced dermatitis in the previous 12 months.[20] Logistic regression analysis revealed that gender was significant (OR 2.0; 95% CI 1.2-3.0) as was respiratory atopy (OR 1.4; 95% CI 1.01-1.90). In the previously mentioned study[18], the odds ratio for contracting ringworm (dermatophytosis) increased for those who reported work with cattle (OR 1.76; CI 1.17-2.64).

Although some skin disorders such as ringworm and scabies are considered as a zoonotic hazard to agricultural producers[21] due to contact with animals, no other studies could be found that detail the incidence of these conditions in women that work on farms. Several studies of migrant workers on fruit and vegetables farms exist, but there is a void related to exposures in female farm workers.

2.5 Gastrointestinal/Foodborne Illness

Numerous illnesses that are commonly associated with food also may present a risk of exposure due to work on a farm. Due to the farm environment, it can be difficult to determine whether the cause of such an illness can be attributed to a farm exposure or an outside exposure. Specific data pertaining to gastrointestinal illnesses and foodborne illness in farm women were not available. Causative agents of gastrointestinal disorders have been associated with farm exposures including dairy cattle and the consumption of raw milk. Through contact with dairy cattle, humans could be exposed to the following pathogens: *Salmonella* spp. *Campylobacter jejuni*, *E. coli* O157, *Listeria monocytogenes*, *Cryptosporidia parvum*, and *Giardia* spp.[22] Based on a study of farm families in Ontario, the researchers believed that many dairy farm residents experience subclinical immunizing infections with vero cytotoxigenic *E. coli* at a young age.[23] They believe that these exposures came from exposure to cattle carrying non-O157 strains. Twenty-one members of the sample group of farm familes were positive for VTEC in fecal samples. Study participants were less likely to carry antibiodies to vero cyctotoxin as age decreased.

Numerous foodborne illness outbreaks due to a variety of causative agents have been linked to raw milk consumptions. The following are some examples. An outbreak due to *E. coli* O157:H7 occurred in 2006 in California after 6 children became ill from the consumption of raw milk or raw colostrum.[24] Two of these children were hospitalized with hemolytic uremic syndrome (HUS). In Pennsylvania, 29 cases of illness due to *Salmonella enterica* serotype Typhimurium following consumption of raw milk and raw milk products.[25] Another *Salmonella enterica* serotype Typhimurium infection in 62 people was linked to raw milk consumption in Ohio in 2003.[26] *Campylobacter jejuni* was determined as the cause of 13 illnesses that resulted from raw milk consumption at a dinner.[27] Mexican-style cheese made from unpasteurized milk was implicated in twelve illnesses due to *Listeria monocytogenes* in a Hispanic community in North Carolina.[28]

Despite the possible presence of pathogens, raw milk is consumed by some farm families and other community members. During a survey of raw milk producers in Pennsylvania, 42.3% of the respondents (n = 248) reported consuming raw milk. In the same study, bulk tank samples from farmers also were analyzed and found to contain the following pathogens: *Salmonella* spp.

(6.0%), *Campylobacter jejuni* (2.0%), Shiga-toxin producing *E. coli* (2.4%), *Listeria monocytogenes* (2.8%), and *Yersinia enterocolitica* (1.2%).[29] Farm residents were three times more likely to consume raw milk. A survey of Wisconsin dairy producers (n = 587) found that raw milk consumption habits and risk perception were related to herd size with less consumption as herd size increased and the perception of greater risk as herd size increased.[30] Raw milk consumption within the previous year was reported by 45.3% of dairy producers (n = 150) in survey of New York Cooperative Extension clientele.[31]

In a study of related interest, data were not analyzed by gender, however an examination of deaths due to Crohn's disease and uclerative colitis indicated that agricultural occupations demonstrated significantly reduced mortality.[32] Further, a grouping by industry also indicated reduced mortality among livestock producers. The authors noted that physical jobs such as farming demonstrated lower rates than sedentary jobs.

Foodborne illness is underreported for reasons such as the illness is frequently attributed to other causes such as the flu or the illness may not be viewed as severe enough to seek medical attention. It can be difficult to determine the cause of foodborne illnesses especially among the farming population that is exposed to animals. Another risk factor that has been attributed to foodborne illness outbreaks is the consumption of raw milk. Farm families, especially those from smaller farms, report consuming raw milk.

2.6 Respiratory Illness/Exposure

Several studies of respiratory illness in farmers have included separate analyses of data for women or have focused entirely on farm women. In a stratified, random survey that was conducted through the National Agricultural Statistics Service farmers from all 50 states (n = 7,137) were included.[33] The results, indicated as prevalences for specific health problems among minority farmers and women, demonstrated that in general, women tended to have more respiratory and musculoskeletal problems than the men who were surveyed.

The Agricultural Health Study examined the health of pesticide applicators and their spouses in Iowa and North Carolina.[34] They concluded that growing up on a farm was protective for atopic asthma (OR 0.55; 95% CI 0.43-0.70). Animal exposures were not statistically significant, but an increased odds ratio was noted. However, that odds ratio included 1, thereby lacking unity. An association resulting in farmer's lung was made between spouses of pesticide applicators and work with dairy cattle. Farmer's lung was reported by 51 spouses (0.2%). Assessed exposures included hay and grain, animal, pesticides and other agricultural exposures such as diesel fumes or welding.

Farm-related health condition prevalence differed between men and women as stronger associations were observed for men.[35] The conditions for which farm women had a significantly higher prevalence than non-farm women were extrinsic allergic alveolitis, dislocations, and open wounds. Farm women were less likely to have asthma.

A study of Croatian farm workers including female workers demonstrated that exposures from farms could be responsible for respiratory symptoms and ventilatory capacity impairment.[36] Another study from the same researchers that focused on livestock farm workers demonstrated that most respiratory symptoms were more prevalent in farmers than in controls.[37] They reported that the length of employment was a significant factor for decreased lung function tests among female workers, while smoking was significant among male workers. A dose-dependent relationship was suggested between employment in agriculture and lung symptoms and changes in respiratory functions.

Of the respondents to a survey on respiratory symptoms and farming practices, 31% were women.[38] The survey results indicated that 36% of those responding had experienced symptoms consistent with organic dust toxic syndrome (ODTS) with symptoms that were likely to occur after handling grain. Interestingly, there was an association with the use of respirators and ODTS (OR, 2.7; 95% CI 1.3-5.9) possibly indicating that farmers began using respirators after experiencing respiratory symptoms. Female crop and livestock workers were included in a study where significantly elevated mortality was indicated when a comparison was made with non-agricultural workers.[39] Hypersensitivity pneumonitis was 10 to 50 times higher in the livestock and crop workers. The prevalence of wheeze was elevated for female farm workers.

Not all respiratory studies have yielded similar results. Contrary to other studies, a study that examined chronic bronchitis among nonsmoking farm women reported no association between animal exposures and chronic bronchitis, however applying manure to crops and operating a combine demonstrated a positive association.[40] Further, a group of women in Poland that primarily tended to animals on their family farms were exposed to amounts of dust within the allowable concentrations, however the researchers felt that agricultural dust exposure should still be considered a high health risk.[41]

In several studies, female farm workers were found to have a greater risk for respiratory problems than women employed in non-agricultural fields. While animal exposures are reported as a risk factor in some studies, not all researchers are in agreement on this. Other studies have not observed an increased risk due to work with animals. Research indicates that farm women may be less likely to experience asthma.

2.7 Reproductive Health Issues

Women manifest diseases differently than men due to hormonal and anatomic differences.[42] Pregnant women are more susceptible to certain infectious diseases for three reasons: changes in immunity and physiology, effects on the fetus may be unknown and difficult to predict and/or diagnose, and prophylaxis and treatment may not be appropriate for pregnant women.[43]

Several agents such as gases, zoonoses, veterinary obstetric drugs, and pesticide exposure are of concern to women working in agriculture. Gases associated with heating units in animal confinement operations such as carbon monoxide are a concern for pregnant women as they have been associated with acute abortion.[44] During a survey of female veterinarians, the most severe side-effect reported followed an accidental needlestick with the prostaglandin, dinoprost tromethamine, which resulted in a miscarriage at 15 weeks.[45] Farm women may have cause to handle veterinary obstetric drugs which subsequently may have harmful implications if improper usage occurs.

A case of intrauterine fetal death due to leptospirosis occurred at 23 weeks. Maternal leptospirosis was contracted as the mother assisted with milking cattle in a parlor in the UK.[46] *Borrelia burgdorferi* has caused fetal infections and been associated with stillbirth, however the authors caution that the low prevalence of the disease and poor sensitivity of diagnostic tests should be kept in mind when determining the clinical significance of these findings.[42] *Coxiella burnetii*, the causative agent of Q fever, poses a disproportionate threat to women as they take care of sheep or cattle.[42] This agent is known to have a low inhalational infectious dose.[42] Pregnant women are more likely to develop chronic Q fever with endocarditis than nonpregnant women.[42] Women in the UK who had midtrimester miscarriages (n = 136) were recruited for a study.[47] In an attempt to link zoonotic agents to the miscarriages, tests for *Toxoplasma*, L*eptospira*, *Chlamydia psittaci*, cytomegalovirus, *Listeria monocytogenes*, parvovirus B19 revealed one positive for cytomegalovirus and five of the 136 were positive for parvovirus B19.

Exposure to agricultural chemicals through maternal occupation in agriculture may increase the risk of limb defects.[48] Other studies that have examined fertility demonstrated differing results. Farm factors were protective of fertility including making a residence on a farm, ranch or in a rural area and drinking 3 or more glasses of milk per day.[49] These researchers also found that pesticide exposure had a negative effect on fertility. Women who were medically diagnosed as infertile (n = 281) completed a questionnaire about work history and other factors.[50] When compared to controls who gave birth in the same hospitals, women who worked in agricultural fields including crop or livestock farming, crop services, farm management, and horticulture were more likely to report infertility. The researchers suggested further investigation into exposure to pesticides or other toxic chemicals. The conclusions from a study that compiled data from multiple investigations indicated that further research needs to be conducted to make a link between stillbirths and exposure to agricultural chemicals during the second trimester.[51]

Another effect of agricultural work on pregnant women was determined using data collected during the Agricultural Health Study. This study indicated a two-fold increase in gestational diabetes mellitus associated with agricultural pesticide exposure during the first trimester with particular association of specific herbicides and insecticides.[52] Although it does not pertain to women's reproductive health, an interesting finding from a recent study was that pesticide poisoning was nearly double in female agricultural workers versus male workers, however the reasoning for this was unknown.[53]

Farm women may face exposures that could affect their reproductive health that women with other vocations may not face such as exposure to infectious diseases, toxic gases, pesticides or veterinary obstetric drugs. Some of these exposures have been linked to miscarriages. Pesticide exposure has been associated with an increased risk of limb defects, a negative effect on fertility and an increase in gestational diabetes. Pregnant women who work on farms need to exercise caution.

The data on exposure rates for many of the infectious diseases reported in the previous sections may be lacking. Exposure rates may be higher as there is no systematic collection of data or surveillance for some of these conditions. Recall bias may be introduced when data are collected through surveys. For conditions such as foodborne illness or skin conditions such as ringworm, the person who is affected by the condition may not think that it is serious enough to report or they may misdiagnose themselves and the condition will go unreported. For these reasons, it is difficult to obtain accurate data on the prevalence of these conditions.

2.8 Mental Health

Findings were varied as to mental health status and women with farm or rural residences. Farm women experience high levels of stress and fatigue due, in part, to role conflict and high workloads. Farm women are responsible for household tasks in addition to farm-related tasks.[54] Life on a farm may be associated with certain stressors to women including a lack of recognition for participation in the business, isolation both emotionally and geographically, shouldering large burdens without support for their own needs, lack of time to manage required tasks, and the possibility or aftermath of accidents and trauma.[55]

Researchers have examined specific behaviors in relation to depression on farms. Farm safety and depression were linked in a study that reported specific farm safety behaviors were less likely to be practiced by male and female farmers that were depressed.[56] A higher percentage of farm women was depressed as determined using the Center for Epidemiologic Studies-Depression scale. The only safety practice that differed by gender was that women were less likely to be calm around animals. Another study included a stratified, random sample of 657 farm women in southeast Louisiana that were at least 18 years of age.[57] Additional data were gathered through 30 phone interviews. Depressive symptoms were reported by 24% (95% C.I. 20.9-27.5) of the respondents. Depressive symptoms were more prevalent among divorced women, those with reduced health status, those who had experienced injury during farm work, and those participating in specific farm practices including pesticide use, tractor use, and long-term exposure. Women involved in farming for 20 or more years were more likely to show depressive symptoms. While some studies indicated a greater prevalence of depression among farm residents, a study of women of reproductive age between the ages of 18 and 45 in Central Pennsylvania indicated that farm residence may be protective of overall mental health.[58]

In a survey of farm families conducted in New York, the researchers concluded that men and women had differing views on farm health and safety concerns and they received their information from different sources.[59] The safety and health issue that was most concerning to women was physical injury and their own safety, while men were concerned with counseling needs related to farm accidents, skin hazards, and the convenience of medical services. Another study sought to determine the stressors affecting farmers and farm families in New York.[60] Finances were a stressor in 51% of the cases followed by family interactions and health problems. A stressor of note among middle-aged women was grief possibly due to the loss of parents, a spouse, or children. Notably, farmers were considered as relatively healthy individuals who were placed in stressful situations for extended periods of time.

The findings on mental health status among farm women are varied. Farm women have many stressors related to their work and lifestyle that other women may not have. Research has indicated that depression affects the likelihood of following safe practices on the farm. Other studies have noted that male and female farmers are plagued by different stressors.

2.9 Injuries

The role that a woman had on the farm such as management versus involvement in day to day production may dictate the type of exposures to injury that she faced.[61] A compilation of data from several studies indicated that women were at risk from injury by large animals.[61] These authors also raised the question as to whether farm women were injured more frequently performing tasks that they did on a regular basis or performing tasks occasionally when filling in for absentee helpers.

A group of women who were actively involved in farming in Louisiana and Texas was studied to determine the incidence of injuries.[62] Phone interviews conducted with those selected as part of a stratified, random sample indicated a 5% injury rate (95% CI 3.7-6.3). Lower body extremities were the most frequent sites of injury. Working on a large animal farm (OR 7.84; 95% CI 1.42-43.08) increased the risk of injury as did working more than 5-7 days a week on the farm (OR 3.10; 95% CI 1.53-6.30) and driving a tractor (OR 3.45; 95% CI 1.68-7.09).

During a case-control study conducted in Wisconsin, 2 major risk factors to females working on farms included the presence of bulls on the farm and the number of hours worked. An increased risk of 3% for every hour worked was demonstrated.[10] These findings added support to the third shift phenomenon experienced by women on farms who juggle family, household duties, off-farm work and farm work. The farms in the study area were primarily family-owned dairy farms and a cow was the primary source for injuries. Of the injuries that were reported 42.5% were to the lower extremities.

Female farmers were interviewed and then follow-up interviews were conducted for 2 consecutive years.[63] Of the participants, 12.1% reported some kind of injury related to agricultural work. While nearly 60% were injured one time, the others were injured more than once. Interestingly, those who reported injuries were: more likely to have depressive symptoms, between the ages of 30 and 39, or involved with farmwork for more than 30 years. These data may suggest a complacency that accompanies working on the farm for a longer period of time or fatigue due to the third shift phenomenon or reflect changes in agricultural practices over this time period. Also, the type of animals associated with the injuries in this study was small animals which is contradictory to other studies.

Results from a survey that included male and female farmers indicated those who worked with livestock including dairy cattle had a significantly higher risk of being injured.[64] Factors that were significant for injury in a logistic regression analysis included younger age, experiencing hearing loss, having joint trouble, being an owner/operator, working more hours per day, and being from a farm with higher gross sales.

Back pain was an occupational health problem associated with farming as it was reported in 22.5% of female farmers with the lower back being the part of the back that was most frequently injured.[65] The prevalence for males was slightly higher at 28.6%. Repeated activities were the most common cause and most injuries occurred at home. For both genders, three factors were significantly associated with back pain: being depressed (OR 3.68; 95% CI 2.23-6.09), farming or ranching as main activity (OR 1.66; 95% CI 1.17-2.36), and working in agriculture for 10 to 29 years (OR 1.62; 95% CI 1.14-2.30).

Differences in injuries were observed by gender in several studies. Both males and female farmers demonstrated similarities in rank order of injuries due to agricultural machinery.[66] Females under 14 years of age accounted for a greater portion of injuries than those who were in the age category of 60 and over, while the opposite was observed for males. Harvest season was when the highest rate of injury was observed for both genders. Tractors were the type of equipment that caused the most injuries while entanglements were the most common type of injury.

A case-control study of farm-related falls in a specific geographic area over a defined time revealed that men had a higher rate of falls, however after adjustments were made for hours worked, the rates for men and women were closer to equal.[67] Specific characteristics of the farm increased the risk of injury included being a dairy farm, having non-resident workers on the farm, 300 or more acres, 200 or more head of cattle and 40 or more milking cows.

Gender differences were noted in farm injuries in a Canadian study.[68] Higher numbers of men reported farm injuries, however more men work in agriculture. For farm equipment-related injuries, males were more likely to have been injured by from roll-overs while women were more frequently injured by run-over. Women were proportionally more likely to have been injured by an animal (horses or cattle), while women over 60 were most likely to have injured by falling.

Some possible explanations as to the difference in injuries between men and women were proffered following a study of dairy farms in New York.[69] A two-year observational study revealed higher rates of injuries than expected on dairy farms in New York. Factors that were significant for injuries included age with older workers being injured more frequently, more hours worked, and heavier workloads than the non-injured. Men were more frequently injured than women with a ratio of 2.8:1. The authors suggest possible reasons were that women perform fewer risky tasks on the farm and they may be safer workers. Additional study results indicated that owner/operators were most frequently injured (RR 2.76).

The association between stress and injury appears to differ by gender.[70] Women who were employed off the farm had a lower risk of injury than those who worked only on the farm. For both men and women, strains/sprains/torn ligaments were the most common injury with the most common anatomical site being upper extremities. Respondents who milked cows on a regular basis had increased odds ratios for injury. Risk of injury was especially pronounced among women who did not work off of the farm.

Work with large animals appeared to be a recurrent cause of injury to farm women as does working longer hours on the farm. Several studies also indicated that older farmers were more likely to be injured. Men also were more likely to be injured than women, however a larger percentage of men work in agriculture.

2.10 Prevention

Other researchers have examined the use of various preventative measures by women on farms. The findings from a retrospective cohort study of farm women indicated that farm life, in general, had preventative factors as farm women had lower mortality rate than non-farm women.[71] Protective factors that were suggested included diet such as a higher intake of high-fiber and low-fat foods, greater physical activity, and lower rates of alcohol consumption and smoking as compared to the general population.

The use of personal protective equipment was determined as related to the amount of time a woman worked on the farm in a week.[72] Women in southeast Louisiana (n = 519) most of whom worked on dairy or beef cattle (78.9%) farms were surveyed for 30 minutes by telephone. The survey focused on tasks performed and the use of personal protective equipment (PPE). Women who worked more than 20 hours per week on the farm were more likely to use PPE including hearing, eye, or breathing protection and gloves or boots. No differences in skin protection, hair holders, or helmets on ATVs were noted according to the hours worked.

The usage of other preventative health measures by women has been examined. A study of farm women at least 40 years in age in six rural counties in Minnesota revealed that 78% of respondents reported ever having a mammogram, while 49% reported having one within the preceding 12 months.[73] These findings indicated that these rates met or exceeded rates observed in urban settings and contradict the hypothesis that preventative care is underutilized in rural populations. In another study, women on farms in Wisconsin (n = 675) and a group of women who did not reside on farms (n = 825) were given brief examination, self-administered questionnaire, and their medical charts were checked for their most recent Pap smear, mammogram, blood pressure, and blood cholesterol measurements.[74] Farm residents were significantly less likley to have had Pap smears or blood pressure measurements. Finally, a stratified, random sample of 657 women in southeastern Louisiana was conducted to examine the utilization of tetanus immunizations.[11] Of those surveyed, 53.6% had current immunizations.

Findings are varied as to prevention practices utilized by farm women. Due to their rural location, researchers have explored whether farm women utilized preventative health practices. One study found that farm women were more likely than expected to have mammograms while other researchers found that farm women were less likely to have had a pap smear or blood pressure measurements. Women who worked longer hours on farms were more likely to employ personal protective equipment.

In summary, women continue to be involved in farmwork in the United States with more taking on roles as principal operators. However, the extent to which women are involved in farm work tends to be underreported because many women do not consider themselves as farmers and they are not paid for their labor. Women who work on farms have many demands on their time including farm work, caring for their family, and work off of the farm which can lead to stress and fatigue. One responsibility for many women on farms is caring for animals which is also a leading cause of injury.

In addition to injury, work with animals presents risks of infection from zoonotic diseases which, in some cases, can cause abortions. Gastrointestinal illnesses also may result from work with animals, however it is very difficult to link the exposure that caused the illness to work with farm animals. Raw milk consumption is a risk factor for gastrointestinal illness as many pathogenic bacteria can be found in raw milk. Although farming practices provide opportunity for skin problems to occur, there is little documentation on these problems as they pertain to farm women. Much more documentation exists regarding respiratory problems. Farm women have a greater likelihood of developing some respiratory problems when compared to women in non-farming occupations. Farm women also may be exposed to biological and chemical agents that could have negative effects on their reproductive health. Some aspects of farming present special risks to women, while other aspects of farming provide positive effects on the health of those involved.

2.11 References

1. U. S. Department of Agriculture. 2009 Census of Agriculture. Washington (DC): U. S. Department of Agriculture, National Agricultural Statistics Service. Available at: http://www.agcensus.gov. Accessed on 4/14/09.

2. Roberts CA. 2001. The food safety information handbook. Oryx Press: Westport, CT.

3. Smith JL. 1998. Foodborne illness in the elderly. *J Food Protect* 61:1229-1239.

4. Gerba CP, Rose JB, Haas CN. 1996. Sensitive populations: who is at the greatest risk? *Int J Food Micrbiol* 30: 113-123.

5. Meyers BR, 1989. Infectious diseases in the elderly: an overview. Geriatrics 44:4-6.

6. Sachs C. 1983. The invisible farmers. Rowman & Allenheld: Totowa, NJ.

7. Rosenfeld R. 1985. Farm women: work, farm and family in the United States. The University of North Carolina Press: Chapel Hill, NC.

8. Reed DB, Westneat SC, Browning SR, Skarke L. 1999. The hidden work of the farm homemaker. *J Agr Saf Health* 5(3):317-327.

9. Stallones L, Beseler C. 2003. Farm work practices and farm injuries in Colorado. *Inj Prev* 9:241-244.

10. Stueland DT, Lee BC, Nordstrom DL, Layde PM, Wittman LM, Gunderson PD. Case-control study of agricultural injuries to women in Central Wisconsin. *Women Health* 25(4):91-103.

11. Holland C, Carruth AK. 2001. Exposure risk and tetanus immunization in women of family owned farms. *AAOHN J* 49(3):130-136.

12. Kubik W, Moore RJ. 2005. Health and well-being of farm women: contradictory roles in the contemporary economy. *J Agr Saf Health* 11(2):249-256.

13. Carruth AK, Skarke L, Gilmore K, Brown ER. 2006. Potential exposure to hazardous work activities: tractor usage among farmwomen. *J Agromed* 11(3/4):25-34.

14. Bolwerk CAL. 2002. The culture of farm work and it's implications on health, social relationships and leisure in farm women and men in the United States. *J Cult Div* 9(4):102-107.

15. Gallagher E, Delworth U. 1993. The third shift: juggling, employment, family, and the farm. *J Rural Community Psychol* 12(2):21-36.

16. Eaker ED, Wittman LM, Bergs RE. 2000. The rural women's health study: health and behavior of farm and nonfarm resident women. *Wisc Med J* 99(1):37-40.

17. Reif JS, Wimmer L, Smith JA, Dargatz DA, Cheney JM. 1998. Human cryptosporidiosis associated with an epizootic in calves. *Am J Public Health* 79(11):1528-1530.

18. Thomas DR, Salmon RL, Coleman TJ, Morgan-Capner P, Sillis M, Caul EO, Morgan KL, Paiba GA, Bennett M, Ribeiro D, Lloyd G, Kench SM, Meadows D, Softley P, Chalmers RM. 1999. Occupational exposure to animals and risk of zoonotic illness in a cohort of farmers, farmworkers, and their families in England. *J Agr Saf Health* 5(4):373-382.

19. Park H, Sprince NL, Whitten PS, Burmeister LF, Zwerling C. 2001. Farm-related dermatoses in Iowa male farmers and wives of farmers: a cross-sectional analysis of the Iowa Farm Family Health Hazard Surveillance Project. *J Occup Environ Med* 43(4):364-369.

20. Susitaival P, Beckman R, Samuels SJ, Schenker MB. 2004. Self-reported dermatitis and skin cancer in California farm operators. *Am J Ind Med* 46:136-141.

21. Langley RL, Morrow WEM. 1997. Zoonotic hazards in humans in agriculture, forestry, and fisheries. In Safety and health in agriculture, forestry, and fisheries. Langley RL, McLymore RL, Meggs WJ, and Roberson GT, Eds. Government Institutes Inc.: Rockville, MD.

22. Wells SJ, Ott SL, Hillberg Steitzinger A. 1998. Key health issues for dairy cattle –new and old. *J Dairy Sci* 81:3029-3035.

23. Wilson JB, Clarke RC, Renwick SA, Rahn K, Johnson RP, Karmali MS, Lior H, Alves D, Gyles CL, Sandhu KS, McEwen SA, Spika JS. 1996. Vero cytotoxigenic *Escherichia coli* infection in dairy farm families. *J Infect Dis* 174:1021-1027.

24. Centers for Disease Control. 2008. Escherichia coli)157:H7 infections in children associated with raw milk and raw colostrums from cows –California, 2006. *Morb Mortal Wkly Rep* 57(23):625-628.

25. Centers for Disease Control. 2007. Salmonella typhimurium infection associated with raw milk and cheese consumption –Pennsylvania, 2007. *Morb Mortal Wkly Rep* 56(44):1161-1164.

26. Mazurek J, Salehi E, Propes D, Holt J, Bannerman T, Nicholson LM, Bundesen M, Duffy R, Moolenaar RL. 2004. A multistate outbreak of *Salmonella enterica* serotype typhimurium infection linked to raw milk consumption –Ohio, 2003. *J Food Protect* 67(10):2165-2170.

27. Peterson MC. 2003. Campylobacter jejuni enteritis associated with consumption of raw milk. *J Environ Health* 65(9):20-21,24,26.

28. Boggs JD, Whitwarm RE, Hale LM, Briscoe RP, Kahn SE, MacCormack JN, Maillard JM, Grayson SC, Sigmon KS, Reardon JW, Saah JR. 2001. Outbreak of listeriosis associated with homemade Mexican-style cheese –North Carolina, October 2000-January 2001. *J Am Med Assoc* 286(6):664-665.

29. Jayarao BM, Donaldson SC, Straley BA, Sawant AA, Hegde NV, Brown JL. 2006. A survey of foodborne pathogens in bulk tank milk and raw milk consumption among farm families in Pennsylvania. *J Dairy Sci* 89:2451-2458.

30. Hoe FGH, Ruegg PL. 2006. Opinions and practices of Wisconsin dairy producers about

biosecurity and animal well-being. *J Dairy Sci* 89:2297-2308.

31. Kaylegian KE, Moag R, Galton DM, Boor KJ. 2008. Raw milk consumption beliefs and practices among New York state dairy producers. *Food Protect Trends* 28(3):184-191.
32. Cucino C, Sonneberg A. 2001. Occupational mortality from inflammatory bowel disease in the United States 1991-1996. *Am J Gastroenterol* 96(4):1101-1105.
33. Alterman TA,Steege L, Li J, Petersen MR, Muntaner C. 2008. Ethnic, racial, and gender variations in health among farm operators in the United States. *Ann Epidemiol* 18(3):179-186.
34. Hoppin JA, Umbach DM, London SJ, Henneberger PK, Kullman GJ, Alavanja MCR, Sandler DP. 2008. Pesticides and atopic and nonatopic asthma among farm women in the Agricultural Health Study. *Am J Resp Crit Care* 177:11-18.
35. Greenlee RT, Zentner J, Kieke Jr. B, Elliot J, Marlenga B. 2005. Farm health surveillance in the Marshfield Epidemiologic Study Area: a pilot study. *J Ag Saf Health* 11(2):211-218.
36. Kern J, Mustajbegovic J, Schachter EN, Zuskin E, Vrcic-Keglevic M, Ebling Z, Senta A. 2001. Respiratory findings in farmworkers. *J Occup Environ Med* 43(10):905-913.
37. Mustajbegovic J, Zuskin E, Schachter EN, Kern J, Vrcic-Keglevic M, Vitale K, Ebling Z. 2001. Respiratory findings in livestock workers. *J Occup Environ Med* 43(6):576-584.
38. Von Essen S, Fryzek J, Nowakowski B, Wampler M. 1999. Respiratory symptoms and farming practices in farmers associated with an acute febrile illness after organic dust exposure. *Chest* 116:1452-1458.
39. Greskevitch M, Kullman G, Bang KM, Mazurek JM. 2007. Respiratory disease in agricultural workers: mortality and morbidity statistics. *J Agromed* 12(3):5-10.
40. Valcin M, Henneberger PK, Kullman GJ, Umbach DM, London SJ, Alavanja MCR, Sandler DP, Hoppin JA. 2007. Chronic bronchitis among nonsmoking farm women in the Agricultural Health Study. *J Occup Environ Med* 49:574-583.

41. Molocznik A, Zagorski J. 2000. Exposure of female farmers to dust on family farms. *Ann Agr Env Med* 7:43-50.

42. Theiler RN, Rasmussen SA, Treadwell TA, Jamieson DJ. 2008. Emerging and zoonotic infections in women. *Infect Dis Clin N Am* 22:755-772.

43. Jamieson DJ, Theiler RN, Rasmussen SA. 2006. Emerging infections and pregnancy. *Emerg Infect Dis* 12(11):1638-1642.

44. Donham KJ, Thelin A. 2006. *Agricultural medicine: occupational and environmental health for health professionals.* Blackwell Publishing: Ames, IA.

45. Wilkins JR, Bowman ME. 1997. Needlestick injuries among female veterinarians: frequency, syringe contents and side-effects. *Occup Med* 47(8): 451-457.

46. Aker N, James EB. 1996. Leptospirosis in pregnancy: an unusual and relative unrecognized cause of intrauterine death in man. *J Obstet Gynaecol* 16(3):163-165

47. Sanghi A, Morgan-Capner P, Hesketh L, Elstein M. 1997. Zoonotic and viral infection in fetal loss after 12 weeks. *Brit J Obstet Gynaec* 104:942-945.

48. Engel LS, O'Meara ES, Schwartz SM. 2000. Maternal occupation in agriculture and risk of limb defects in Washington State, 1980-1993. *Scand J Work Environ Health* 26(3):193-198.

49. Greenlee AR, Arbuckle TE, Chyou P. 2003. Risk factors for female infertility in an agricultural region. *Epidemiol* 14(4):429-436.

50. Fuortes L, Clark MK, Kirchner HL, Smith EM. 1997. Association between female infertility and agricultural work history. *Am J Ind Med* 31:445-451.

51. White FM, Cohen FG, Sherman G, McCurdy R. 1988. Chemicals, birth defects and stillbirths in New Brunswick: associations with agricultural activity. *Can Med Assoc J* 138(13):117-1224.

52. Saldana TM, Basso O, Hoppin JA, Baird DD, Knott C, Blair A, Alavanja MCR, Sandler DP. 2007. Pesticide exposure and self-reported gestational diabetes mellitus in the Agricultural Health Study. *Diabetes Care* 30(3):529-534.

53. Calvert GM, Karnik J, Mehler L, Beckman J, Morrissey B, Sievert J, Barrett R, Lackovic M, Mabee L, Schwartz A, Mitchell Y, Moraga-McHaley S. 2008. Acute pesticide poisoning among agricultural workers in the United States, 1998-2005. *Am J Ind Med* 51:883-898.

54. Fraser CE, Smith KB, Judd F, Humphreys JS, Fragar LJ, Henderson A. 2005. Farming and mental health problems and mental illness. *Int J Soc Psychiatr* 51:340-349.

55. Bushy A. 1998. Health issues of women in rural environments: an overview. *J Am Med Women Assoc* 53(2):53-56.

56. Stallones L, Beseler C. 2004. Safety practices and depression among farm residents. *Ann Epidemiol* 14:571-578.

57. Carruth AK, Logan, CA. 2002. Depressive symptoms in farm women: effects of health status and farming lifestyle characteristics, behaviors, and beliefs. *J Commun Health* 27(3):213-228.

58. Hillemeier MM, Weisman CS, Chase GA, Dyer A. 2008. Mental health status among rural women of reproductive age: findings from the Central Pennsylvania Women's Health Study. *Am J Public Health* 98(7):1271-1279.

59. Dewar DM. 1996. Farm health and safety issues: do men and women differ in their perceptions? *AAOHN J* 44(8):391-401.

60. May JJ. 1998. Clinically significant occupational stressors in New York farmers and farm families. *J Agr Saf Health* 4(1):9-14.

61. McCoy CA, Carruth AK, Reed DB. 2002. Women in agriculture: risks for occupational injury within the context of gendered role. *J Agr Saf Health* 8(1):37-50.

62. Carruth AK, Skarke L, Moffett B, Prestholdt C. 2001. Women in agriculture: risk and injury experiences on family farms. *J Am Med Women Assoc* 56(1):15-18.

63. Xiang H, Stallones L, Chiu Y, Epperson A. 1998. Non-fatal agricultural injuries and risk factors among Colorado female farmers. *J Agromed* 5(4):21-33.

64. Hwang S, Gomez MI, Stark AD, St. John TL, May JJ, Hallman EM. 2001. Severe farm injuries among New York farmers. *Am J Ind Med* 40:32-41.

65. Xiang H, Stallones L, Keefe TJ. 1999. Back pain and agricultural work among farmers: an analysis of the Colorado Farm Family Health and Hazard Surveillance Survey. *Am J Ind Med* 35:310-316.

66. Locker AR, Pickett W, Hartling L, Dorland JL. 2002. Agricultural machinery injuries in Ontario, 1985-1996: a comparison of males and females. *J Agr Saf Health* 8(2):215-223.

67. Nordstrom DL, Layde PM, Olson KA, Stueland D, Follen MA, Brand L. 1996. Fall-related occupational injuries on farms. *Am J Ind Med* 29:509-515.

68. Dimich-Ward H, Guernsey JR, Pickett W, Rennie D, Hartling L, Brison RJ. 2004. Gender differences in the occurrence of farm related injuries. *Occup Environ Med* 61:52-56.

69. Pratt DS, Marvel LH, Darrow D, Stallones L, May JJ, Jenkins P. 1992. The dangers of dairy farming: the injury experience of 600 workers followed for two years. *Am J Ind Med* 21:637-650.

70. Simpson K, Sebastian R, Arbuckle TE, Bancej C, Pickett W. 2004. Stress on the farm and its association with injury. *J Agr Saf Health* 10(3):141-154.

71. Wang Y, Hwang S-A, Lewis-Michl EL, Fitzgerald EF, Stark AD. 2003. Mortality among a cohort of female farm residents in New York State. *Arch Environ Health* 58(10):642-648.

72. Meeker BJ, Carruth A, Holland CB. 2002. Health hazards and preventative measures of farm women. *AAOHN J.* 50(7):307-314.

73. Carr WP, Maldonado G, Leonard PR, Halberg JU, Church TR, Mandel JH, Dowd B, Mandel JS. 1996. Mammogram utilization among farm women. *J Rural Health* 12(4):278-290.

74. McCarty CA, Chyou P-H, Greenlee R, McCarty DJ, Gunderson P, Reding D. 2003. Differences in preventative screening rates in Wisconsin farm and non-farm resident women. *Wis Med J* 102(5):22-26.

Chapter 3

Occupational Health Characteristics of Women on Dairy Farms in Pennsylvania

G. D. Fenton, K. J. Brasier, G. F. Henning, R. B. Radhakrishna, B. M. Jayarao

The Department of Veterinary and Biomedical Sciences

The Pennsylvania State University

University Park, PA 16802

To be published in the Journal of Agromedicine (2009). Nov. 14 (4).

3.1 Abstract

Women play a significant role in Pennsylvania production agriculture, thereby exposing them to occupational health risks. The goal of this cross-sectional study was to assess the incidence of health conditions with a possible zoonotic origin in this underserved population.

A written survey was sent to a stratified, random sample of dairy farms in Pennsylvania (n = 3709) using a modified version of the Dillman method. In addition to demographic data, the survey was used to collect information on the occurrence of zoonotic diseases, gastrointestinal illnesses, respiratory problems, dermatoses, and women's reproductive health issues. Of the 624 respondents, 10.4% (n = 65) reported that they had contracted a disease from an animal. Interestingly, only 9 respondents indicated that they had suffered from foodborne illnesses in the past year including salmonellosis (n = 1), campylobacteriosis (n = 1), and gastroenteritis due to *Escherichia coli* (n = 1). A risk factor associated with difficulty breathing was the lack of use of a breathing mask, while ventilation in the free stall area appeared to offer a protective effect. Difficulty breathing was reported by 9.8% (n = 61) of the respondents. Risk factors associated with skin disorders included growing fruits and/or vegetables, raising swine, and not wearing gloves when milking. The findings of the study suggest that many of the illnesses and conditions could have been acquired by working with dairy animals and their environment. Based on the findings of this study, additional investigations on the causes and prevention of these illnesses are warranted.

3.2 Introduction

Persons employed in agricultural occupations, regardless of their gender, face many risks of injury or illness due to occupational exposure to hazards including machinery, chemicals and pesticides, temperature extremes, biological hazards, and injuries from animals through their work. While researchers have examined the occupational health risks of farm-related injuries, a void exists in data related to occupational risks of infectious diseases in women working in animal agriculture. Women comprise a significant and growing portion of the production agriculture workforce and play a key role in the daily functions of the farm. Reports demonstrated that female principal farm operators in Pennsylvania rose in number by 21.4% between 1997 and 2002 to a total of 6,079.[1] It is of note that female principal operators only represent a small portion of women working on dairy farms because many of the women involved with dairy farming in Pennsylvania do not consider themselves as principal operators. The majority of women who are principal operators in Pennsylvania typically raise poultry, sheep or goats, beef cattle, crops, are involved with aquaculture or other livestock production that is not categorized, or operate nurseries[2]. While the number of female principal operators in agriculture has increased dramatically, the number of female principal operators on dairy farms has seen a very slight increase[2].

Women farmers are at risk for many reasons. The average age of farmers is increasing[3,4], and with this increase in age, comes greater occupational health risks from zoonotic disease as susceptibility increases with age. Data from the 2002 Census of Agriculture indicated that the national average age of female farmers was 56.7 years, while it was 55.3 years for all farm principal operators.[1] Occupational health risks to women vary according to the role in which they serve on the farm.[5] Women face some unique occupational health risks related to farming. Such as, some farming hazards can influence their reproductive health or affect an unborn child. Several zoonotic disease agents such as *Coxiella burnetti* (Q fever), *Listeria monocytogenes* (listeriosis), *Leptospira interrogans* (leptospirosis), and *Brucella abortus* (brucellosis) can cause abortions.[6] Health care professionals may overlook diseases with zoonotic origin, therefore animal handlers need to be aware of possible hazards related to their work and to report these encounters to their physician if they become ill.[7]

Surveillance for work-related illnesses in farming is inadequate.[8] Surveillance can be difficult as the farm workforce frequently includes family members and turnover of hired help can be frequent due to the nature and demands of the work. It is difficult to quantify the risks of agricultural work because many farms are small family farms that do not have enough employees to require reporting of illnesses and injuries (10 or fewer employees).[9] Further complicating the matter of reporting illnesses on farms is the difficulty in determining whether these illnesses can be attributed to work on the farm can be difficult to trace or the specific causative agent could come from other sources unrelated to farming. The objective of this study was to assess the exposure of diseases with possible zoonotic origin experienced by women working on dairy farms in Pennsylvania.

3.3 Materials and Methods

3.3.1 Study Population

The subjects for this cross-sectional study were females who were at least 18 years of age, worked on dairy farms in Pennsylvania, and had direct contact with dairy cattle on at least a monthly basis. A cooperative agreement was arranged through the Pennsylvania Field Office of the National Agricultural Statistics Service (NASS) that allowed the mailing of surveys to a stratified, random sample of Pennsylvania dairy farms in their database (n = 9,293). The sample was stratified according to the number of cows that were milked on the farm, henceforth referred to as herd size. The strata were as follows: stratum 1: ≤49, stratum 2: 50-99, stratum 3: 100-199, stratum 4: 200-499, stratum 5: ≥500.

3.3.2 Survey Instrument

A total of 3,709 surveys were mailed to dairy farms of various sizes throughout Pennsylvania. The survey instrument was developed from a model of possible routes of exposure to likely zoonotic diseases on dairy farms and the factors that may affect exposure. (See Figure 1.) Based on a review of the literature, four areas of interest were chosen on which to focus the health-related questions: gastrointestinal disorders, skin conditions, respiratory disorders, and women's reproductive health issues. The survey instrument also included sections on demographic information about the farm and the respondent such as health status, educational background, prevention practices, and the use of personal protective equipment that could be related to possible exposure to disease.

To establish content validity, the survey instrument was reviewed by a panel of experts including a physician, veterinarians, and several extension professionals who work with the dairy industry. The survey instrument also was pilot-tested by a group of women (n = 14) who worked on dairy farms in two counties in Pennsylvania to establish reliability. The women were asked complete the survey as well as provide feedback on clarity, omissions, readability, time to complete, and suggestions for improvement. The Cronbach's alpha was calculated at 0.971 for the ordinal questions in the survey. All materials were approved by the Internal Review Board for Human Subjects through the Penn State University Office for Research Protections (#25237). A modified version of the Dillman method[10] was used for mailing the surveys. The method was modified because a pre-notification mailing was not included.

3.3.3 Statistical Analysis

All data were entered into SPSS 16.0 (SPSS, Inc., Chicago, IL). Descriptive statistics including frequency, mean, and standard deviation were calculated for demographic characteristics as well as the health-related data. Educational level was measured using an ordinal scale and a corresponding number was assigned to each level for analysis. T-tests, one-way analysis of variance (ANOVA) tests, and logistic regression also were performed when applicable. Mann-Whitney tests were performed instead of t-tests for the ordinal education data and for data that were not normally distributed according to a Kolmogorov-Smirnov test.[11]

3.4 Results

3.4.1 Response Rates

While a total of 870 responses were received, 246 of the responses received could not be analyzed because the recipient did not have a dairy farm, no women worked on the farm, or other reasons. The valid response rate was 17.7% when recipients without a dairy farm or those that did not have any women working on the farm were excluded. The response rates varied according to herd size strata. (See Table 1.) The surveys were addressed to the farms as they were listed in the NASS database for Pennsylvania. To maintain the confidentiality of the list members, the surveys were addressed to a farm, not specifically to a woman on the farm, therefore some farms may not have had a women involved with the operation. Although they were listed in the database, 125 surveys were returned incomplete because they did not reach a dairy farm. Due to the confidentiality associated with cooperating with NASS for mailing, options for increasing the response rate were limited because the researchers did not have access to the mailing list for follow-up contacts with non-respondents. However, non-respondents typically respond in a manner similar to late respondents, therefore generalizability can be increased by comparing late respondents with early respondents using key variables[12]. T-tests, used to compare key demographic variables of the early and late respondents, indicated very little significant difference in the groups. Overall, the number of surveys returned from each county correlated (R^2 = 0.849) with the number of dairy farms in each county which was reported by the 2002 Census of Agriculture, however stratification for mailing was according to herd size, not by county.

3.4.2 Respondent Demographics

The respondents indicated an average age of 47 ± 13 years with a minimum of 18 and a maximum of 86. All but one of the respondents were born in the United States and 55% (n = 344) indicated that they were raised on dairy farms. Respondents from larger farms were more likely to have traveled outside of the United States in the previous year. The farm property served as the current residence for 92% (n = 575) of the respondents. The roles on the farm of the respondents varied with 67.7% (n = 422) classifying themselves as owners or partners. On average, the respondents reported spending 4.8 ± 2.9 hours per day with the herd. The demographic characteristics of the respondent are of note when considering some of the relevant health issues.

3.4.3 Skin Disorders

The term skin disorder referred to any problem with the skin in the past year including rash, eczema, dermatitis or inflammation. Skin problems were the most commonly reported health condition of those in the survey. These problems were reported by 16.7% (n = 104) of the respondents, however only 43.3% (n = 45) of those with a skin condition sought medical treatment. The hands (44.2%; n = 46) and the arms (47.1%; n = 49) were the areas most commonly affected and itchy skin (80.8%; n = 84) or red patches of skin (61.5%; n = 64) were the most common symptoms. (See Table 2.) Additional analysis using logistic regression indicated several risk factors for skin disorders including the production of fruits and/or vegetables on the farm, raising swine in addition to dairy cattle, and not using gloves while milking. Operating a pressure washer appeared to have a protective effect.

3.4.4 Respiratory Disorders

Difficulty breathing was a problem that 61 of 624 (9.8%) of the respondents indicated they had experienced within the past year of which 19 (31.8%) were smokers. (See Table 3.) Smoking was reported by 22 of 624 (3.5%) of the respondents. Analysis of the data using logistic regression did not indicate a significant association between smoking and difficulty breathing. The logistic regression analysis further indicated factors that appeared to have a protective effect against difficulty breathing including the use of a breathing mask and the presence of ventilation in the free stall area. (See Table 3.)

3.4.5 Gastrointestinal Disorders

A total of 9 cases (1.4%) of foodborne illness were reported in the previous year. These diagnoses were not confirmed with medical records rather they were self-reported by the respondent. The respondent was asked in the survey to report foodborne illnesses and further asked if these illnesses had been diagnosed by a physician. (See Table 4). Salmonellosis, campylobacteriosis, giardiasis, and gastroenteritis due to *Escherichia coli* were among the nine cases of foodborne illness reported while the causes of the other five cases were unknown. Additional analysis of the foodborne illness incidence was not conducted due to the low number of cases reported.

3.4.6 Other Health Conditions

Contracting a disease from an infected animal was reported by 10.4% (n = 65) of the respondents. (See Table 4.) The condition that was most commonly reported was ringworm (8.7%; n = 54), followed by pinkeye (0.6%; n = 4), and Lyme disease (0.5%; n = 3). Changes in farming activities within the past year due to health conditions were reported by 8.0% (n = 50) of the women. The average age of respondents was 47.0 years old while the average age of those who indicated that they had changed activities was 49.2 years old and not statistically significantly different (p = 0.172).

3.4.7 Reproductive Conditions

Most of the women who responded to the question (89.6%; n = 536) indicate that they had been pregnant in the past. On average, the respondents who reported pregnancies worked in the barn until 9.7 days before their delivery. Some indicated that they worked in the barn until the day that they delivered. Irregular or painful menstruation was reported by 43.8% (n = 273) of the women. There were no reports of listeriosis or Q-fever and one case of brucellosis was reported, although this was not confirmed by medical records. It is of note that Pennsylvania eradicated brucellosis in cattle and was granted brucellosis free status in 1983. These infectious diseases do not appear to have played a role in the reproductive health of the respondents. There also were no notable observations with regards to veterinary obstetric drug usage and women's reproductive health issues.

3.4.8 Raw Milk Consumption

Raw milk consumption is an issue of continuing debate because, while it may contain pathogens and has been associated with foodborne illness outbreaks, some feel that there are beneficial reasons for consuming raw milk. Raw milk consumption habits were included in this survey to gain insight about the connection between raw milk consumption and various illnesses. The majority of the respondents (76.9%; n = 476) indicated that they consumed raw milk (Table 5). As such, the assumption was explored that many of those who did not drink raw milk may be older as they may have written "used to" or "did for __ years". An independent sample t-test indicated a significant difference (p = 0.044) between the ages of those who consumed raw milk and those who did not. Consumers of raw milk were younger by an average of 2.8 years, although this may be of little practical significance. There was a significantly higher consumption of raw milk by those who had farms with smaller herd sizes, reported a greater number of pregnancies, and had lower education levels.

3.5 Discussion

The reported skin problems could be attributed to many causes, some of which may not have a biological origin. Chemicals that are frequently employed on dairy farms such as iodine, teat dips, sanitizers, abrasive cleaners, and insecticides could be a cause for skin irritation. Raising fruits and vegetables in addition to dairy cattle also may be a source of exposure to yeasts, molds, or pesticides. Latex allergies or sensitivities may affect those who wear gloves. Future studies of this nature should include questions about other exposures. Interestingly, operating a pressure washer had a protective effect against skin problems which is the opposite of what might be expected. The use of a pressure washer may be a confounder because the majority of respondents who reported operating a pressure washer also indicated that they wore gloves when milking.

The frequency of reports of difficulty breathing was lower than observed in other studies. Potentially hazardous conditions in air quality previously have been demonstrated in dairy barns.[13] A survey in New York reported that 18.6% of the female respondents indicated that they had experienced wheezing within the past 12 months.[14] Another study demonstrated increased odds ratios for wheeze in all individuals that milked cows, regardless of atopy or asthma status.[15]

Based on the reported tasks performed by the respondents, they may have a lower likelihood of performing some tasks that could pose a greater hazard such as moving animals, pressure washing, or removing manure from the barn, however milking and feeding were commonly performed and have a stronger association with difficulty breathing. Sawdust and straw were reported as the most frequently used bedding materials. More than 70% of respondents indicated that the stall area of the barn was ventilated. It is possible that the respondents may work in ventilated areas which could contribute to fewer reports of difficulty breathing. The type of housing for cattle reported was 38.9% (n = 243) tie stalls, 28.7% (n = 179) free stalls, 14.1% (n = 88) stanchions, 13.6% (n = 85) multiple types of housing and the remainder reporting other types. However, these data reflect where the cattle are housed, but may not reflect where the women spend time working which may be more dependent on the type of milking facility. The 27.9% of respondents that reported milking in a parlor, therefore they are more likely to spend time in the parlor working versus where the cattle are housed, whereas 55% (n = 343) of respondents indicated milking with a pipeline and the 7.2% (n = 45) who indicated using bucket milkers and would be more likely to spend more time in the area where the cattle are housed. The logistic regression results were specific to ventilation in the free stall area of the barn as opposed to the stall area and may have little biological relevance if the women are not likely to spend a great deal of time working in this area. The average herd size of the farms was 78 head of cattle, therefore on these smaller farms, women may perform many tasks and frequently move from task to task which may allow them to be outside or in ventilated areas with greater frequency.

Exposure to gastrointestinal illness can occur through the consumption of raw milk or if pathogens are ingested due to poor hygiene practices or lack or protective equipment. Milk is readily available at dairy farms, therefore farm families and employees frequently consume raw milk. Despite the large number of participants consuming raw milk, relatively few foodborne illnesses were reported on this survey. Many foodborne illnesses go unreported or are misdiagnosed. The current survey asked only about foodborne illnesses experienced within the previous year instead of lifelong experiences, however it is likely that the portion of respondents who grew up on a farm have been consuming raw milk and working with animals for many years. More than 75% of the respondents indicated that they had private wells for their water supply which could serve as another source for bacterial contamination. Many behaviors, in addition to raw milk consumption, can be related to foodborne illness outbreaks.

A limitation to the current study is the use of self-reported data. Some exposures may be difficult to accurately diagnose without the aid of medical professionals. The low response rate is another limitation. The researchers made efforts to increase the response rate by using the Dillman method for mailing. Additional analysis was conducted to increase the generalizability of the findings by making comparisons between the early and late respondents as previously discussed. Mailing the surveys through a cooperative agreement with NASS provided access to a large sample population as well as a truly random sample, however several sampling errors may be attributed to the sampling method including possible frame error as some of those receiving surveys did not have dairy farms, selection error again as some recipients did not meet the criteria, and non-response error to which limited improvements could be applied due to confidentiality agreements with NASS. Limited detail was collected about the various health conditions in an effort to keep the survey length to a minimum, however this was a limitation because information on alternate exposures, causes and diagnoses was omitted. Because the survey was self-administered, readability was an important consideration which also limited the amount of detail that could be asked regarding exposures and the conditions reported. Another limitation with the survey instrument is the inability to make a temporal association with exposures.

3.6 Conclusions

The current survey provides additional insight into selected aspects of the current health status of women working on dairy farms in Pennsylvania. In general, many respondents commented on their good health, however some zoonotic diseases were reported that may be attributed to work on a dairy farm. This study brings to the forefront issues facing the underserved population of female farmers and may facilitate more focused exploration on the specific health issues related to work on a dairy farm. Recommendations for future studies include alternate exposures such as chemicals, yeasts, and molds that could cause skin irritations, more in-depth analysis of air quality to develop a greater understand of respiratory exposures and illnesses resulting from work in dairy barns, and a more detailed analysis of foodborne illnesses over a longer period of time.

3.7 References

1. U. S. Department of Agriculture. 2002 Census of Agriculture–counting diversity in American Agriculture. Washington (DC); U. S. Department of Agriculture, National Agricultural Statistics Service; 2004.
2. U. S. Department of Agriculture. 2007 Census of Agriculture-Table 50 Women Principal Operators –Selected Characteristics: 2002 and 2007 –Pennsylvania. Washington (DC): U. S. Department o f Agriculture. National Agricultural Statistics Service: 2009.
3. Frank AL, McKnight R, Kirkhorn SR, Gunderson P. 2004. Issues of agricultural safety and health. Annu Rev Public Health. 2004; 25:225-245.
4. Amshoff SK, Reed DB. Health, work, and safety of farmers ages 50 and older. Geriatr Nurs. 2005; 26(5):304-308.
5. McCoy CA, Carruth AK, Reed DB. Women in agriculture: risks for occupational injury within the context of gendered role. J Agric Saf Health. 2002; 8(1):37-50.
6. Langley RL, Morrow WEM. Zoonotic hazards in humans in agriculture, forestry, and fisheries. In: Langley RL, McLymore RL, Meggs WJ, Roberson GT, editors. Safety and Health in Agriculture, Forestry, and Fisheries. Rockville, MD: Government Institutes; 1997. p. 127-141.
7. Warick C. Gastrointestinal disorders: are health care professionals missing zoonotic causes? J Roy Soc Promot Health. 2004; 24(3):137-142.
8. Rautiainen RH, Reynolds SJ. Mortality and morbidity in agriculture in the United States. J Agric Saf Health. 2002; 8(3):259-276.

9. United States Department of Labor. OSHA Publication 169: Recordkeeping. Washington (DC): United States Department of Labor, Occupational Safety and Health Administration; 2001.

10. Dillman DA. Mail and internet surveys: the tailored design method. New York, NY: John Wiley & Sons, Inc.; 2000.

11. Zar JH. Biostatistical analysis. Upper Saddle River, NJ: Prentice Hall; 1999.

12. Radhakrishna, RB, Doamekpor, P. Strategies for generalizing findings in survey research. J Ext. 2008;46. Available at: http://www.joe.org/joe/2008april/tt1.php.

13. Kullman GJ, Thorne PS, Waldron PF, Marx JJ, Ault B, Lewis DM, Siegel PD, Olenchock SA, Merchant JA. Organic dust exposures from work in dairy barns. Am Ind Hyg Assoc J. 1998; 59:403-413.

14. Gomez MI, Hwang S, Lin S, Stark AD, May JJ, Hallman EM. Prevalence and predictors of respiratory symptoms among New York farmers and farm residents. Am J Ind Med. 2004; 46:42-54.

15. Hoppin JA, Umbach DM, London SJ, Alavanja MCR, Sandler DP. Animal production and wheeze in the Agricultural Health Study: interactions with atopy, asthma, and smoking. Occup Environ Med. 2003; 60:e3. Available at: http://www.occenvmed.com/cgi/content/full/60/8/e3.

Table 3.1 depicts the sampling scheme and response rate by herd strata that was developed in cooperation with the Pennsylvania Field Office of the National Agricultural Statistics Service.

Stratum	**Number of Cows**	**Number Mailed**	**Percent of Sample**	**Number Returned**	**Percent Returned**
1	≤49	1892	38.5	240	12.7
2	50-99	1306	43.4	271	20.8
3	100-199	388	13.9	87	22.4
4	200-499	95	3.2	20	21.1
5	≥500	28	1.0	6	21.4
	Total	3709	100.0	624*	

*246 additional responses were unable to be analyzed because the recipient did not have a dairy farm (n = 125), no women worked on the farm (n = 78), they were returned blank (n = 22), they were completed by a minor (n = 13), or for other reasons (n = 8).

Table 3.2 lists the frequency of occurrence of skin disorders within the previous year, the areas of the body that were affected, the symptoms and risk factors.

	Frequency	Percent	Odds Ratio (95% C.I.)	P-Value
Skin condition in past 12 months	104	16.7		
Medical treatment	45	43.3		
Area Affected				
Hands	46	44.2		
Arms	49	47.1		
Face, head, or neck	28	26.9		
Legs	33	31.7		
Other body part(s)	14	13.5		
Symptoms				
Itchy skin	84	80.8		
Dry skin	48	46.1		
Scaly patches of skin	36	34.6		
Red patches of skin	64	61.5		
Swollen patches of skin	20	19.2		
Produce fruits and/or vegetables	136	21.8	1.83 (1.01, 3.33)	.047
Raise swine	50	8.0	2.79 (1.31, 5.96)	.008
Pressure washing	172	27.6	0.45 (0.31, 0.99)	.045
Not wearing gloves when milking	318	51.0	1.75 (1.04, 2.96)	.036

Table 3.3 provides the frequency of respiratory problems, the symptoms, the time of day when the problems are apparent and possible risk factors.

	Frequency	Percent	Odds Ratio (95% C.I.)	P-Value
Difficulty breathing	61	9.8		
And red eyes	33	54.0		
And dizziness	16	26.2		
And coughing	60	98.3		
And wheezing	41	67.2		
And other symptoms	11	18.0		
Time of day				
In the morning	28	45.9		
In the afternoon	10	16.4		
In the evening	22	36.1		
At night	25	40.1		
Ventilation in free stall area	177	28.4	0.35 (0.15, 0.82)	.016
Not using a breathing mask	195	31.3	2.34 (1.23, 4.45)	.010

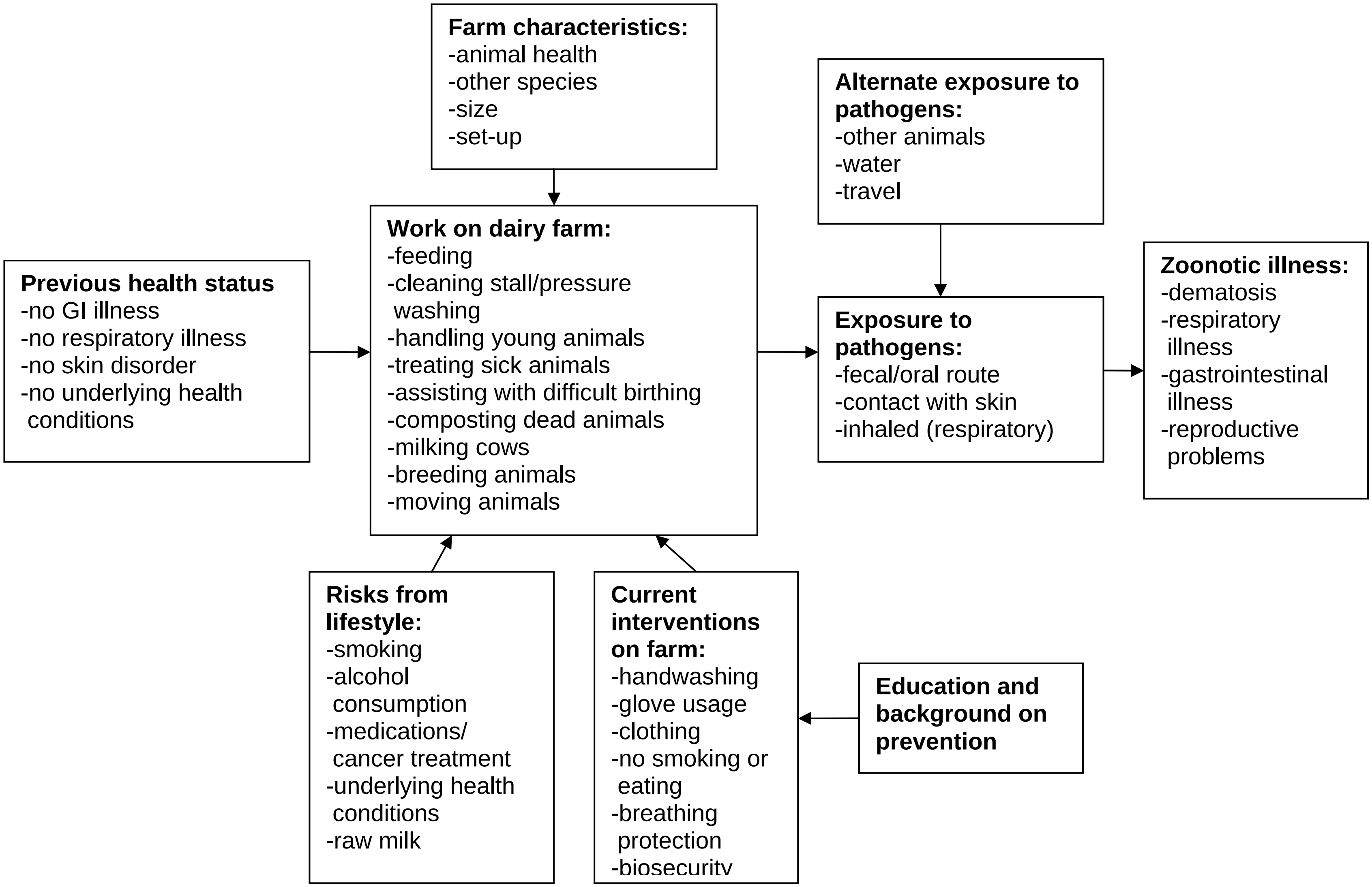
Table 3.4 includes gastrointestinal conditions, zoonotic diseases and conditions related to handling animals.

	Frequency	**Percent**
Contracted a disease from an infected animal	65	10.4
Health caused change in farming activity	50	8.0
Irritable Bowel Syndrome	24	3.8
Other diseases (not zoonotic)	19	3.0
Foodborne illness in past 12 months	9	1.4
Inflammatory Bowel Syndrome	5	0.8
Crohn’s Disease	3	0.5
Ulcerative Colitis	3	0.5
Colitis	3	0.5
Other zoonotic disease	3	0.5
Brucellosis	1	0.2
Tuberculosis	1	0.2
Tick fever	1	0.2
Q-fever	0	0
Leptospirosis	0	0

Table 3.5 depicts the significance of selected demographic characteristics related to raw milk consumption habits.

	Consume raw milk	Do not consume raw milk	Significance
Consumption habits	76.9%	23.1%	
Average age in years	46.5	49.3	0.044
Average herd size	63.8	125.8	0.002
Average hours per day with herd	4.7	5.1	0.114
Number of pregnancies	4.03	2.96	<0.0001
Education level*	2.42	2.88	<0.0001
Education levels were as follows: 1 = less than high school, 2 = high school diploma, 3 = some post-high school education, 4 = 2 year degree, 5 = 4 year degree, 6 = graduate or professional degree			

Figure 3.1: Model for Zoonotic Disease Risk and Dairy Farm Work



Chapter 4

Occupational Health Behaviors and Habits of Women on Dairy Farms in Pennsylvania

G. D. Fenton, K. J. Brasier, G. F. Henning, R. B. Radhakrishna, B. M. Jayarao

The Department of Veterinary and Biomedical Sciences

The Pennsylvania State University

University Park, PA 16802

To be published in the Journal of Agromedicine (2009). Nov. 14 (4).

4.1 Abstract

The goal of this study was to determine what tasks women perform, behaviors that could result in exposure to zoonotic disease, and preventative measures practiced by women on dairy farms. A written survey was sent to a stratified, random sample of dairy farms in Pennsylvania (n = 3709) using a modified version of the Dillman method.

The tasks most commonly performed by the respondents (n = 624) included milking (70.8%), feeding (60.6%), and cleaning stalls (42.6%). The use of personal protective equipment was infrequent. Gloves were always worn when milking by 32.7%. More respondents, 96.5%, changed their clothes at least sometimes before working in the barn as compared to when leaving the barn. Handwashing was always performed by 86.7% after assisting with delivering calves, while 71.1% always washed their hands after milking. Eating and drinking in the barn were practiced by 45.0% and 72.0%, respectively. Veterinary obstetric drugs were administered by 28.2% of the respondents. Most of the respondents, 89.7%, indicated that they felt they had minimal to no risk of contracting a disease from the animals with which they worked.

4.2 Introduction

Research has demonstrated that the contribution to agriculture by women tends to be under-reported. In Pennsylvania in the year 2000, a total of 29,160 women were recorded as farm managers or supervisors, agricultural product inspectors or graders, or miscellaneous agricultural workers.[1] Despite their substantial contribution, many women do not consider themselves as primary farm operators, but rather they consider themselves as “agricultural helpers”.[2] A similar observation noted that women may refer to themselves as a “farm wife” to indicate involvement in both the home and the farm, while not considering themselves as farmers.[3] Some farm women may downplay the work that they do and therefore, do not report it as work. Researchers previously noted that women may have perceived less risk due to injury on the farm because they did not view their farm work as active involvement in production.[4]

Women are involved in farm work to varying degrees. In many cases, the type of farm operation dictates the role that women take in the farm work. In one study, women were more likely to be involved in farming activities on a livestock operation than they were on a crop farm.[5] Women frequently work directly with animals and include animal care with their responsibilities.[3,6] Operations including dairy and livestock that required constant labor were more likely to utilize women for work.[3]

Work with animals is accompanied by inherent occupational health risks. In previous studies, animal care was determined to be the leading cause of injury.[4,7] Women who worked with large animals were at an increased risk for injury when performing tasks such as milking, feeding, and cleaning the barn.[8] Dairy farming was designated as an especially hazardous type of agriculture, particularly for injuries, because it involved a high volume of animal contact during milking[9,10] and infrequent use of protective equipment when cleaning and milking.[11] Injury has been demonstrated to be an occupational risk to women in animal production agriculture; however data on zoonotic disease risk that women face due to frequent animal contact is not readily available.

Certain behaviors can expose farm workers to a greater risk of ingesting zoonotic pathogens through a fecal/oral route.[12] This concern has come to light in recent years as illness outbreaks have resulted from exposure to animals at county fairs and petting zoos where food consumption and a lack of adequate handwashing facilities were mingled.[13] Personal habits in the barn also can serve as risk factors for zoonotic disease exposure. In order to reduce the spread of pathogenic bacteria to farmers from cattle, between cattle and between farms, various protective measures can be used including disposable gloves, changing clothing, changing or cleaning boots, and washing hands. The goal of this study was to determine what tasks women perform, behaviors that could result in exposure to zoonotic disease, and preventative measures practiced by women on dairy farms.

4.3 Methods

All subjects in this cross-sectional study were at least 18 years old, worked on a farm located in Pennsylvania, and had direct contact with dairy cattle on at least a monthly basis. A cooperative agreement was arranged through the Pennsylvania Field Office of the National Agricultural Statistics Service (NASS) that allowed the mailing of surveys to a stratified, random sample of Pennsylvania dairy farms in their database (n = 9,293) using a modified version of the Dillman method.[14] The Dillman method was modified in that no pre-notification was sent to potential respondents. These farms were stratified in the database according to the number of cows that were milked on the farm, also referred to as herd size. A total of 3,709 surveys were mailed to dairy farms of various sizes throughout Pennsylvania. Due to a concern of respondent burden, the cooperator, NASS, eliminated a portion of farms (n = 831) from the current study that previously were randomly selected to take part in routine sampling.

The survey instrument was developed by the researchers and included sections on demographic information about the participant and the farm, the tasks performed by the participant, the perceived risks faced by the participant, the usage of personal protective equipment, and hygiene habits. To establish content validity, the survey instrument was reviewed by a panel of experts including a physician, veterinarians, several extension professionals who work with the dairy industry, an evaluation specialist, and a faculty member who works with women in agriculture. The survey instrument also was pilot-tested by a group of women (n = 14) who worked on dairy farms in two counties in Pennsylvania to establish reliability. The women were asked complete the survey as well as provide feedback on clarity, omissions, readability, time to complete, and suggestions for improvement. The Cronbach's alpha was calculated at 0.971 for the ordinal questions in the survey. All materials were approved by the Internal Review Board for Human Subjects through the Penn State University Office for Research Protections (#25237).

All data were entered into SPSS 16.0 (SPSS, Inc., Chicago, IL). Reliability analyses were performed using SPSS. Descriptive statistics including frequency, mean, and standard deviation were calculated for the responses when applicable. T-tests and one-way analysis of variance (ANOVA) tests also were performed when applicable. Data were stratified by herd size as reported in the survey and not by the original stratification through NASS for additional analysis. The following categories were used: 49 or fewer, 50 to 99, 100 to 199, 200 to 499, and 500 or more. Nominal, ordinal and ratio data were collected.

4.4 Results

The valid response rate was 17.7% when recipients without a dairy farm or those that did not have any women working on the farm were excluded. While a total of 870 responses were received, 246 of the responses received could not be analyzed because the recipient did not have a dairy farm, no women worked on the farm, or other reasons. The response rated varied according to herd size strata. (See Table 1.)

4.4.1 Demographic Information

The respondents had an average age of 47.0 ± 12.7 years. The farm was the current residence of 92.1% (n = 575), while 55.0% (n = 344) indicated that they were raised on a dairy farm. The majority of the respondents (67.7%; n = 422) considered themselves as an owner or partner in the farm. All but one of the respondents (99.8%; n = 623) was born in the United States. Education levels varied with 14.8% (n = 92) reporting a 4-year degree or a professional degree, 6.1% (n = 38) indicating a 2-year degree, 56.1% (n = 349) had a high school degree or some post-high school education, and 23.0% (n =143) reported that they did not have a high school diploma. Involvement in the dairy industry for 21 or more years was reported by 67.4% (n = 421).

The type of housing for the cattle could influence the amount and type of contact that women have with the cattle. The type of housing for cattle reported was 38.9% (n = 243) tie stalls, 28.7% (n = 179) free stalls, 14.1% (n = 88%) stanchions, 13.6% (n = 85) multiple types of housing and the remainder reporting other types. However, these data reflect where the cattle are housed, therefore, the type of milking system that is employed may provide a more accurate reflection of where the women are working and provide insight into the amount and type of contact that the women may have with cattle. The 27.9% (n = 174) of respondents that reported milking in a parlor, therefore they may have less contact and differing exposures when compared to women milking with a pipeline (55%; n = 343) or bucket milkers (7.2%; n = 45).

The average amount of time spent per day with the herd varied by farm size. (See Table 2.) Some of the respondents indicated no time was spent with the herd on average, while others indicated they spent as many as 16 hours a day on average. A one-way ANOVA of hours spent with the herd according to herd size demonstrated a significant difference ($p<0.001$) in time spent as herd size changed, while post hoc analysis using a Tukey HSD test demonstrated a significant difference between the lowest herd size stratum and the two strata of middle sizes.

4.4.2 Tasks Performed

When the respondents were asked whether there are animal handling tasks that they will not perform because they or others feel these tasks could be hazardous to their health, 15.7% (n = 98) responded affirmatively. Some of the specific tasks mentioned included handling a bull 2.6% (n = 16), giving lutalyse or prostaglandins 2.6% (n = 16), moving or sorting cattle 2.4% (n = 15), milking heifers or problem cows 1.0% (n = 6), giving injections of any type 0.8% (n= 5), and lifting heavy objects 0.5% (n = 3). Other responses were given with less frequency. A notable observation in Table 3 is that most task frequencies increase with herd size with the exception of herds with 500 or more head of cattle which decrease in frequency, possibly indicating more specialized job tasks on very large farms.

By assessing the tasks that women are most likely to perform on the farm, we can gain a better understanding of the possible hazards to which they are most likely exposed. Some farm tasks appear to be routinely performed by most women. (See Table 3 for frequencies of tasks performed.) Tasks that need not performance on a routine basis, especially on smaller farms, include euthanizing animals, composting animals, and breeding animals, and have a much lesser likelihood of ever be performed by most women on the farm.

There was variation in the frequency of performance of various tasks according to herd size. For some tasks such as moving animals, assisting with breeding animals, and identifying young such as by tattooing or ear tagging, there was little variation by herd size. However, respondents from farms with smaller herd sizes were more likely to be involved with feeding animals, removing manure from the barn, and cleaning stalls. Respondents from farms with larger herd sizes were more frequently involved in treating sick animals and vaccinating animals. No significant difference was observed in the average number of tasks performed by a respondent according to herd size as determined by a one-way ANOVA.

4.4.3 Use of Protective Measures

The usage of personal protective equipment (PPE) on a regular basis was infrequent. (See Table 4.) Women who regularly wear eye glasses may consider them as eye protection and may have included themselves in the 36.0% (n = 218) of the respondents that indicated that they wore eye protection at least rarely. Glove usage when milking appeared to be related to herd size since higher percentages indicated that they always wore gloves as herd size increased.

4.4.4 Risk Perception and Training

Only 17 respondents (2.7%) indicated that they felt a moderate or considerable risk of getting a disease from the cattle with which they work (Table 5), yet 10.4% (n = 65) indicated that they had contracted a disease from an animal and another 3.2% (n = 20) were unsure as to whether or not they had contracted a disease from an infected animal. A Kruskal-Wallis test was performed after the moderate and considerable choices were combined and the “don’t know” response was dropped. This test indicated that there was no significant difference in risk perception according to herd size ($p = 0.424$). None of the respondents with herds of 500 or more head of cattle nor those who were over 65 years old felt that their risk was greater than minimal.

Most respondents (81.9%; n = 511) report learning to work with cattle on their family farm (Table 6). This proportion is 30% higher than the proportion of women who indicate that they were raised on a dairy farm (55.1%; n = 344), therefore it is likely that these women learned when they went to work on a dairy farm or married a dairy farmer. The methods of learning varied by herd size with more than 50% of the women from farms with 200-499 and 500 or more cows indicating that they learned through books and magazines in combination with other methods.

4.5 Discussion

Many respondents are engaging in potentially risky behaviors related to working with animals, but they do not perceive them as risky. This may be at least partially related to the lack of training. Informal and self-taught education methods including learning from others on the farm, learning on the job, and reading books or magazine were the most common methods that women reported utilizing when learning to work with cattle. The largest portion of those who learned on-line was observed in herd of 500 or more cows. All of the respondents with a herd size of 200 or more head of cattle had at least a high school education while the rates observed for those with less than a high school education were higher with smaller herd sizes. Female farmers tend to prefer less formal methods of education and may not utilize learning opportunities at producer meetings.[15] Newsletters, articles in farm publications, on-line learning modules, and hands-on, informal programs that specifically target women may be possible methods for delivery of educational programming.[16]

The question has been posed as to whether women are being injured as a result of tasks performed everyday or due to tasks that are occasionally performed (uncommon exposures).[5] This suggestion could be parlayed to disease exposure as proper precautions may not be used with tasks that are not routinely performed. Based on the physical nature of some tasks, it is reasonable to assume that women are less likely to perform them. Many women also indicate never performing tasks that involve machinery operation such as transporting manure, composting, or using a pressure washer. Of the tasks listed that are performed, a larger portion of women indicate performing a greater number of these tasks on a monthly basis rather than on a daily or weekly basis. Many respondents denoted a differentiation if they fed calves as opposed to feeding cows since a greater volume of animal contact could be observed when feeding calves. Differentiation of these tasks would be beneficial in future studies.

The use of breathing masks and the use of respirators were included as separate items on the survey to clearly distinguish which type of protective equipment was being utilized. The use of PPE and other protective measures appears to be less frequent than previously reported. The infrequent use of gloves when respondents had cuts or wounds on their hands or when they treated sick animals hints at a lack of concern or possibly lack of knowledge regarding the possible transmission of zoonotic disease. There may be other reasons that gloves are not used such as a skin irritation, an allergy to latex, or usage could be viewed as time-consuming or a hassle. Since the risk perception of contracting a zoonotic disease is low, the respondents may not feel that they need to wear gloves. However, handwashing appears to be the protective measure that is most frequently employed by the respondents. Handwashing may be more engrained in daily habits than other protective measures. There may be a lack of awareness regarding the possibility of clothing, boots, or other objects serving as a fomite for potential pathogen transfer and subsequent illnesses. Another notable observation is that more caution appears to be used to prevent taking pathogens away from the barn than from introducing pathogens. In general, biosecurity practices may be less stringent on dairy farms as opposed to other types of farm operations possibly due to a lack of awareness, lack of education on protective practices, and a lower risk of disease transmission.

A limitation to the current study is the use of self-reported data. There may be recall bias as the respondents report the activities that were performed and the frequency. The low response rate is another limitation. Due to confidentiality issues associated with the NASS database, the options for follow-up with non-respondents were limited. The researchers made efforts to maximize the response rate by using the Dillman method for mailing. Additional analysis was conducted to increase the generalizability of the findings by making comparisons between key variables for the early and late respondents using t-tests[17]. There was very little difference in the groups. Another limitation the survey instrument is the limited time frame covered as tasks that have been performed in the past year and not lifetime exposures.

4.6 Conclusions

Based on the tasks that women on dairy farms reported performing most frequently, they are at risk of exposure to zoonotic pathogens, however these risks are perceived as minimal by most women. Additional studies may seek to further explore the reasoning behind this perception. Further studies may be conducted to examine the types of pathogens and the risk of illness related to the routes of exposure resulting from the performance of the tasks indicated in the present study.

4.7 References

1. Pennsylvania Department of Labor and Industry. US census labor force data by gender for farming, fishing, and forestry occupation in Pennsylvania for 2000. Harrisburg: Pennsylvania Department of Labor and Industry, Center for Workforce Information and Analysis; 2000.
2. Sachs C. The invisible farmers. Totowa, NJ: Rowman & Allenheld; 1983.
3. Rosenfeld R. Farm women: work, farm, and family in the United States. Chapel Hill, NC: University of North Carolina Press; 1985.
4. Stallones L, Beseler S. Farm work practices and farm injuries in Colorado. Inj Prev 2003;

9:241-244.

5. Meeker BJ, Carruth A, Holland CB. Health hazards and preventative measures of farm women. AAOHN J. 2002; 50(7):307-314.

6. McCoy, CA, Carruth AK, Reed DB. Women in agriculture: risks for occupational injury within the context of gendered role. J Agric Saf Health. 2002; 8(1):37-50.

7. Reed DB, Westneat SC, Browning SR, Skarke L. The hidden work of the farm homemaker. J Agric Saf Health. 1999; 5(3):317-327.

8. Donham KJ, Thelin A. Agricultural medicine: occupational and environmental health for health professionals. Ames, IA: Blackwell Publishing; 2006.

9. Von Essen SG, McCurdy SA. Health and safety risks in production agriculture. West J Med. 1998; 169(4):214-220.

10. Boyle D, Gerberich SG, Gibson RW, Maldonado G, Robinson RA, Martin F, Renier C, Amandus, H. . Injury from dairy cattle activities. Epidemiology. 1997; 8(1):37-41.

11. Cecchini, M, Monarca, D, Porceddu, PR. Workers' safety in milking premises. J Agric Saf Health. 2005; 11(3):293-300.

12. Campagnolo, ER, Warwick MC, Marx Jr HL, Cowart RP, Donnell HD, Bajani MD, Bragg SL, Esteban JE, Alt DP, Tappero, JW, Bolin CA, Ashford DA. Analysis of the 1998 outbreak of leptospirosis in Missouri in humans exposed to infected swine. Vet Med Today. 2000; 216(5):676-682.

13. Durso, LM, Reynolds, K, Bauer, Keen, JE. Shiga-toxigenic *Escherichia coli* O157:H7 infections among livestock exhibitors and visitors at a Texas county fair. Vector Borne Zoonotic Dis. 2005; 5(2): 193-201.

14. Dillman, D. Mail and Internet surveys: the tailored design method. New York, NY: John Wiley & Sons, Inc.; 2000.

15. Trauger AK, Sachs C, Barbercheck M, Kiernan NE, Brasier. Agricultural education: gender

identity and knowledge exchange. J Rural Studies 2008; 24:432-439.

16. Barbercheck M, Brasier K, Kiernan NE, Sachs C, Trauger A, Findeis J, Stone A, Moist L. Meeting the extension needs of women farmers: a perspective from Pennsylvania. J Ext; forthcoming.

17. Radhakrishna, RB, Doamekpor, P. Strategies for generalizing findings in survey research. J Ext. 2008;46. Available at: http://www.joe.org/joe/2008april/tt1.php.

Table 4.1 depicts the sampling scheme and response rate by herd strata that was developed in cooperation with the Pennsylvania Field Office of the National Agricultural Statistics Service.

Table 1: Survey Response Rate by Strata

Stratum	Number of Cows	Number Mailed	Percent of Sample	Number Returned	Percent Returned
1	≤49	1892	38.5	240	12.7
2	50-99	1306	43.4	271	20.8
3	100-199	388	13.9	87	22.4
4	200-499	95	3.2	20	21.1
5	≥500	28	1.0	6	21.4
	Total	3709	100.0	624*	

*246 additional responses were unable to be analyzed because the recipient did not have a dairy farm (n = 125), no women worked on the farm (n = 78), they were returned blank (n = 22), they were completed by a minor (n = 13), or for other reasons (n = 8).

Table 4.2 demonstrates the distribution of herds by size, the number of hours spent with the herd per day, and affirmative responses to performance of the tasks listed.

Table 2: Demographic information by herd size							
	≤49 cows	50-99 cows	100-199 cows	200-499 cows	≥500 cows	Total	Mean
Number of farms	263	248	66	19	9	605	78 cows
Average hours with herd per day	4.1	5.1	5.4	5.6	5.3	Median 4.0	4.8
Haul animals	27.8	31.8	36.4	57.9	44.4	31.4	
Eat in the barn	43.3	46.0	51.5	52.6	44.4	45.0	
Drink in the barn	70.7	75.4	71.2	78.9	55.5	72.0	
Administer hormones	21.7	31.4	33.3	63.2	55.5	28.2	
Tasks not performed due to perceived hazard	11.8	18.5	18.2	26.3	11.1	15.7	
Received training on diseases	7.2	11.7	19.7	47.3	22.2	12.3	

Table 4.3 lists the percentage of respondents that perform the tasks listed at each frequency.

Table 3: Percentage of frequency of tasks being performed by respondents					
	Never	**Monthly**	**Weekly**	**Daily**	**Not Applicable**
Feeding	13.0	12.3	9.3	**60.6**	4.8
Treating sick	**33.5**	26.2	16.0	15.2	9.1
Vaccinating	**56.9**	24.1	4.2	3.3	11.5
Birthing	25.3	**54.1**	7.4	4.9	8.3
Breeding	**75.9**	4.7	4.9	4.0	10.5
Moving	9.9	**37.6**	15.0	31.7	5.8
Compost	**79.9**	4.5	0.9	1.4	13.3
Identifying young	**49.4**	31.3	8.1	4.2	7.0
Euthanizing	**83.2**	3.1	0.4	0.2	13.2
Pressure washing	**57.6**	17.0	4.9	8.2	12.3
Sanitizing	**52.0**	20.1	7.8	8.3	11.8
Transporting manure	**67.6**	10.6	3.9	10.9	7.0
Removing manure from barn	**47.6**	13.4	6.3	25.6	7.1
Cleaning stalls	27.8	15.2	9.3	**42.6**	5.1
Milking	10.0	8.3	7.7	**70.8**	3.2

Table 4.4 lists the percentage of respondents who practice the following protective behaviors at the listed frequencies.

Table 4: Glove usage			
	Never	**Rarely / Sometimes**	**Often / Always**
Milking	44.6	15.7	40.3
Treating sick animals	49.3	29.7	21.0
Assisting with calving	47.5	32.8	19.7
Breeding	71.4	2.1	26.5
Cuts or wounds on hands	32.0	42.5	25.5
Clothing changes after given tasks			
Before beginning work	0.8	14.5	84.7
When leaving work	68.1	14.1	17.8
After treating sick animals	32.4	40.6	27.0
After milking	18.5	24.4	57.1
Assisting with calving	19.0	40.6	40.4
After pressure washing	32.6	31.0	36.4
After hauling manure	39.8	33.9	26.3
Changing or cleaning boots after given tasks			
After moving manure	14.7	21.6	63.7
After pressure washing	27.3	26.7	46.0
After sanitizing facilities	25.4	25.2	49.4
After milking	13.2	17.8	69.0
After assisting with calving	16.9	25.8	57.3
Between areas of the barn	27.0	29.8	43.2
Entering the barn	43.4	34.3	22.3
Leaving the barn	20.7	16.8	62.5
Handwashing			
Entering barn	38.2	41.7	20.1
Leaving barn	5.6	19.1	75.3
Hauling manure	12.1	13.5	74.4
Assisting with birthing	2.1	2.7	95.2
Before milking	19.5	29.5	51.0
After milking	4.1	12.2	83.7
Treating sick animals	4.2	12.8	83.0
Breeding animals	24.2	13.7	62.1
Usage of personal protective equipment			
Hearing protection	71.5	21.4	7.1
Eye protection	64.0	25.8	10.2
Breathing mask	67.7	28.2	4.1
Respirator	93.4	6.3	0.3
*Percentages exclude respondents who indicated “not applicable”.			

Table 4.5 provides the number of respondents and percent of respondent who felt various degrees of risk of disease from working with cattle.

Table 5: Risk of disease from working with cattle (n = 621)		
	Frequency	**Percent**
Not at all	329	53.0
Minimal	228	36.7
Moderate/considerable	17	2.7
Don't know	47	7.6

Table 4.6 depicts how respondents reported that they learned to work with cattle.

Table 6: How respondents were trained to work with animals (n = 624)			
	Frequency*	**Percent**	
On family farm	511	81.9	Informal
On the job	140	22.4	
Through school or college	43	6.9	Formal
Through 4-H	70	11.2	
Through Cooperative Extension	45	7.2	
Through breed associations	29	4.6	
Through books or magazines	183	29.3	Self-taught
On-line	35	5.6	
Other way	61	9.8	
*Respondents were asked to mark all answers that applied to their situation.			

Chapter 5

Dynamics of Airborne Bacteria in Milking Parlors in Pennsylvania

5.1 Abstract

Dairy farms with milking parlors in Pennsylvania (n = 40) were visited. Environmental conditions were monitored in the parlor and adjacent outdoors and descriptive data were recorded. A baseline sample was collected for 30 minutes prior to the cows entering the parlor and every 30 minutes (t = 0, 30, 60, 90, 120, 150, 180) for up to three hours or for the duration of milking. Simultaneously, the button sampler and a bio-aerosol sampler collected a personal air sample. All samples were plated onto Standard Plate Count agar (SPC), Mannitol-salt agar (MSA), MacConkey agar (MAC), and CHROMagar™ *E. coli* O157 and incubated for 48 hours. Samples also were enriched for the detection of *Salmonella* spp. and *Listeria monocytogenes*.

The volume of the parlors averaged 493 m^3 with a range of 118 to 2646 m^3. The average final total bacterial count ranged from 2.551 to 4.435 $\log_{10}$ CFU/m^3. The average Staphylococcal count at the final time ranged from 2.330 to 4.255 $\log_{10}$ CFU/m^3 with the average presumptive *Staphylococcus aureus* count ranged from 0 to 4.109 $\log_{10}$ CFU/m^3 with similar ranges for *Enterobacteriaceae* and coliforms. The final total bacterial counts were significantly different from the baseline counts with the exception of coliform counts. Counts from the personal air sampler at the maximum time demonstrated significant correlations with the total bacterial counts with the exception of coliform counts. No correlations were observed between the following variables: parlor volume, number of cows being milked, the temperature of the parlor, the relative humidity in the parlor, the volume of the parlor, the number of workers, or the ventilation in the parlor and the various bacterial counts.

No difference was observed in bacterial counts on the various media according to the parameters measured in this study, therefore other factors such as cleaning and sanitizing practices, herd health, age of the parlor, or milking practices that were not examined may have influenced bacterial counts in milking parlors. *Escherichia coli* O157, *Listeria monocytogenes*,

and *Salmonella* spp. were not recovered from air, therefore the occupational hazard resulting from airborne exposure to these bacteria is uncertain.

5.2 Introduction

Respiratory problems are a common health concern of farmers and have been documented in chapters 3 and 4 of the current study, where 9.8% of the women working on dairy farms in Pennsylvania that responded to our survey indicated that they had experienced breathing problems within the past year. Work with dairy cattle was positively associated with respiratory illnesses in farmers.[1]

Although the exposure was not statistically significant, a positive association between dairy cattle work and farmer's lung (OR 1.28; 95% CI 0.86 to 1.89) was reported[2]; the same association was evident for farmers' spouses (OR 1.50; 95% CI 0.72 to 3.14). An earlier study from the same researchers indicated that milking cattle daily increased the risk of wheeze (OR 1.33; 95% CI 1.11 to 1.58).[3] Co-exposures to other agricultural dusts, molds, gases, and mites could increase possibility of respiratory infection[4], thereby increasing the likelihood of spreading bacteria that may have colonized the nasal passages and respiratory tract.

In addition to respiratory pathogens and irritants, other pathogens such as *Escherichia coli* O157, *Salmonella* spp., *Listeria monocytogenes*, and *Staphylococcus aureus* are of concern since they are frequently present in dairy farm environments and could become airborne. As part of the milking process, the teats are usually stripped of milk prior to attaching the milking machine. This milk splatters on a concrete or rubber floor and may cause pathogens that are found in raw milk to become aerosolized and possibly breathed in by the milker. These pathogens also could attach to water particles during cleaning with high pressure hoses and become aerosolized droplets. During a survey of raw milk in Pennsylvania, samples (n = 248) were found to contain the following pathogens: *Salmonella* spp. (6.0%), *Campylobacter jejuni* (2.0%), Shiga-toxin producing *E. coli* (2.4%), *Listeria monocytogenes* (2.8%), and *Yersinia enterocolitica* (1.2%).[5]

Air samples were collected in another study in which *Salmonella* spp. was detected on a dairy farm.[6] Samples were taken monthly over 12 months to include all seasons at one dairy farm. Air samples were collected in calf barn and milking parlor. The highest prevalences in the milking parlor were observed in winter and spring, 62% and 60%, respectively. Calf barns demonstrated the highest prevalence in the fall with 71% followed by summer with 42%. The same researchers recovered *Salmonella* spp. from air in a dairy barn in a previous study.[7]

5.2.1 Rationale

A milking parlor is typically an enclosed space in which a cohort of cows is milked. This enclosed place is unique as milkers come in direct contact with cows and their secretions (milk) and waste (feces, urine, and respired air). In a milking parlor, the milkers typically stand in a pit, thereby placing the cows approximately 3.5 feet higher for ease of reaching the cows' udders with the milking machines. When the cows defecate or urinate, the milkers are in very close range for exposure to these excretions. The cows are typically stripped of milk by hand prior to the placement of the milking machine which also could expose the milker to pathogens that could be present in the milk. These working conditions place the milker at an increased risk of coming in contact with opportunistic bacteria and bacterial pathogens, thereby increasing the likelihood of illnesses of individuals working in a milking parlor.

The focus of this study is to determine the number and type of bacteria in air samples collected in milking parlors, thereby gauging the likelihood of coming in contact with bacterial pathogens. To address this issue, a study was designed and conducted to assess if persons working in milking parlors were exposed to airborne pathogenic bacteria and whether this route of exposure constituted an occupational health risk.

5.2.2 Objectives

The literature indicated that these bacteria were present on farms and may, therefore, become aerosolized through various activities on the farm. The objectives of this study were as follows: 1.) to determine number and type of bacteria in air samples collected in milking parlors and changes in bacterial counts over time including the total aerobic bacterial count, the total staphylococcal count, and the presumptive *Staphylococcus aureus* count, *Enterobacteriaceae* count, and the coliform count, and 2.) to determine if relative humidity, wind speed, and temperature affect the number and the type of aerosolized bacteria in milking parlors.

5.3 Materials and Methods

5.3.1 Study Parameters

A group of study farms (n = 40) was recruited allowing the collection of air samples during various weather conditions. The study included farms of various sizes located in Pennsylvania. A purposive sample was collected as dairy producers were solicited to participate in the study through contact by the Veterinary Extension Field Investigation Group. Necessary approvals were obtained from the Office for Research Protections at Penn State University (IRB #29262).

Each farm was visited once. Data including the temperature, the relative humidity, and the wind speed were recorded using the Skymaster SM-28 (Speedtech Instruments, Great Falls, VA) inside each parlor and outside of the barn at the start of each visit. Data on the dimensions and type of parlor were collected using a laser measurer. Information on the herd size and frequency of milking also was recorded and participant consent forms were signed.

5.3.2 Environmental Bio-aerosol Sampling

A time-series of environmental samples was collected during milking including a baseline before milking and a sample every 30 minutes for the duration of milking or for a total of 3 hours. Environmental air samples were gathered using the VAC-U-GO (SKC, Inc., Eighty Four, PA) bio-aerosol sampler. The device was placed on a cart that was approximately 3.0 feet high at every farm to ensure that air samples were always taken at the same level. The cart was placed in the pit and efforts were made to make it as unobtrusive to the milkers as possible. The environmental air sampler was set at a flow rate of 12.5 L/min[8] using The Defender 510 (SKC, Inc. Eighty Four, PA) for calibration. The collection medium placed in the collection vial of the impinger consisted of 20 mL of 1% peptone in distilled water and 0.01% Tween 80.[9,8,10] The antifoam A was excluded as no issues with foaming during sampling were observed in preliminary testing. Prior to starting the sampler and every 30 minutes (t = 0, 30, 60, 90, 120, 150, 180), an aliquot of approximately 0.5 mL of sampling medium was withdrawn from the collection vial and placed into a labeled tube. The tubes were stored on ice in a cooler for transportation back to the lab[8]. Samples were processed within 24 hours of collection.

5.3.3 Personal Air Sampling

Simultaneously, a personal air sample was collected beginning 30 minutes prior to milking and continuing for the duration of milking or for a total of 3 hours. The button sampler and AirCheck® XR5000 air pump (SKC, Inc., Eighty Four, PA) were adjusted to an intake of 2.0 L/min as is standard. A commercially prepared gelatin disk (SKC, Inc., Eighty Four, PA) was used in the personal air sampler button. The personal air sampler was also calibrated using The Defender 510. After the sample was collected, the disk was placed in a 50 mL centrifuge tube containing 10mL of sterile saline and transported back to the lab on ice in a cooler.

5.3.4 Culturing of Samples

Upon return to the lab, the tube containing the gelatin disk was placed in an incubator at 37°C for 30 minutes, thereby dissolving the disk. Upon removal from the incubator, the tube was vortexed for 3-5 seconds to ensure thorough mixing. Aliquots of the innoculum (100 µL each) were spread-plated onto Standard Plate Count agar (SPC) to determine the total aerobic bacterial count, MacConkey agar (MAC) to determine the *Enterobacteriaceae* and coliform counts, and Mannitol-salt agar (MS) to determine the staphylococcal and *Staphylococcus aureus* counts. The aliquots collected at each of the set times also were spread-plated onto SPC, MAC, and MS. All plates were incubated at 35 ± 2°C. Colony counts were recorded at 24 and 48 hours.

5.3.5 Detection of *Salmonella* spp. and *Listeria monocytogenes*

Additionally, aliquots of the environmental sample from the maximum time and the personal air sample were enriched for detection of *Salmonella* spp. and *Listeria monocytogenes*. Media that is enriched contains certain substances such as blood, serum, hemoglobin, or growth factors like vitamins or amino acids that the target species need to grow.[11] When samples are enriched, the likelihood of detecting the presence of a pathogen is increased as the cells are given the needed conditions to multiply. Enrichment for *L. monocytogenes* was per the USDA's Food Safety Inspection Service Laboratory Guidebook[12] and included incubation in 9.0 mL of UVM Modified Listeria Enrichment broth at 30 ± 2°C for 22 ± 2 hours followed by plating on modified Oxford Medium (MOX) which was incubated at 35 ± 2°C for 24 and 48 hours. An aliquot (100 μL) of the enriched UVM broth was subsequently enriched in Fraser Broth (FB) and incubated at 35 ± 2°C for 24 and 48 hours. Darkening of the Fraser Broth was recorded and these samples were plated onto MOX and incubated at 35 ± 2°C for 24 and 48 hours.

Enrichment for *Salmonella* spp. was per the Bacteriological Analytical Manual Online.[13] An aliquot of 1.0 mL of sampling medium was transferred into 9.0 mL of Tetrathionate (TT) broth and incubated at 37 ± 2°C for 24 hours. An aliquot of 0.1 mL of sampling medium was transferred into 9.9 mL of Rappaport-Vassiliadis (RV) broth and incubated at 42 ± 2°C and incubated for 24 hours. A loopful of each of the enriched broths was streaked onto Hektoen Enteric agar (HE) and Xylose Lysine Desoxycholate (XLD) agar which were incubated at 37± 2°C for 24 and 48 hours. All enriched samples were stored in glycerol at -80°C for additional analysis.

MacConkey agar was determined as the best medium for recovering gram-negative strains when air sampling through testing with several reference strains that were both gram-negative and gram-positive.[14] MacConkey agar inhibited the gram-positive bacteria while providing favorable conditions for the gram-negative bacteria. No enrichment was performed.

No enrichment was performed for *Staphylococcus* spp. before the samples were plated onto Mannitol-salt agar. Colonies that ferment mannitol turned yellow and were presumptive *Staphylococcus aureus* while other *Staphylococcus* species appeared red (BBL™, Becton, Dickinson and Co., Sparks, MD).

Presumptive positive colonies from MacConkey agar and Mannitol-salt agar were streaked onto their respective agars and incubated again at 35 ± 2°C for 24. Colonies that were presumptive positive after additional culturing were transferred into 1.0 mL of tryptic soy broth and incubated at 37 ± 2°C for 24 hours. The isolates were stored in glycerol solution and placed in the -80°C freezer.

5.3.6 Statistical Analysis

Bacterial counts were converted into colony forming units (CFU)/m^3 using the following formula[8]:

$$\text{CFU/m}^3 = \frac{\text{number of colonies X dilution factor X final solution volume}}{\text{volume of aliquot plated X sampled air volume}}$$

For example:

$$\log_{10}\left(\frac{\text{28 colonies X 1 (no dilutions) X 20 mL}}{\text{.100 mL X ((12.5 L/min X 90 min) X .001 m}^3)}\right) = 3.697 \log_{10} \text{CFU/m}^3$$

The counts were then underwent $\log_{10}$ transformation.

Statistical analysis was conducted using SPSS 16.0 (SPSS, Inc. Chicago). Descriptive statistics including the mean, the standard deviation, the median, the minimum and the maximum value were stated when necessary. Kolmogorov-Smirnov tests were performed to test for parametric distribution of data. The parlors were categorized according to their volume with the following categories: less than 180 m^3, 181-356 m^3, 357m^3 or more. These categories were used for one-way ANOVA tests considering that some large parlors had a small number of cows milked while some small parlors had a large number of cows milked. A rate of the number of cows milked per minute was calculated for use in correlations and one-way ANOVA's. The categories were as follows: ≤0.738 cows milked per minute, 0.739-1.016 cows milked per minute, and ≥1.017 cows milked per minute. In the cases where data were not normally distributed, Kruskal-Wallis tests were performed in place of one-way ANOVA's. The data from other variables including parlor temperature, parlor relative humidity, outdoor temperature, and outdoor relative humidity were categorized into three categories for analysis. Wilcoxon paired sample tests were performed in place of paired t-tests in cases where data were not normally distributed. Pearson correlations were calculated for normally distributed data, while Spearman correlations were calculated for non-normally distributed data.

5.4 Results

5.4.1 Parlor Parameters

A total of 40 milking parlors were visited between October 2008 and January 2009. A personal air sample was collected in each parlor as were environmental bio-aerosol samples. Descriptive characteristics about the parlor and milking practices are found in Table 1. Of the 40 farms, 29 (72.5%) milked twice a day while the other 11 milked three times per day. The number of cows milked in the parlors ranged from 28 to 3000 with an average of 266 ± 475. The volume of the parlors ranged from 118 to 2646 m^3 with an average of 493 ± 613 m^3. As expected, a positive correlation was observed between parlor volume and the number of cows milked (R^2 = 43.4%; $p < 0.001$). One to six workers were working in the parlors milking with an average of 2.3 workers. Ventilation in the parlor was defined as fans operating, windows or large doors open constantly, or if the entire back of the parlor was open by design to allow cows to enter, of which 16 farms (40%) met these criteria at the time of sampling.

5.4.2 Bacteriological Analysis of Bio-aerosol Samples

The mean bacterial counts on for total aerobic, Staphylococci, and presumptive *S. aureus* for both the environmental bio-aerosol sampler and the personal air sampler were all normally distributed. The *Enterobacteriaceae* and coliform counts were not despite $\log_{10}$ transformation. The average total bacterial count on SPC at the final time was 3.709 $\log_{10}$ CFU/m^3 while the average baseline total bacterial count was 2.081 $\log_{10}$ CFU/m^3 which demonstrated a significant difference ($p< .0001$) (See Table 2). The average baseline staphylococcal count on Mannitol-salt agar was 2.189 $\log_{10}$ CFU/m^3 while the average at the final count was 3.528 $\log_{10}$ CFU/m^3 which demonstrated a significant difference ($p<.0001$). The average baseline presumptive *S. aureus* count was 1.604 $\log_{10}$ CFU/m^3 while the average final count was 3.123 $\log_{10}$ CFU/m^3 which also was significantly different ($p<.0001$). The average baseline *Enterobacteriaceae* count on MacConkey agar was 0.0 $\log_{10}$ CFU/m^3 and the final average count 0.748 $\log_{10}$ CFU/m^3 which demonstrated a significant difference ($p=.013$). The average baseline coliform count was 0.0 while the average final count was 0.097 $\log_{10}$ CFU/m^3 which did not demonstrate a significant difference. The average final counts for total bacterial count, Staphylococcal count and the presumptive *S. aureus* count followed a similar pattern of increasing from t = 0 until t = 90, then remaining fairly steady for the remainder of the sampling (See Figure 1).

5.4.3 Bacteriological Analysis of Personal Air Samples

The counts on various media from the personal air sampler are depicted in Table 3. The average total bacterial count was 3.266 $\log_{10}$ CFU/m^3. The average staphylococcal count was 3.008 $\log_{10}$ CFU/m^3 with a presumptive *S. aureus* count of 2.691 $\log_{10}$ CFU/m^3. The *Enterobacteriaceae* count was 0.366 $\log_{10}$ CFU/m^3 with a coliform count of 0.049 $\log_{10}$ CFU/m^3.

Correlations were made between the personal air sampler counts and the environmental bio-aerosol sampler counts at the final time. A statistically significant correlation existed between the counts for the two types of samplers for the presumptive *S. aureus* count (R^2 = 16.2%; p = 0.010). None of the other correlations were statistically significant. Further analysis according to the rate of number of cows milked per minute was not significant.

5.4.4 Bacteria Counts by Parlor Volume

The following categories were created according to the volume of the parlors: less than 180 m^3 (n = 13), 181 -356 m^3 (n = 14), and greater than 356 m^3 (n = 13). One way ANOVA's and Kruskal-Wallis tests were conducted to compare the various counts by parlor volume (See Table 4). No significant differences were observed in any of the counts according to parlor volume. Additional analysis to measure the volume of air exchange in the parlors could not be completed because the anemometer did not register any air movement in 39 of the 40 parlors at the time of the visit.

5.4.5 Bacteria Counts and Parlor Parameters

The possibility of correlations between each of the types of bacterial counts and various parameters of the parlors including the number of cows, the temperature of the parlor, the relative humidity in the parlor, the volume of the parlor, the number of workers, and the presence of ventilation in the parlor was examined (See Table 5). None of the correlations was significant for environmental bio-aerosol samples or for the personal air samples.

5.4.6 Bacteria Counts and Rate of Cows Milked

The following categories were created according to the rate of cows milked per minute: less than or equal to 0.738 (n = 13), 0.739-1.016 (n = 14), and greater than or equal to 1.017 (n = 13). One way ANOVA's and Kruskal-Wallis tests were conducted to compare the various counts by rate of cows milked per minute (See Table 6). Significant differences were observed were observed between rate categories and for the personal air sampler and the Staphylococcal counts ($p = 0.050$) as well as for rate categories and presumptive *S. aureus* counts ($p = .010$). Correlations also conducted between rates and bacteria counts (See Table 7). Significant correlations were observed between Staphylococcal counts and the rate of cows milked for personal air sampler ($R^2 = 10.9\%$; .038) and for presumptive *S. aureus* count and the rate of cows milked for the personal air sampler ($R^2 = 10.1\%$; $p = .046$).

5.4.7 Detection of Specific Pathogens

No *Salmonella* spp. was detected following enrichment. No *Listeria monocytogenes* was detected following enrichment, however five samples had black colonies on MOX, but the Fraser Broth did not darken. While *E. coli* was detected in some samples on ChromAGAR™, no *E. coli* O157 was indicated on this medium. Six samples indicated possible coliforms on MacConkey agar upon initial plating of samples; however after streaking a second time on MacConkey agar, none of the isolates appeared to ferment lactose. No further attempts at identification of these *Enterobacteriaceae* were made. Presumptive *Staphylococcus aureus* colonies were recovered from all 40 farms using Mannitol-salt agar. However, further efforts to confirm the identity of these isolates indicated that none were *Staphylococcus aureus*. Identification efforts included Staph API (Biomériux, France) and coagulase testing.

5.5 Discussion

The construction and function of a milking parlor make it an ideal space to find aerosolized bacteria. Parlors provide a somewhat enclosed environment where microorganisms can be found in animal wastes including feces, urine, respired air, and milk that has been stripped by hand or dumped. The working conditions in this environment facilitate possibility of an occupational hazard as the workers could be exposed to these bacteria in the air that they breathe. To assess this exposure, samples were collected using an environmental bio-aerosol sampler and a personal air sampler and examined for total bacterial count, Staphylococci, *Staphylococcus aureus*, *Enterobacteriaceae*, and coliforms.

Several of the factors that were examined in the current study were found, by other researchers, to have an effect on bacterial counts. Relative humidity, air temperature, and wind speed all affected the total bacterial count in one barn.[15] The role of relative humidity in the milking parlors in determining the amount and type of bacteria that are recovered is unclear. Air humidity affected the amount of *Pseudomonadaceae* that were recovered indicating that higher humidity may favor the presence of these bacteria.[14] Another study yielded contrary results since the researchers found no influence of relative humidity on bacterial counts.[9] Similarly, in the current study, no relationship was observed between relative humidity and the bacterial counts. The relative humidity varied considerably in the milking parlors that we observed and this could have been influenced by milking practices. In some parlors, the concrete was not washed between groups of cows while in other parlors, the entire floor was washed with a high pressure hose or automatic sprayers were engaged as the gates lifted. Some farms used a mist of chlorinated water to disinfect the teats prior to placement of the milkers while others used methods with fewer aerosols.

The wind speed in most parlors was negligible or lower than the capacity of the measuring device that was employed in the current study. Many of the parlors were closed due to the cold winter weather which also minimized air movement. As parlors are better ventilated and fans are in operation during the summer, the microbial population may change. Seasonal factors influenced the likelihood of isolating pathogens from cattle wastes where *Listeria* spp. was isolated with greater frequency in March to June while *E. coli* O157 was found more readily in May to June in the UK.[16] However, in another study, *L. monocytogenes* was isolated from dairy cattle and their environment with a high prevalence during winter months.[17] In another study on several types of farms, differences in bacterial counts were observed according to seasons.[18] The fluctuations in weather that accompany changes in seasons may influence bacterial counts and the presence and subsequent detection of pathogens in the air. In another study, *Salmonella* spp. was isolated in 46% of the fall (Oct–Dec) and 62% of the winter (Jan-March) air samples[6]. There may have been a previously established issue with *Salmonella* on the farm where all of the samples were collected. This study also reported the highest prevalence of *Salmonella* in the parlor environment on the floor, walls, windows, and stalls during the summer months, however the lowest prevalence of *Salmonella* in air was observed during the same season.[6]

As previously mentioned, milking has been associated with increased risks for respiratory illness on dairy farms. However, milking was an activity that demonstrated lower levels of dust as compared to other activities such as feeding and bedding cattle, liming the floor, and removing manure.[19] There is a possibility that other factors may be influencing the possibility of respiratory illness in those who milk cows including cow-urine antigens, dander, hair, feces, bacteria, and fungi. Another difference in milking compared to some other farm activities is the amount of time that is required. In our study, the number of airborne bacteria observed increased as the milking process continued, thereby possibly exposing milkers to a larger bacterial population for a longer time than an event of shorter duration such as bedding cattle or liming the floors.

There may be factors that were not examined in the current study that influence bacterial counts. Practices in milking parlors vary greatly. Specific practices such as the type and method of disinfecting the teats before and after milking, washing the platform in between groups of cattle, the health and cleanliness of the cattle, the proximity and openness of the parlor to the holding area, the age of the parlor, the maintenance of the parlor including sanitation practices, and the air circulation may be relevant to bacterial counts.

Bacterial counts have been reported in other studies of airborne bacteria, however several factors should be considered when comparing these numbers to the current study. Alternate sampling methods such as Andersen samplers were frequently employed. The flow rates for sampling often differ when Andersen samplers are used and the sampling times are frequently much shorter or much longer. The media on which the total bacterial counts were determined may differ between the studies as well. In one study, the geometric mean for viable mesophilic bacteria collected using all glass impingers (AGI) in dairy barns was 5.8×10^5 CFU/m^3 which is equivalent to 5.763 $\log_{10}$ CFU/m^3.[19] In another study of dairy calf barns, the mean total bacterial count in calf pens was 5.050 log10 CFU/m3 and 4.648 log10 CFU/m3 in alleys.[20] These counts were determined using an impaction sampler with sheep blood agar plates. Mean bacterial counts of 3.05 $\log_{10}$ CFU/m^3 were recovered from feedlots using Andersen samplers and blood agar.[21] Air samples collected from residences in Texas using two-stage Andersen samplers with tryptic soy agar plates demonstrated a mean of 2.538 $\log_{10}$ CFU/m^3.[22]

In the current study, 20 of the 22 samples from the environmental bio-aerosol sampler that were positive for *Enterbacteriaceae* had less than 10 colonies, while the seven samples from the personal air samplers all had four or fewer colonies. In their study, Zucker et al. (2000)

reported that gram-negative bacteria made up low portions (0.02 to 5.2%) of the bacteria recovered from animal housing including cattle barns using Andersen samplers.[14] Wilson et al. (2002) only recovered non-pathogenic gram-positive microorganisms using Andersen samplers.[21] The sampling method may influence the ability to recover gram-negative microorganisms. AGI was determined as the more effective method for collecting bacterial and fungal samples from open-air swine houses when compared to a one-stage Andersen sampler.[9,10] A notable difference exists in the flowrates used for sampling with all glass impingers and Andersen samplers. The flowrate of the sampler controls the amount of air that is sampled. The flowrates for the two sampling methods differed in the study by Thorne et al.[10] as the AGI method used the standard 12.5 L/min while the Andersen method used a flowrate of 28.3 L/min. The sampling times also differed with the Andersen samplers being run for 15 to 90 seconds and the environmental bio-aerosol impingers running for up to 30 minutes. The studies by Pangloli et al. (2003, 2008) used an air flow rate at 37.56 L/min for 20 minutes.[6,7]

One outbreak of gastrointestinal illness has been attributed to a possible association *E. coli* O157 that may have been airborne in contaminated environment.[23] Cattle were in the building at various times throughout the week, thereby possibly contaminating the building. Even though those who became ill were not directly exposed to cattle, illness was linked to exposure to the building and could have been due to aerosolized bacteria. This case is concerning as other pathogens are commonly found in farm environments and may become aerosolized. *Listeria monocytogenes* has been found on dairy farms, but not previously studied in air samples. In one study, *L. monocytogenes* was recovered from fecal, feedstuff, soil and water samples on dairy farms.[24] In another study, *L. monocytogenes* was recovered from fecal, environmental, and animal samples on dairy farms.[25] *L. monocytogenes*, *Salmonella* spp., and *Entercoccus* were observed with varying prevalences in fecal samples in another study.[26] An important point to note is that while these bacteria were not recovered from the air in the present study, they still may be present in the environment on farms including on walls, floors, in drains, and on equipment.

Suggestions for future research include visiting parlors and collecting data over all four seasons and in a variety of weather conditions. Monitoring the changes in the relative humidity, temperature, and wind speed repeatedly during sampling such as every 30 minutes when the aliquots are collected. A continuation of sampling at the conclusion of milking during the cleaning process could provide useful data, however this could be difficult as the environmental bio-aerosol sampling equipment is fragile and requires electricity for operation. It may be difficult to protect the equipment and still accurately collect data during the cleaning process. A more sensitive anemometer may be of use in collecting air movement data. Additional data regarding milking practices and cleaning practices may be recorded.

5.6 Conclusions

Total bacterial counts, Staphylococcal counts, presumptive *S. aureus* counts and *Enterobacteriaceae* counts demonstrated a significant increase from the baseline totals to the final sample totals indicating that the bacteria counts increased with the presence of the cattle in the parlor. No concordance was observed between the bacterial counts in the parlors and the parameters examined including parlor air volume, number of cows milked, parlor temperature, parlor relative humidity, number of milkers, and the presence of ventilation in the parlors. The bacterial counts typically increased during the first 90 minutes of sampling and then held relatively steady for the remainder of the sampling. The number of total bacteria, Staphylococci, presumptive *S. aureus*, and *Enterobacteriaceae* recovered from the environmental bio-aerosol sampler and the personal air sampler were comparable as the counts demonstrated statistically significant correlations. Designers of future studies should consider collecting data on milking and cleaning practices, herd health status, and air circulation and movement.

5.7 References

1. Hoppin JA, Umbach DM, London SJ, Henneberger PK, Kullman GJ, Alavanja MCR, Sandler DP. 2008. Pesticides and atopic and nonatopic asthma among farm women in the Agricultural Health Study. *Am J Resp Crit Care* 177:11-18.

2. Hoppin JA, Umbach DM, Kullman GJ, Henneberger PK, London SJ, Alavanja MCR, Sandler DP. 2007. Pesticides and other agricultural factors associated with self-reported farmer's lung among farm residents in the Agricultural Health Study. *Occup Environ Med* 64:334-341.

3. Hoppin JA, Umbach, London SJ, Alavanja MCR, Sandler DP. 2003. Animal production and wheeze in the agricultural health study: interactions with atopy, asthma, and smoking. *Occup Environ Med* 60:e3(http://www.occenvmed.com/cgi/content/full/60/8/e3).

4. Spurzem JR, Romberger DJ, Von Essen SG. 2002. Agricultural lung disease. *Clin Chest Med* 23:795-810.

5. Jayarao BM, Donaldson SC, Straley BA, Sawant AA, Hegde NV, Brown JL. 2006. A survey of foodborne pathogens in bulk tank milk and raw milk consumption among farm families in Pennsylvania. *J Dairy Sci* 89:2451-2458.

6. Pangloli P, Dje Y, Ahmed O, Doane CA, Oliver SP, Draughon FA. 2008. Seasonal incidence and molecular characterization of Salmonella from dairy cows, calves, and farm environment. *Foodborne Pathogens Dis* 5(1):87-96.

7. Pangloli P, Dje Y, Oliver SP, Mathew A, Golden DA, Taylor WJ, Draughon FA. 2003.

Evaluation methods for recovery of Salmonella from dairy cattle, poultry, and swine farms. *J Food Protect* 66(11):1987-1995.

8. Thorne PS, Kiekhaefer MS, Whitten P, Donham KJ. 1992. Comparison of bioaerosol sampling methods in barns housing swine. *Appl Environ Microbiol* 58(8):2543-2551.

9. Chang CW, Chung H, Huang CF, Su HJJ. 2001. Exposure of workers to airborne microorganisms in open-air swine houses. *Appl Environ Microbiol* 67(1):155-161.

10. Thorne PS, Lange JL, Bloebaum P, Kullman GJ. 1994. Bioaerosol sampling in field studies: can samples be express mailed? *Am Ind Hyg Assoc J* 55(11):1072-1079.

11. Talaro K, Talaro A. 1996. Foundations in microbiology -Second edition. Times Mirror Higher Education Group Inc.: Dubuque, IA.

12. United States Department of Agricutlure –Food Safety Inspection Service. 2008. Isolation and identification of Listeria monocytogenes from red meat, poultry, egg, and environmental samples. Laboratory QA/QC Division: Athens, GA.

13. US Food and Drug Administration –Center for Food Safety and Applied Nutrition. 2007. *Salmonella*. Available at: http://www.cfsan.fda.gov/~ebam/bam-5.html.

14. Zucker B-A, Trojan S, Müller W. 2000. Airborne gram-negative bacterial flora in animal houses. *J Vet Med* 47(1):37-46.

15. Matković K, Vučemilo M, Vinković B, Šeol B, Pavičić Ž, Tofant A, Matković S. 2006. Effect of microclimate on bacterial count and airborne emission from dairy barns on the environment. *Ann Agric Environ Med* 13:349-354.

16. Hutchison ML, Walters LD, Avery SM, Munro, Moore A. 2005. Analyses of livestock production, waste storage, and pathogen levels and prevalences in farm manures. *Appl Environ Microbiol* 71(3):1231-1236.

17. Mohammed HO, Stipetic K, McDonough PL, Gonzalez RN, Nydam DV, Atwill ER. 2009.

Identification of potential on-farm sources of *Listeria monocytogenes* in herds of dairy cattle. *Am J Vet Res* 70:383-388.

18. Lee S-A, Adhikari A, Grinshpun SA, McKay R, Shukla R, Reponen T. 2006. Personal exposure to airborne dust microorganisms in agricultural environments. *J Occup Environ Hyg* 3:118-130.

19. Kullman GJ, Thorne PS, Waldron PF, Marx JJ, Ault B, Lewis DM, Siegel PD, Olenchock SA, Merchant JA. 1998. Organic dust exposures from work in dairy barns. *Am Ind Hyg Assoc J* 59(6):403-413.

20. Lago A, McGuirk SM, Bennett TB, Cook NB, Nordlund KV. 2006. Calf respiratory disease and pen microenvironments in naturally ventilated calf barns. *J Dairy Sci* 89:4014-4025.

21. Wilson SC, Morrow-Tesch J, Straus DC, Cooley JD, Wong WC, Mitlöhner FM, McGlone JJ. 2002. Airborne microbial flora in a cattle feedlot. *Appl Environ Microbiol* 68(7):3238-3242.

22. Gandara A, Mota LC, Flores C, Perez HR, Green CF, Gibbs SG. 2006. Isolation of *Staphylococcus aureus* and antibiotic-resistant *Staphylococcus aureus* from residential indoor bioaerosols. *Environ Health Perspect* 114(12):1859-1864.

23. Varma JK, Greene KD, Reller ME, DeLong SM, Trottier J, Nowicki SF, DiOrio M, Koch EM, Bannerman TL, York ST, Lambert-Fair M-A, Wells JG, Mead PS. 2003. An outbreak of *Escherichia coli* O157 infection following exposure to a contaminated building. *J AM Med Assoc* 290(20):2709-2712.

24. Nightingale KK, Schukken YH, Nightingale CR, Fortes ED, Ho AJ, Her Z, Grohn YT, McDonough PL, Wiedmann M. 2004. Ecology and transmission of *Listeria monocytogenes* infecting ruminants and in the farm environment. *Appl Environ Microbiol* 70(8):4458-4467.

25. Borucki MA, Reynolds J, Gay CC, McElwain KL, Kim SH, Knowles DP, Hu J. 2004. Dairy

farm reservoir of *Listeria monocytogenes* sporadic and epidemic strains. *J Food Protect* 67(11):2496-2499.

26. Pradhan AK, Van Kessel JS, Karns JS, Wolfgang DR, Hovingh E, Nelen KA, Smith JM, Whitlock RH, Fyock T, Ladely S, Fedorka-Cray PJ, Schukken YH. 2009. Dynamics of endemic infectious diseases of animal and human importance on three dairy herds in the northeastern United States. *J Dairy Sci* 92:1811-1825.

Table 5.1: Milking Parlor Demographic Characteristics (n = 40)

Parameters of selected demographic characteristics of the milking parlors from the study are listed.

Parameter	Range	Mean	Median	Standard Deviation
Cows milked	28 - 3000	266	133	475
Times milked per day	2 - 3	2.3	2	0.5
Parlor volume (m^3)	118 - 2646	493	240.5	613
Workers	1 - 6	2.3	2	1.1

Table 5.2: Bacterial Counts Using Bio-aerosol Sampler ($\log_{10}$ CFU/m^3)

Various bacterial counts are depicted beginning at time 0 through 180 minutes. Data include averages at each time, the average final count, and the results of t-tests comparing counts at 30 minutes with final counts.

Bacterial Count	**Time (minutes)**								**Test statistic (p-value)****
	t=0 (n=40)	**t=30 (n=40)**	**t=60 (n=40)**	**t=90 (n=40)**	**t=120 (n=40)**	**t=150 (n = 33)**	**t=180 (n = 27)**	**Count***	
Total Bacteria Count	0	2.081	3.160	3.356	3.530	3.642	3.691	3.709	6.370 (<.0001)
Staphylococcal Count	0	2.189	2.811	3.318	3.311	3.410	3.534	3.528	5.730 (<.0001)
Presumptive *S. aureus* Count	0	1.604	2.089	2.645	2.922	2.946	3.094	3.123	6.315 (<.0001)
Enterobacteriaceae Count	0	0.156	0.274	0.434	0.477	0.727	0.706	0.748	2.485 (.013)
Coliform Count	0	0	0.061	0.061	0.113	0.101	0.097	0.097	1.414 (.157)

*Sampling time varied as samples were collected between 110 minutes and 180 minutes depending on the number of cows milked.

**Paired t-tests were used for total bacteria, Staphylococcal count, and presumptive *S. aureus* count, while Wilcoxon was used for *Enterobacteriaceae* and coliform counts.

Table 5.3: Bacterial Counts for Personal Air Sampler (log $_{10}$ CFU/m^3) at the maximum time

Various bacterial counts for the personal air sampler are listed along with environmental counts and correlations between each type of count for the two sampling methods.

Bacterial Count	Count* (n = 40)	Environmental Count (n = 40)	Correlation (p-value)**
Total Bacterial Count	3.266	3.709	.214 (.185)
Staphylococcal Count	3.008	3.528	.223 (.166)
Presumptive *S. aureus* Count	2.691	3.123	.403 (.010)
Enterobacteriaceae Count	0.366	0.748	.289 (.071)
Coliform Count	0.049	0.097	-.037 (.822)

*Counts were recorded at t = 180 or at the conclusion of milking.

**Pearson correlation for Total Bacterial Count, Staphylococcal Count, Presumptive *S. aureus* Count. Spearman's rho correlation for *Enterobacteriaceae* Count and Coliform Count.

Table 5.4: Total and Differential Bacterial Counts in Milking Parlors in Pennsylvania According to Volume

Counts acquired from the environmental bioaerosol sampler and the personal air sample categorized according to parlor volume. No differences were observed by volume category.

Bacterial Count	**Parlor Bio-aerosol Sampler**				**Personal Air Sampler**			
	Parlor volume (m^3)			**p ≤ F**	**Parlor volume (m^3)**			**p ≤ F**
	0 – 180 m^3 (n = 13)	**181 – 356 m^3 (n = 14)**	**≥ 357 m^3 (n = 13)**		**0 – 180 m^3 (n = 13)**	**181 – 356 m^3 (n = 14)**	**≥ 357 m^3 (n = 13)**	
Total Bacterial Count	3.611	3.718	3.797	.551	3.274	3.247	3.278	.996
Staphylococcal Count	3.478	3.544	3.560	.882	3.196	3.041	2.783	.488
Presumptive *S. aureus* Count	3.161	3.143	3.065	.943	2.887	2.894	2.275	.147
***Enterobacteriaceae* Count**	0.462	0.992	0.770	.404	0.306	0.300	0.496	.818
Coliform Count	0.000	0.139	0.150	.609	0.150	0.000	0.000	.354

*Kruskal-Wallis tests were performed for *Enterobacteriaceae* and coliform counts.

Table 5.5: Correlations of Parameters with Environmental and Personal Air Sampler Bacterial Counts

Correlations of selected parameters of the milking parlors with the various bacterial counts. The R-value appears in each cell with the p-value in parentheses.

	Number of Cows		Temperature of Parlor		Relative Humidity of Parlor		Volume of Parlor		Number of Workers		Ventilation in Parlor	
Bacterial Count	**Bio-aerosol**	**Per**	**Bio-aerosol**	**Per**	**Bio-aerosol**	**Per**	**Bio-aerosol**	**Per**	**Bio-aerosol**	**Per**	**Bio-aerosol**	**Per**
Total Bacterial Count	.056 (.730)	.135 (.407)	.124 (.446)	-.039 (.813)	-.222 (.169)	-.244 (.129)	.201 (.215)	.143 (.377)	.125 (.443)	.117 (.472)	-.062 (.704)	.054 (.739)
Staphylococcal Count	.166 (.306)	-.286 (.073)	.205 (.205)	-.324 (.042)	-.240 (.135)	-.029 (.859)	.188 (.246)	-.204 (.207)	.230 (.153)	-.194 (.231)	.019 (.906)	-.132 (.417)
Presumptive *S. aureus* Count	-.163 (.316)	-.232 (.150)	.051 (.753)	-.247 (.124)	-.125 (.440)	.022 (.892)	-.109 (.501)	-.216 (.180)	.149 (.358)	-.202 (.212)	-.154 (.343)	-.042 (.799)
***Enterobacteriaceae* Count**	.151 (.353)	.257 (.109)	.178 (.272)	-.033 (.839)	.101 (.535)	.120 (.460)	-.001 (.994)	.047 (.775)	-.113 (.489)	-.089 (.585)	.189 (.244)	-.127 (.435)
Coliform Count	.249 (.122)	-.042 (.799)	.209 (.196)	-.215 (.183)	-.010 (.951)	-.146 (.370)	.149 (.359)	-.215 (.183)	-.053 (.747)	-.037 (.822)	.281 (.079)	.196 (.225)

"Per" represents the personal air sampler counts.
The R value appears in each cell with the p-value in parentheses.
*Significant at $p \leq 0.05$

Table 5.6: Total and Differential Bacterial Counts in Milking Parlors in Pennsylvania According to Rate of Cows Milked per Minute

Various bacterial counts categorized by the rate of cows milked per minute. Results of one-way ANOVA tests also are listed.

Bacterial Count	**Parlor Bio-aerosol Sampler**				**Personal Air Sampler**			
	Rate (number of cows milked/min)			**F statistic (p value)**	**Rate (number of cows milked/min)**			**F statistic (p value)**
	≤0.738 (n = 13)	**0.739-1.016 (n = 14)**	**≥1.017 (n = 13)**		**≤0.738 (n = 13)**	**0.739-1.016 (n = 14)**	**≥1.017 (n = 13)**	
Total Bacterial Count	3.737	3.675	3.679	.084 (.920)	3.482	3.192	3.137	.494 (.614)
Staphylococcal Count	3.610	3.427	3.507	.576 (.567)	3.302	3.149	2.531	3.250 (.050)
Presumptive *S. aureus* Count	3.300	3.152	2.948	.726 (.491)	2.994	2.984	2.065	5.228 (.010)
***Enterobacteriaceae* Count**	0.306	0.810	0.914	2.516 (.284)	0.150	0.445	0.346	1.083 (.582)
Coliform Count	0.150	0.000	0.150	1.105 (.575)	0.150	0.000	0.000	2.077 (.354)

*Kruskal-Wallis tests were performed for *Enterobacteriaceae* and coliform counts.

5.7: Correlations of Rate of Cows Milked per Minute with Environmental and Personal Air Sampler Bacterial Counts

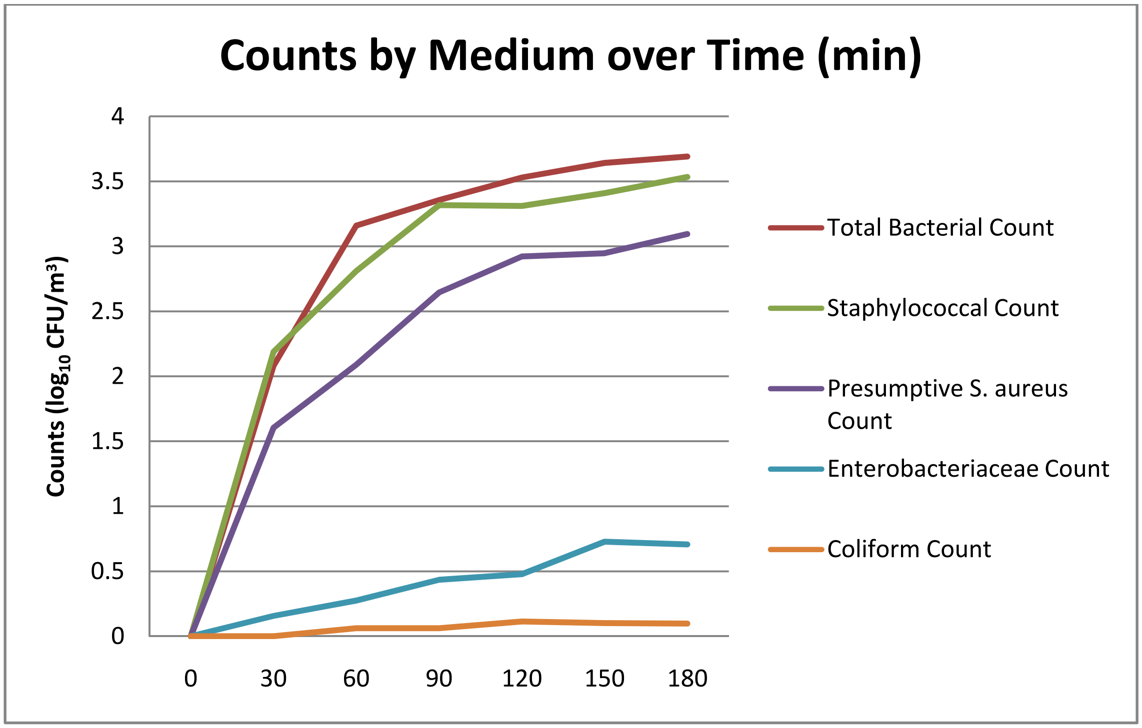
Rate of cows milked per minute correlated with the various bacterial counts using the environmental bio-aerosol sampler and the personal air sampler.

	Rate of Cows Milked per Minute	
Bacterial Count	**Bio-aerosol**	**Personal**
Total Bacterial Count	.035 (.828)	.115 (.479)
Staphylococcal Count	.121 (.459)	-.330 (.038)
Presumptive *S. aureus* Count	-.181 (.264)	-.318 (.046)
***Enterobacteriaceae* Count**	.258 (.108)	.086 (.599)
Coliform Count	-.040 (.807)	-.111 (.495)

The R value appears in each cell with the p-value in parentheses.
*Significant at p≤0.05

Figure 5.1: Bacterial Counts over Time (min)

Points represent average bacterial counts (log_{10} CFU/m^3) at each 30 minute interval.



Chapter 6

Characterization of antimicrobial resistant Staphylococci and Enterococci isolated from parlor bioaerosol samples

6.1 Abstract

Dairy farms with milking parlors in Pennsylvania (n = 40) were visited between October 2008 and January 2009. Parlor air samples were collected using an environmental bio-aerosol sampler and personal air sampler. Bio-aerosol samples were examined for Staphylococci and Enterococci. None of the samples had vancomycin resistant enterococci. Gram positive, catalase positive cocci were screened for resistance to oxacillin using a selective agar and subsequently tested for resistance against oxacillin (1 μg), amoxicillin/clavulanic acid (30 μg), and clarithromycin (15 μg) using the disk diffusion method. The minimum inhibitory concentration (MIC) values were determined for each of the isolates that demonstrated resistance during the screening procedure with the antibiotic disks. Resistant isolates were identified using Staph API and the coagulase test.

Screening using the disk diffusion method indicated that 36 isolates were resistant to clarithromycin, while 20 were resistant to oxacillin, and 2 were resistant to amoxicillin/clavulanic acid. The broth dilution method indicated that 33 isolates were resistant to clarithromycin, while 9 were resistant to oxacillin and none were resistant to amoxicillin/clavulanic acid. None of the 56 isolates that were gram positive and catalase positive were *Staphylococcus aureus*, however many other species of Staphylococci including *S. warneri*, *S. hominis*, *S. xylosus*, *S. capitis*, *S. sciuri*, *S. lentus*, *S. cohnii ssp. cohnii*, *S. auricularis*, and *S. chromogenes* were identified using the API Staph assay. Gram positive, catalase positive bacteria demonstrating antibiotic resistance to clarithromycin and oxacillin were recovered from environmental bio-aerosol samples and personal air samples on dairy farms.

6.2 Introduction

Respiratory problems have been documented in dairy farmers. In the previous chapter, the presence of various airborne pathogens was examined along with variables such as temperature, relative humidity, and parlor volume that may affect the presence of these bacteria. All of the gram-positive, catalase-positive isolates from both personal and environmental air samples were stored and tested against three antibiotics: oxacillin, clarithromycin, and amoxicillin/clavulanic acid.

Antibiotic resistant bacteria on farms are topic of increasing interest as previous research has documented the presence of these bacteria in the air in and around swine concentrated animal feeding operations. However, very few researchers have examined the air on dairy farms for the presence of such bacteria. Based on previous studies of antibiotic usage on dairy farms, it is reasonable that antibiotic resistant bacteria could be present in the air.

Antibiotic usage on dairy farms in Pennsylvania (n = 113) was examined through a survey in which the respondents reported administering 24 antibiotics for various purposes with beta-lactams and tetracyclines receiving the most use.[1] Additionally, Gram-negative bacteria with resistance to ampicillin, florfenicol, spectinomycin, and tetracycline were isolated along with bacteria that demonstrated a decreased susceptibility to other antibiotics.[2] Multidrug resistance was observed in 40% of the *E. coli* isolates collected. Additionally, gram negative, *Salmonella* spp. and *E. coli* isolates recovered from fecal samples collected at dairy farms (n = 97) in 21 states were tested for resistance against a broad panel of 16 antibiotics including amoxicillin/clavulanic acid.[3] Most of the *E. coli* (85.3%) and the *Salmonella* spp. (87.2%) isolates in the study were susceptible to all of the antimicrobials in the panel.

Aerosolized antibiotic resistant bacteria on farms are of concern because when they are inhaled, they can colonize the nasal passages and possibly the lungs of the agricultural workers.[4] Subsequently, the farm worker can serve as a reservoir for spreading these bacteria into the community especially as respiratory problems can be aggravated by co-exposures to agricultural irritants.[5] On swine farms in North America, both the farmers or workers and the animals have been identified as colonized by methicillin resistant *Staphylococcus aureus* (MRSA).[6,7]

As such, most sampling for airborne antibiotic resistant bacteria has been conducted on swine farms, although one small study demonstrated the isolation of antibiotic resistant *S. aureus* in private residences (n = 24) in Texas.[8] In a preliminary study, other researchers found significant levels of antibiotic resistant bacteria in the air at two swine facilities.[9] Levels of antibiotic resistant bacteria that were considered as a potential health hazard were recovered from a swine farm.[10] In another study, levels of antibiotic resistant bacteria inside a swine facility were 2.1 and 3.0 times higher than they were upwind from the facility.[11] The predominant bacterium that was recovered was *Staphylococcus* spp. The all-glass impinger method was used as antibiotic resistant isolates including *Enterococcus*, *Staphylococcus*, *Streptococcus*, and *Micrococcus* were recovered in another study.[5] High levels of resistance to at least 2 antibiotics were demonstrated by 98% of the isolates. Airborne, gram positive bacteria may be environmental contributors of drug resistance genes.[12]

A recent study examined the presence of antibiotic resistant bacteria in the air at a dairy cattle concentrated animal feeding operation in the Southwestern United States.[13] Samples, totaling three for each season, were collected in duplicate for three seasons, then the *S. aureus* isolates were subjected to additional testing for resistance to three antibiotics: ampicillin, penicillin, and cefaclor.

Antibiotic resistant isolates of *S. aureus* have been found in milk in Korea[14,15] and Italy[16] and recovered from a farmer and cattle in Hungary[17]. *S. aureus* is also one of the major causative agents for bovine mastitis. In 1961, very shortly after the introduction of methicillin, the bacterium, *S. aureus*, demonstrated resistance to methicillin, thereby giving rise to methicillin-resistant *Staphylococcus aureus* (MRSA). According to the CDC,[18] *S. aureus* is present in 25% to 30% of the population in the United States while about 1% of the population is colonized with MRSA. While studies have been completed in European and Asian countries, few to no studies have investigated the presence of MRSA on dairy farms in United States.

Another antibiotic resistant, gram positive cocci is vancomycin-resistant enterococci (VRE). These bacteria have been isolated in animals and animal products in Europe, thereby raising concern of a possible transfer of the *vanA* gene from VRE to MRSA.[19] No studies were found which demonstrate recovery of VRE from farms in the United States.[20,21,22]

6.2.1 Rationale

Antibiotics are used on dairy farms, thereby increasing the likelihood of bacteria developing resistance. Antibiotic resistant bacteria have been recovered from the air on swine concentrated animal feeding operations and on one dairy farm in the United States. Antibiotic resistant bacteria also have been recovered from milk and a dairy farmer in studies outside of the United States.

6.2.2 Objective

The objective of this research is to determine if the gram-positive, catalase positive bacteria from air samples that were collected in milking parlors demonstrate antibiotic resistance to oxacillin, amoxicillin/clavulanic acid, and clarithromycin.

6.3 Materials and Methods

6.3.1 Air Sampling

A group of study farms (n = 40) was recruited for the collection of air samples during various weather conditions. The study included farms of various sizes located in Pennsylvania. Dairy producers were solicited to participate in the study through contacts established by the Veterinary Extension Field Investigation Group. Necessary approvals were obtained from the Office for Research Protections at Penn State University (IRB #29262).

A time-series of environmental samples was collected during milking including a baseline before milking and a sample every 30 minutes for the duration of milking or for a total of 3 hours. The VAC-U-GO (SKC, Inc., Eighty Four, PA) environmental air sampler was placed on a cart that was approximately 3.0 feet high at every farm to ensure that air samples were always taken at the same level. The cart was placed in the pit and efforts were made to make it as unobtrusive to the milkers as possible. The environmental air sampler was set at a flow rate of 12.5 L/min[23] using The Defender 510 (SKC, Inc. Eighty Four, PA) for calibration. The collection medium placed in the collection vial of the impinger consisted of 20 mL of 1% peptone in distilled water and 0.01% Tween 80[24,23,25] except Antifoam was not added as foaming was not an issue in preliminary testing. Prior to starting the sampler and every 30 minutes (t = 0, 30, 60, 90, 120, 150, 180), an aliquot of approximately 0.5 mL of sampling medium was withdrawn from the collection vial and placed into a labeled tube. The tubes were stored on ice in a cooler for transportation back to the lab.[23] Samples were processed within 24 hours of collection.

Simultaneously, a personal air sample was collected beginning 30 minutes prior to milking and continuing for the duration of milking or for a total of 3 hours. The button sampler and AirCheck® XR5000 air pump (SKC, Inc., Eighty Four, PA) were adjusted to an intake of 2.0 L/min as is standard using The Defender 510. A commercially prepared gelatin disk (SKC, Inc., Eighty Four, PA) was used in the personal air sampler button. After sample was collected, the disk was placed in a 50 mL centrifuge tube containing 10 mL of sterile saline and transported back to the lab on ice in a cooler.

6.3.2 Plating onto CHROMagar™

An aliquot (100 µL) from the environmental sample that was collected at the maximum time and from the personal air sample were plated onto the chromogenic media, CHROMagar™ (CHROMagar, France), for detection of Methicillin-resistant *Staphylococcus aureus* (MRSA) and Vancomycin-resistant *Enterococcus faecium/faecalis* (VRE) and incubated at 37°C ± 2 for 24 and 48 hours. Presumptive MRSA isolates were streaked onto tryptic soy agar (TSA) and incubated at 37°C ± 2 for 24 hours. If there was growth, the isolates were placed into a broth suspension and stored in glycerol at -80°C for further analysis.

6.3.3 Screening for Antibiotic Resistance

Presumptive *Staphylococcus aureus* isolates from Mannitol-salt agar (see Chapter 5) previously had been placed into a broth suspension in glycerol and stored at -80°C. These isolates were removed from the freezer, streaked onto TSA and incubated at 37°C ± 2 for 24 hours. Antibiotic screening was completed per the protocol set forth in the Clinical and Laboratory Standards Institute manual M7-A7[26]. Cultures were catalase tested and all positive cultures were placed into a direct colony suspension of 0.5 McFarland. Mueller-Hinton agar (MH) plates supplemented 4% NaCl and 6 μg/mL of oxacillin were streaked onto quadrants using cotton swabs and incubated for 24 hours at 35°C ± 2.

Subsequent screening for antibiotic resistance was completed using the disk diffusion method with amoxicillin-clavulanic acid (30 μg), oxacillin (1 μg) and clarithromycin (15 μg).[27] Isolates that demonstrated resistance to oxacillin, amoxicillin-clavulanic acid, and/or clarithromycin were gram stained and identified using API Staph (bioMérieux, France) assays. The antibiotic sensitivities for these isolates were determined using the micro-dilution assay method.[26] All isolates that demonstrated antibiotic resistance were tested for coagulase reactivity using rabbit coagulase plasma with EDTA (Becton, Dickinson and Company, Sparks, MD) per the Bacteriological Analytical Manual.[28] *S. aureus* ATCC 25923 was included as a positive control.

6.3.4 Data Analysis

The parlors were categorized according to their volume with the following categories: less than 180 m^3, 181-356 m^3, 357m^3 or more. Frequencies were tabulated using SPSS 16.0 (SPSS, Inc. Chicago, IL).

6.4 Results

6.4.1 CHROMagar™ VRE

At 48 hours, none of the samples (n = 80) that were plated on the CHROMagar™ were positive for VRE.

6.4.2 CHROMagar™ MRSA

Results from the MRSA CHROMagar™ indicated that at 48 hours, 14 of the environmental samples and 7 of the personal air samples indicated the possible presence of MRSA as mauve-colored colonies appeared on the MRSA CHROMagar™ plates. For the personal air sampler results, 7 farms were positive for MRSA with the CHROMagar™. Five farms had positive samples resulting from both sampling methods.

6.4.3 Supplemented Agar Screening for Resistance

Of the isolates that were plated onto the supplemented MH agar (n = 647), 126 showed a film or colonies in 24 hours. Approximately 70% of the plates that were recorded as positive had a cloudy, film-like cover instead of a lawn of growth or distinguishable colonies. According to CLSI (2006a), resistant organisms appears as "small colonies (>1 colony) or a light film of growth". A positive control strain of MRSA obtained from another lab at Penn State University was used for comparison.

6.4.4 Disk Diffusion Screening for Resistance

Of the 647 isolates that were screened, 36 were resistant to clarithromycin, 2 were resistant to amoxicillin/clavulanic acid and 20 were resistant to oxacillin. Thirty-five isolates were intermediate to clarithromycin and 35 also were intermediate to oxacillin. There were 10 farms that had at least 1 isolate that indicated resistance to oxacillin from environmental bio-aerosol samples while personal air samples from 6 farms demonstrated resistance. For clarithromycin, 14 farms had at least one environmental air isolate that demonstrated resistance while 8 farms had at least one personal isolate. Both environmental and personal air sample isolates from one farm demonstrated resistance to amoxicillin/clavulanic acid.

6.4.5 Broth Dilution Method

The minimum inhibitory concentrations (MIC) were determined for the following antibiotics using the broth dilution method (See Table 1). Clarithromycin resistance was demonstrated by 33 isolates with an MIC of ≥8. Nine were resistant to oxacillin with a MIC of ≥4 µg. None of the isolates were resistant to amoxicillin/clavulanic acid.

6.4.6 Identification of Isolates

All of the isolates that demonstrated resistance using the disk diffusion method (n = 56) were gram stained. One isolate could not be revived. Six of the isolates were gram positive rods which were identified as *Bacillus* spp. using API 50 CH (bioMérieux, France). One of the isolates was a gram negative bacilli. Five of the eight isolates recovered from CHROMagar™ for MRSA were gram positive, catalase positive cocci, but not Staphylococci according to API Staph results. The remainder of the isolates (n = 46) were identified as various staphylococcal species including *S. warneri*, *S. hominus*, *S. xylosus*, *S. aureus*, *S. capitis*, *S. sciuri*, *S. cohnii*, *S. caprae*, *S. auricularis*, and *S. chromogenes* and *Kocuria varians/rosea* or the results for identification were not conclusive. Coagulase tests were conducted on all isolates with *S. aureus* ATCC 25923 included as a positive control. All isolates except the positive control were coagulase negative including the presumptive *S. aureus* isolates (n = 2) per the API Staph results.

6.4.7 Examination of Isolates by Parlor Volume

An examination of the farms that had at least one isolate that demonstrated antibiotic resistance revealed no difference according to the size of the milking parlors by volume (m^3).

6.5 Discussion

Antibiotic usage is common practice on some dairy farms in Pennsylvania, therefore bacteria present on these farms may demonstrate resistance to antibiotics. Antibiotic resistant bacteria previously have been recovered from environmental bio-aerosol samples on swine farms and recently on a dairy farm. In the current study, we examined environmental bio-aerosol samples and personal air samples for the presence of antibiotic resistant, gram positive, catalase positive cocci and then identified isolates that were resistant.

The results from a study from Michigan agree with the findings of the current study as fecal samples were collected over a six year period from farms where various species including beef cattle, dairy cattle, swine, chickens and turkey were raised.[29] In this study, none of the *Enterococcus faecium* isolates and none of the *Entercoccus faecalis* isolates demonstrated resistance to vancomycin.

Antibiotic resistance among *Staphylococcus* spp. isolates on dairy farms was examined in another study. Antibiotic sensitivity of *S. epidermidis* in milk samples indicated 6% were resistant to oxacillin while 13% were resistant to erythromycin and fusidic acid.[30] In the current study, none of the *Staphylococcus* spp. isolates were identified as *S. epidermidis*, however numerous other staphylococci species were present and oxacillin resistant isolates were observed. As noted in the previous chapter, other antibiotic resistant bacteria may be present on the farm, however they may not be airborne.

S.aureus and coagulase negative staphylococci (CNS) are commonly isolated mastitis pathogens that are capable of demonstrating resistance to antimicrobial drugs, therefore researchers explored the possibility of a dose-response effect between the amount of exposure to antimicrobials and susceptible pathogens.[31] In their study, Pol and Ruegg[31] noted that all but 1.3% of the CNS isolates (n = 294) that were recovered were susceptible to oxacillin with 2% NaCl. Most of the CNS isolates that were obtained in that study demonstrated susceptibility to erythromycin at the lowest concentration. Clarithromycin which was used in the current study is a macrolide with a methoxy group instead of a hydroxyl group at position six of the lactone ring, thereby providing greater stability in acids.[32] In our study, 33 isolates were classified as resistant to clarithromycin. Clarithromycin is used in human medicine and a search of the literature indicated that it has not been studied for resistance in isolates of veterinary origin. Antibiotics used in human medicine including penicillin, ampicillin, and cefaclor also were the focus of another study of *Staphylococcus* spp. on dairy farms.[13]

As previously described in the literature review, airborne MRSA has been recovered from swine farms in the United States. Several key differences exist in swine facilities as compared to dairy farms which could contribute to the presence of MRSA on swine farms, but not on dairy farms. Swine farms are totally enclosed and the animals do not go outside unless they are being shipped to another facility or to market. While swine farms are typically well-ventilated to aid in temperature control, there may be less exchange of outside air. Antibiotic usage is different on swine farms as compared to dairy farms and may be more frequent due to the large number of animals and daily processing of litters. Swine houses are constructed so that manure storage is directly underneath the animals in pits and is drained as needed while manure is usually removed from a dairy facility on a frequent basis by scraping with loaders, pressure washing, using barn cleaners, or by manual scraping. Swine herds are typically closed and animals from other farms are rarely mixed with the exception of breeding stock while dairy herds may see new animals introduced to the herd more frequently. Dairy cattle may have more frequent contact with humans as milkers are applied at least twice a day. Wastes such as milk, urine, or feces could become aerosolized in a milking parlor as they hit the hard floor surface or during washing where swine barns have slatted floors. The manure handling practices on dairy farms may actually cause more agitation and increase the likelihood of aerosolizing bacteria between animals. Dairy cattle also may come into contact with each other more easily than swine, thereby facilitating the transfer of bacteria.

All of the samples in the current study were collected between October and January when the weather was cold on most days, however there was a large range of outdoor temperatures recorded during data collection with a range from 15.0°F to 74.6°F. Seasonal effects on the population of *S. aureus* previously were observed.[13] Other factors that may affect the presence of bacteria include the relative humidity and the temperature.

6.6 Conclusions

Isolates of *Staphylococcus* spp. that demonstrated antibiotic resistance to oxacillin and clarithromycin were recovered from the air in milking parlors using an environmental air sampler and a personal air sampler. None of the isolates that were recovered demonstrated resistance to amoxicillin/clavulanic acid. The isolates were identified as various species of *Staphylococcus* using Staph API and coagulase testing.

6.7 References

1.Sawant AA, Hegde NV, Straley BA, Donaldson SC, Love BC, Knabel SJ, Jayarao BM. 2005. Antimicrobial-resistant enteric bacteria from dairy cattle. *Appl Environ Microbiol* 73(1):156-163.

2. Sawant AA, Sordillo LM, Jayarao BM. 2007. A survey on antibiotic usage in dairy herds in Pennsylvania. *J Dairy Sci* 88:2991-2999.

3. Lundin JI, Dargatz DA, Wagner BA, Lombard JE, Hill AE, Ladely SR, Fedorka-Cray PJ. 2008. Antimicrobial drug resistance of fecal Escherichia coli and Salmonella spp. isolates from United States dairy cows. Foodborne Pathogens and Disease 5(1); 7-19.

4. Aubry-Damon H, Grenet K, Sall-Ndiaye P, Che D, Cordeiro E, Bougnoux M-E, Rigaud E, Le Strat Y, Lemanissier V, Armand-Lefèvre L, Delzescaux D, Desenclos J-C, Liènard M, Andremont A. 2004. Antimicrobial resistance in commensal flora of pig farmers. *Emerg Infect Dis* 10(5):873-879.

5. Chapin A, Rule A, Gibson K, Buckley T, Schwab K. 2005. Airborne multidrug-resistant bacteria isolated from a concentrated swine feeding operation. *Environ Health Perspect* 113(2):137-142.

6. Smith TC, Male MJ, Harper AL, Kroeger JS, Tinkler GP, Moritz ED, Capuano AW, Herwaldt LA, Diekema DJ. 2009. Methicillin-resistant Staphylococcus aureus (MRSA) strain ST398 is present in Midwestern U. S. swine and swine workers. *PLoS ONE* 4(1):e4258. Doi:10.1371/journal.pone.0004258.

7. Khanna T, Friendship R, Dewey C, Weese JS. 2008. Methicillin resistant *Staphylococcus aureus* colonization in pigs and pig farmers. *Vet Microbiol* 128:298-303.

8. Gandara A, Mota LC, Flores C, Perez HR, Green CF, Gibbs SG. 2006. Isolation of

S*taphylococcus aureus* and antibiotic-resistant *Staphylococcus aureus* from residential indoor bioaerosols. Environ Health Perspect 114(12):1859-1864.

9. Scarpino PV, Quinn H. 1998. Bioaerosol distribution patterns adjacent to two swine-growing-finishing housed confinement units in the American Midwest. *J Aerosol Sci* 29(S1):S553-554.

10. Gibbs SG, Green CF, Tarwater PM, Scarpino PV. 2004. Airborne antibiotic resistant and nonresistant bacteria and fungi recovered from two swine herd confined animal feeding operations. *J Occup Environ Hyg* 1(11):699-706.

11. Gibbs SG, Green CF, Tarwater PM, Mota LC, Mena KD, Scarpino PV. 2006. Isolation of antibiotic –resistant bacteria from the air plume downwind of a swine confined or concentrated animal feeding operation. *Environ Health Perspect* 114(7):1032-1037.

12. Sapkota AR, Ojo KK, Roberts MC, Schwab KJ. 2006. Antibiotic resistance genes in multidrug-resistant *Enterococcus* spp. and *Streptococcus* spp. recovered from the indoor air of a large-scale swine-feeding operation. *Lett Appl Micrbiol* 43:534-540.

13. Alvarado CS, Gandara A, Flores C, Perez HR, Green CF, Hurd WW, Gibbs SG. 2009. Seasonal changes in airborne fungi and bacteria at a dairy cattle concentrated animal feeding operation in the Southwest United States. *J Environ Health* 71(9):40-44.

14. Lee JH. 2003. Methicillin (oxacillin)-resistant *Staphylococcus aureus* strains isolated from major food animals and their potential transmission to human. *Appl Environ Microbl* 69(11):6489-6494.

15. Kwon NH, Park KT, Moon JS, Jung WK, Kim SH, Kim JM, Hong SK, Koo HC, Joo YS, Park YH. 2005. Staphylococcal cassette chromosome *mec* (SCC*mec*) characterization and molecular analysis for methicillin-resistant *Staphylococcus aureus* and novel SCC*mec* subtype IVg isolated from bovine milk in Korea. *J Antimicrob Chemother* 56:624-632.

16. Normanno G, Corrente M, La Salandra G, Dambrosio A, Quaglia NC, Parisi A, Greco G, Bellacicco AL, Virgilio S, Celano GV. 2007. Methicillin-resistant *Staphylococcus aureus* (MRSA) in foods of animal origin in Italy. Int J Food Microbiol 117:219-222.

17. Juhász-Kaszanyitzky E, Jánosi S, Somogyi P, Dán A, van der Graaf-van Bloois L, van Duijkeren E, Wagenaar JA. 2007. MRSA transmission between cows and humans. *Emerg Infect Dis* 13(4):630-632.

18. Centers for Disease Control. 2007. MRSA and the workplace. Available at: http://www.cdc.gov/niosh/topics/mrsa. Accessed on 1/22/09.

19. Bates J. 1998. Epidemiology of vancomycin-resistant enterococci in the community and the relevance of farm animals to human infection. *J Hosp Infect* 37(2):89-101.

20. Beier RC, Duke SE, Ziprin RL, Harvey RB, Hume ME, Poole TL, Scott HM, Highfield LD, Alali WQ, Andrews K, Anderson RC, Nisbet DJ. 2008. Antibiotic and disinfectant susceptibility profiles of vancomycin-resistant *Enterococcus faecium* (VRE) isolated from community wastewater in Texas. *Bull Environ Contam Toxicol* 80:188-194.

21. Clifford McDonald L, Kuehnert MJ, Tenover FC, Jarvis WR. 1997. Vancomycin-resistant enterococci outside the health-care setting:prevlance, sources, and public health implications. *Emerg Infect Dis* 3(3):311-317.

22. Coque TM, Tomayko JF, Ricke SC, Okhyusen PC, Murray BE. 1996. Vancomycin-resistant enterococci from nosocomial, community, and animal sources in the United States. *Antimicrob Agents Chemother* 40(11):2605-2609.

23. Thorne PS, Lange JL, Bloebaum P, Kullman GJ. 1994. Bioaerosol sampling in field studies: can samples be express mailed? *Am Ind Hyg Assoc J* 55(11):1072-1079.

24. Chang CW, Chung H, Huang CF, Su HJJ. 2001. Exposure of workers to airborne microorganisms in open-air swine houses. *Appl Environ Microbiol* 67(1):155-161.

25. Thorne PS, Kiekhaefer MS, Whitten P, Donham KJ. 1992. Comparison of bioaerosol sampling methods in barns housing swine. *Appl Environ Microbiol* 58(8):2543-2551.

26. Clinical and Laboratory Standards Institute. 2006a. *Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically; approved standard-seventh edition.* CLSI document M7-A7 [ISBN 1-56238-587-9]. Clinical and Laboratory Standards Institute: Wayne, PA.

27. Clinical and Laboratory Standards Institute. 2006b. *Performance standards for antimicrobial susceptibility testing; sixteenth informational supplement.* CLSI document M100-S16 [ISBN 1-56238-588-7]. Clinical and Laboratory Standards Institute: Wayne, PA.

28. Bennett RW, Lancette GA. 2001. *Staphylococcus aureus* –Jan. 2001 Chapter 12. In Bacteriological Analytical Manual, 8th Edition, Revision A. Available at: http://www.cfsan.fda.gov/~ebam/bam-12.html.

29. Hershberger E, Oprea SF, Donabedian SM, Perri M, Bozigar P, Bartlett P, Zervos MJ. 2005. Epidemiology of antimicrobial resistance in enterococci of animal origin. *J Antimicrob Chemother* 55:127-130.

30. Thorberg B-M, Kuhn I, Aerestrup FM, Brandstrom B, Jonsson P, Danielsson-Tham M-L. 2006. Pheno- and genotyping of Staphylococcus epidermidis isolated from bovine milk and human skin. *Vet Microbiol* 115:163-172.

31. Pol M, Ruegg PL. 2007. Relationship between antimicrobial drug usage and antimicrobial susceptibility of gram-positive mastitis pathogens. *J Dairy Sci* 90:262-273.

32. Lonks JR. 2004. What is the clinical impact of macrolide resistance? *Curr Infect Dis Rep* 6:7-12.

Table 6.1: Minimum Inhibitory Concentrations of Gram positive, Oxidase Positive Cocci

Table includes the identification of each isolate and the MIC for the antibiotics tested.

	MIC (µg/mL)		
Isolate	**Oxacillin**	**Amoxicillin/ clavulanic acid**	**Clarithromycin**
Staphylococcus warneri			128
Identification not conclusive			128
S. hominis/warneri			128
S. xylosus			>128
S. aureus	2		
S. xylosus			16
Identification not conclusive	1		
S. xylosus			128
S. capitis	2		
S. chromogenes			128
S. xylosus	>128		32
S. xylosus			<.125
S. xylosus			128
S. sciuri	>128		
S. lentus	32		
Identification not conclusive	128		
Identification not conclusive	128		
Identification not conclusive	32		
Identification not conclusive		<.25/<.125	
S. xylosus			128
S. capitis	4		
S. xylosus			>128
S. cohnii ssp. cohnii			>128
S. xylosus			>128
S. sciuri			>128
S. xylosus			128
S. sciuri			128
S. xylosus			32
S. xylosus			128
S. xylosus			64
Identification not conclusive	8		
S. auricularis			128
S. aureus			64
S. sciuri	>128		
S. sciuri			>128
S. xylosus			128
S. chromogenes			128
S. xylosus			128
S. xylosus			128
S. xylosus			128

S. xylosus			128
S. auricularis			128
S. auricularis			128
S. auricularis			128
S. chromogenes			<.125
Kocuria varians/rosea			64

Chapter 7

Summary and Conclusions

A survey of women working on dairy farms in Pennsylvania (n = 624) was conducted yielding a valid response rate of 17.7%. Skin disorders were reported by 16.7% of the respondents, however only 43.4% sought medical treatment for this condition. Analysis using logistic regression indicated that possible risk factors for skin disorders included producing fruits and vegetables, raising swine in addition to dairy cattle, and not using gloves while milking. Respiratory problems were indicated by 9.8% of the respondents. Factors that appeared to have a protective effect against these problems were the use of a breathing mask and ventilation in the free stall area. Only 9 cases of foodborne illness were reported in the previous year. Raw milk consumption was reported by 76.9% of the respondents and the consumers typically were younger, from smaller farms, reported a greater number of pregnancies, and had lower education levels. Based on the observations, some conditions were reported that may have zoonotic origins. We feel that additional studies will be justified in these areas based on the reports of these conditions.

Behaviors and practices that could expose women to zoonotic pathogens also were reported in the survey. Milking cows was the task most frequently performed on a daily basis by 70.8%, while 60.6% indicated that they fed animals and 42.6% cleaned stalls. Even though milking was the most commonly performed task, only 32.7% of the respondents reported that they wore gloves when milking and 71.1% said that they always washed their hands after milking cows. Eating in the barn was reported by 45.0% while 72.0% said that they drank in the barn. The use of personal protective equipment including hearing protection, eye protection, and breathing masks was infrequent. Minimal to no risk of getting a disease from an animal with which they worked was reported by 89.7% of the respondents. Additional exploration as to why risk perception is minimal may be of interest.

Environmental bio-aerosol samples and personal air samples were collected on 40 farms in the milking parlor. Total bacterial counts, Staphylococci counts, presumptive *Staphylococcus aureus* counts, *Enterobacteriaceae* counts, and coliform counts were monitored over a three hour period or for the duration of milking and all but coliform counts significantly increased between a baseline sample and the final sample. Total bacterial counts ranged from 2.551 to 4.435 $\log_{10}$ CFU/m^3. Counts from the personal air sampler significantly correlated with counts from the environmental bio-aerosol sampler. None of the parameters that were examined including parlor volume, relative humidity, temperature, the number of cows being milked, the number of workers in the parlor, and the presence of ventilation in the parlor demonstrated a correlation with the bacterial counts that were observed. *Escherichia coli* O157, *Listeria monocytogenes*, and *Salmonella* spp. were not recovered from the air samples, therefore the occupational hazard due to these organisms in the air is uncertain.

All of the gram positive, catalase positive cocci isolated from the air samples were further examined for resistance to antibiotics including oxacillin, amoxicillin/clavulanic acid, and clarithromycin. The isolates were screened using the disk diffusion method and the minimum inhibitory concentrations were determined for isolates that demonstrated resistance. Following determination of the MIC's, the isolates were identified using Staph API and coagulase testing. Thirty-six were resistant to clarithromycin, 20 were resistant to oxacillin, and none were resistant to amoxicillin/clavulanic acid. The isolates were identified as various species of Staphylococci including *S. aureus*, *S. warneri*, *S. hominis*, *S. xylosus*, *S. capitis*, *S. sciuri*, *S. lentus*, *S. cohnii spp. cohnii*, *S. auricularis*, and *S. chromogenes*.

As future studies are conducted to build upon this study, consideration should be given to Hispanic farm workers including women. Future survey materials could be bi-lingual or a translator may be of use if interviews are conducted. This shift in the workforce may bring additional health considerations that warrant examination due to differences in previous exposures, diet, vaccination records, training, and preventative practices. More in-depth questions could be used to explore additional exposures that may aid in pinpointing zoonotic causes of disease. Inquiry regarding life-time incidence of foodborne illness may be of greater value. Although recall bias is a consideration, an attempt to make temporal associations with exposures and illnesses would be of use as would the association of biomarkers such as antibody levels which could mark previous exposures. Triangulation of data through the use of medical records, physical examinations, and health department records would lend validity to results. A study in which a cohort of farm women is monitored for an extended time may lend invaluable information about exposures. The study also should include women who previously were not exposed to farming and have made a lifestyle change that has involved them in farming such as new employees on a commercial farm.

Appendix A

Survey

PENNSTATE

1855

College of Agricultural Sciences

Assessing Health of Women in Dairy Farming

Department of Veterinary & Biomedical Sciences
Penn State University

This survey assesses the risks you as **WOMEN** might face because of your work with dairy cattle. If you are a man and you have received this survey, please help us by asking a woman who works on your farm to complete the survey. To make this assessment, the survey asks about:

❑Characteristics of the farm that you work on
❑Your experiences working with dairy cattle.
❑Your past and current health status.

We recognize just how busy you are, but taking the time to share this information is very important, even if you don't believe that your health is at risk. Without your answers, we can't accurately and objectively describe the risks to women who work on dairy farms in Pennsylvania. The information you provide will help us develop better animal handling practices so that people will be less likely to contract a disease from an animal that they work with.

Please…

❑Read all the directions carefully and make your answers clear.
❑Answer all the questions to the best of your knowledge. Remember, all answers will be kept completely confidential.
❑Mail your completed form back to us in the postage-paid envelope.

If you have questions, you may contact us at:
Ginger Fenton (814)863-9639 or gdc3@psu.edu
Dr. Bhushan Jayarao (814)863-5939 or bmj3@psu.edu

SECTION A: FARM INFORMATION

1. Please check the box that describes where you work the most with dairy cattle?
❑Family or individual farm
❑Contract or company-owned farm
❑Partnership operation
❑Other:___________________________

2. Other than DAIRY what else do you produce on your farm? (check all that apply)
❑Crops
❑Vegetables/fruit
❑Beef
❑Sheep/goats
❑Swine
❑Poultry
❑Horse
❑Other: __________________________

3. Approximately how many cows are you currently milking? ________ cows

4. How many times each day are your cows milked? __________ times

5. How many people are involved in operating the dairy farm on a daily basis?
Men:___________
Women:__________

6. Approximately, how many pounds of milk are produced at each milking? ______pounds

7. What kind of housing do you have for your milk cows?
❑Free stall
❑Tie Stall
❑Stanchion
❑Bedded pack
❑Other:______________________

8. What kind of bedding do you use for your milk cows?
❑Straw
❑Sawdust
❑Sand
❑Recycled Manure
❑Newspaper
❑Other:________________________

9. What kind of milking facility does this farm have?
❑Pipeline
❑Parlor

10. Which areas of your farm are ventilated by fans? (check all that apply)
❑Stalls
❑Milking parlor
❑Calving pens
❑Sick animal pens
❑Alleys
❑Free stalls
❑Other: _________________________

11. What type of water supply does the farm have?
❑Public water supply
❑Spring
❑Well
❑Cistern
❑Other: _________________________

12. What is the zip code for your farm? ____________

SECTION B: INFORMATION ABOUT YOU

13. How old were you on your last birthday? ______ years

14. How long have you been involved in dairy farming?
❑Less than 5 years
❑5-10 years
❑11- 15 years
❑16-20 years
❑21-30 years
❑More than 30 years

15. What is your role on the farm?
❑Owner
❑Partner
❑Manager
❑Herdsperson
❑Employee
❑Other: _________________________

16. Do you live on the farm property?
❑YES ❑ NO

17. Were you raised on a dairy farm?
❑YES ❑ NO

18. In what country were you born?
❑United States
❑Mexico
❑Canada
❑Other: ________________________

19. What is your educational background?
❑Less than high school
❑High school graduate or GED
❑Some post-high school education
❑Completed 2-year technical or associate degree
❑Completed 4-year college degree (B.A./B.S.)
❑Completed graduate or professional degree

20. What was the gross farm sales from your farm in 2006?
❑Less than $1000
❑$1,000 - 10,000
❑$10,001 - 99,999
❑$100,000 - 249,999
❑$250,000 - 500,000
❑Greater than $500,000

21. Have you traveled outside of the United States within the past 12 months?
❑ YES❑ NO

If you answered YES, to where did you travel? (please specify)
____

22. Do you consume raw milk?
❑ YES ❑ NO

If you answered YES, for how long have you been consuming raw milk?
_________ years

SECTION C: YOUR WORK WITH CATTLE

23. Approximately how many hours do you spend with the herd on an average day?______ hours

24. Do you feel that working with cattle puts you at risk of contacting a disease from cattle?
❑Not at all
❑Minimal
❑Moderate
❑Considerable
❑Don't know

25. Is there any task related to animal handling that you do not do because you or your family feel it could be hazardous to your health? ❑ YES ❑ NO

If you answered YES, please describe the tasks that you prefer not to do.

____

____

26. Do you haul animals to the market, fairs, or livestock shows? ❑ YES ❑ NO

27. Are you responsible for administering any type of reproductive hormones (Lutalyse, Oxytocin) to animals to induce labor or cause heat cycles?
❑ YES ❑ NO ❑ Unsure

28. Do you ever eat in the barn?
❑YES❑ NO

29. Do you ever drink in the barn?
❑ YES❑ NO

30. Have you ever received formal training on communicable diseases from animals?
❑YES ❑ NO ❑ Don't know

31. Which statements best describe the way that you learned to work with cattle. (check all that apply)
❑I learned on my family's farm.
❑I received on the job training.
❑I worked with dairy cattle through 4-H.
❑I received formal training in school or college (vo-ag programs of FFA).
❑I received formal training through Cooperative Extension programs.
❑I received formal training through breed associations.
❑I learned by reading books and magazines.
❑I learned by looking on-line.
❑Other:_________________________

32. Below are listed a number of tasks you might do on a dairy farm. For each task, please check the box that best describes how often you have done this task *in the past year*.

	Never	Monthly	Weekly	Daily	Not applicable
Feeding	❑	❑	❑	❑	❑
Treating sick animals	❑	❑	❑	❑	❑
Vaccinating calves and cows	❑	❑	❑	❑	❑
Assisting with difficult birthing	❑	❑	❑	❑	❑
Breeding animals	❑	❑	❑	❑	❑
Moving animals within or between barns	❑	❑	❑	❑	❑
Composting dead animals	❑	❑	❑	❑	❑
Identifying young animals (tagging, tattooing)	❑	❑	❑	❑	❑
Euthanizing animals	❑	❑	❑	❑	❑
Pressure washing animal housing facilities	❑	❑	❑	❑	❑
Sanitizing animal housing facilities	❑	❑	❑	❑	❑
Transporting manure	❑	❑	❑	❑	❑
Removing manure from barn	❑	❑	❑	❑	❑
Cleaning stalls	❑	❑	❑	❑	❑
Milking cows	❑	❑	❑	❑	❑
Other: ______________________________	❑	❑	❑	❑	❑

Below are listed a number of practices that some people use when working on a dairy farm.

33. Please check the box that best describes how often you have used latex gloves at these times *in the past year*.

USE OF LATEX GLOVES	Never	Rarely	Sometimes	Often	Always	Not applicable
Milking	❑	❑	❑	❑	❑	❑
Treating sick animals	❑	❑	❑	❑	❑	❑
Assisting with calving	❑	❑	❑	❑	❑	❑
Breeding animals	❑	❑	❑	❑	❑	❑
Have cuts or wounds on your hands	❑	❑	❑	❑	❑	❑
Other:____________________ ___	❑	❑	❑	❑	❑	❑

34. Please Please check the box that best describes how often you have used the following protective equipment while performing farm work *the past year*.

USE OF PERSONAL PROTECTIVE EQUIPMENT	Never	Rarely	Sometimes	Often	Always
Ear protection	❑	❑	❑	❑	❑
Eye protection (safety glasses or goggles)	❑	❑	❑	❑	❑
Breathing mask	❑	❑	❑	❑	❑
Respirator	❑	❑	❑	❑	❑
Other: ____________________________	❑	❑	❑	❑	❑

35. Please check the box that best describes how often you have changed barn clothes at these times *in the past year*.

FARM WORK CLOTHES	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**	**Not applicable**
How frequently do you change into clean washed clothes at the beginning of each work day?	❑	❑	❑	❑	❑	❑
How frequently do you change out of your barn clothes before leaving the barn?	❑	❑	❑	❑	❑	❑
Do you routinely change clothes AFTER any of the following tasks?						
Treating sick animals	❑	❑	❑	❑	❑	❑
Milking	❑	❑	❑	❑	❑	❑
Assisting with birthing calves	❑	❑	❑	❑	❑	❑
Pressure washing	❑	❑	❑	❑	❑	❑
Hauling manure	❑	❑	❑	❑	❑	❑
Other: _______________	❑	❑	❑	❑	❑	❑

36. Please check the box that best describes how often you have cleaned or changed boots at these times *in the past year*.

How frequently do you change boots or clean your boots AFTER…	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**	**Not applicable**
Moving manure	❑	❑	❑	❑	❑	❑
Pressure washing	❑	❑	❑	❑	❑	❑
Sanitizing facilities	❑	❑	❑	❑	❑	❑
Milking	❑	❑	❑	❑	❑	❑
Assisting with birthing	❑	❑	❑	❑	❑	❑
Moving from one area to another such as from the milking parlor to the sick animal pens	❑	❑	❑	❑	❑	❑
Entering the barn	❑	❑	❑	❑	❑	❑
Before leaving the barn	❑	❑	❑	❑	❑	❑

37. Please check the box that best describes how often you have washed your hands at these times *in the past year*.

HANDWASHING	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**	**Not applicable**
When entering the barn	❑	❑	❑	❑	❑	❑
Before leaving the barn	❑	❑	❑	❑	❑	❑
After hauling manure	❑	❑	❑	❑	❑	❑
After assisting with birthing	❑	❑	❑	❑	❑	❑
Before milking	❑	❑	❑	❑	❑	❑
After milking	❑	❑	❑	❑	❑	❑
After smoking	❑	❑	❑	❑	❑	❑
After treating sick animals	❑	❑	❑	❑	❑	❑
After breeding animals	❑	❑	❑	❑	❑	❑
Other:___________________	❑	❑	❑	❑	❑	❑

SECTION F: YOUR HEALTH

38. Have you been diagnosed by your doctor with any of the following conditions? (check all that apply)
❑Crohn's disease
❑Inflammatory bowel syndrome
❑Ulcerative colitis
❑Colitis
❑Irritable bowel syndrome
❑Other: ________________________
❑None

39. Have you ever been diagnosed with an illness or condition that was from contact with an infected animal?
❑ YES ❑ NO ❑ Unsure

If you answered YES, what was illness or condition? ________________________

40. In the past 12 months, has a health condition caused you to change your farming activities? ❑ YES ❑ NO

41. Below is a list of diseases that people can get from animals. Please check any diseases that a physician has diagnosed you with. (mark all that apply)
❑Brucellosis
❑Tuberculosis
❑Q fever
❑Leptospirosis
❑Tick fever
❑Other: ________________________
❑None

42. In the past 12 months, have you had foodborne illness (food poisoning)?
❑ YES ❑ NO (if NO, skip to #47)

43. If you answered YES, when were you sick? _______(month); _______(year)

44. How long did the sickness last?
_______(days) OR ________(weeks)

45. Did you seek professional medical help?
❑ YES ❑ NO (if NO go to #47)

If you answered YES to #45, where did you go?
❑Emergency room
❑Family physician
❑Other: ________________________

46. What were the symptoms? (check all that apply)
❑Headache
❑Nausea
❑Pain in the stomach
❑Cramps
❑Loose stools
❑Blood in stools
❑Other: ________________________

If you answered YES to #45, was a laboratory test of your stool sample performed?
❑ YES ❑ NO

If a stool sample was tested, what was the cause of the infection? (check all that apply)
❑*Salmonella*
❑*Campylobacter*
❑*Listeria monocytogenes*
❑*Staphylococcus aureus*
❑*Clostridium perfringens*
❑*Cryptosporidium*
❑*Giardia duodenalis*
❑Other: ________________________
❑Don't know

47. During the past 12 months, have you had any skin conditions such as a rash, eczema, dermatitis or inflammation?
❑ YES ❑ NO (if NO go to #51)

48. Did you seek treatment from a medical professional for this skin condition?
❑ YES ❑ NO

49. What body parts were affected by this skin condition?
❑Hands
❑Arms
❑Head, neck, or face
❑Legs
❑Other: ______________________

50. What symptoms did you observe? (mark all that apply)
❑Itchy skin
❑Dry or cracked skin
❑Scaly skin
❑Redness of skin
❑Swollen patches of skin

51. In the past 12 months, have you experienced difficulty breathing?
❑ YES ❑ NO

52. Since you began working with dairy cattle, have you experienced difficulty breathing **AND** any of the following conditions? (check all that apply)
❑Red eyes
❑Dizziness
❑Coughing
❑Wheezing
❑Other: ________________________

53. If you have had difficulty breathing, at what times do you typically have difficulty breathing?
❑Morning
❑Afternoon
❑Evening
❑Night

54. Do you smoke? ❑ YES ❑ NO

If you answered YES to #58, how many packs a day? ________ packs

55. How frequently do you consume alcohol?
❑Not at all
❑1 drink per week
❑2-3 drinks per week
❑4-6 drinks per week
❑7 or more drinks per week

56. Are you taking any medications or undergoing treatment for cancer?
❑ YES ❑ NO

57. Has a physician ever diagnosed you with a liver disease?❑ YES ❑ NO

58. Has a physician ever diagnosed you with a kidney disorder?
❑ YES ❑ NO

59. Have you ever had a mammogram?
❑ YES ❑ NO

60. Have you ever had a breast exam by a medical professional?
❑YES ❑ NO

61. Have you ever had a pap smear?
❑YES ❑ NO

62. How many times have you been pregnant? ________ times

If you have never been pregnant, skip to #72.

63. How many pregnancies resulted in a live birth? _______ pregnancies

64. How many pregnancies resulted in a miscarriage (a loss of pregnancy before 20 weeks passed)? _______ pregnancies

65. How many babies have you had that were born more than 3 weeks before the due date? _______ babies

66. Were you ever given medicine because you were in labor too early?
❑ YES ❑ NO

If you answered YES, during how many pregnancies were you treated?
_______ pregnancies

67. Have you ever had difficulty getting pregnant?
❑YES ❑ NO

68. How many times have you had labor induced because you were overdue?
_______ times

69. Have you ever experienced the loss of a baby before birth (stillbirth)?
❑ YES ❑ NO

70. Have you ever had a child with a birth defect that required medical or surgical treatment?
❑YES ❑ NO

If you answered YES, how many children required treatment? ________ children

71. How close to your delivery did you continue to work in the barn?
________ days

72. Have you ever experienced irregular or painful menstruation?
❑ YES ❑ NO

73. Have you ever experienced a time when you did not menstruate that was not due to pregnancy or menopause?
❑ YES ❑ NO

74. Have you ever been diagnosed by a mental health professional with any of the following?
❑Depression
❑Obsessive Compulsive Disorder
❑Bipolar Disorder
❑Seasonal Affective Disorder
❑Autism
❑Attention Deficit Hyperactivity Disorder
❑Post-Traumatic Stress Disorder
❑Anxiety Disorder
❑Eating Disorder
❑Other: __________________________
❑None

In the space below, please write any additional comments you have about this survey or about your health and dairy farming.
____
____
____
____
____
____

Thank you very much for your time and participation!! We greatly appreciate your thoughts. Please put your completed survey in the enclosed postage-paid envelope and place it in the mail. Thanks again!

OPTIONAL INFORMATION

Are you interested in participating in an extended study on women's health? If you are interested, please provide information for us to contact you.

Name: ______________________________
Address: ____________________________
____
____
Phone: ______________________________
E-mail (optional): ______________________

Appendix B

Human Subjects Participant Form #29262

Informed Consent Form for Biomedical Research
The Pennsylvania State University

ORP USE ONLY: IRB#29262 Doc. #1
The Pennsylvania State University
Office for Research Protections
Approval Date: 09-29-2008 DWM
Expiration Date: 09-10-2009 DWM
Social Science Institutional Review Board

Title of Project: Surveillance for Aerosolized Antibiotic Resistant Bacteria on Dairy Farms in Pennsylvania

Principal Investigator: Ginger D. Fenton,115 W. L. Henning Building, University Park, PA 16802 (814)863-9639 gdc3@psu.edu

Advisor: Dr. Bhushan M. Jayarao, 115 W. L. Henning Building, University Park, PA 16802
(814)863-5939 bmj3@psu.edu

Other Investigator(s):
Dr. David Wolfgang,115 W. L. Henning Building,University Park, PA 16802
(814)865-5849 drw12@psu.edu
Dr. Kathryn J. Brasier, 105B Armsby Building, University Park, PA 16802
(814)865-7321 kjb24@psu.edu
Dr. Rama B. Radhakrishna, 212 Ferguson Building, University Park, PA 16802
(814)863-7069 brr100@psu.edu
Dr. George Henning, HP08 Palmyra Clinic, Hershey, PA 17033
(717)838-6305 gfh2@psu.edu

1. Purpose of the study: The purpose of this research is to determine whether airborne antibiotic resistant bacteria are present on dairy farms in Pennsylvania. A small number of milking parlors on dairy farms will be sampled during various weather conditions to determine if the weather conditions influence the presence of these bacteria.

2. Procedures to be followed: You will be asked to allow the researchers to collect air samples using environmental air samplers and personal air samplers while you milk.

3. Discomforts and risks: There should be no discomfort or risks aside from a small piece of extra equipment in your milking parlor which will be the environmental air sampler.

4. Benefits: The benefits to society include a determination whether these bacteria are present on dairy farms. If they are present, steps may be developed for reducing the risks in the future such encouraging more prudent usage of antibiotics.

5. Duration/time of the procedures and study: Each farm will be visited once for the duration of 30 minutes prior to milking until 30 minutes after milking. Air samples will be continuously collected during this time.

6. Statement of confidentiality: Your participation in this research is confidential. The data will be stored and secured at 30 Agricultural Sciences and Industries Building at Penn State University in a password protected file. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Penn State's Office for Research Protections, the Biomedical Institutional Review Board, and the Office for Human Research Protections may review records related to this research study.

7. Right to ask questions: Please contact Ginger Fenton at 814-863-9639 or gdc3@psu.edu with questions, complaints or concerns about the research. You can also call this number if you feel this study has harmed you. Questions about your rights as a research participant may be directed to Penn State University's Office for Research Protections at (814) 865-1775.

8. Voluntary participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

9. Injury Clause: In the unlikely event you become injured as a result of your participation in this study, medical care is available. It is the policy of this institution to provide neither financial compensation nor free medical treatment for research-related injury. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

____

Participant SignatureDate

____

Person Obtaining ConsentDate

Appendix C

Farm Residence, Local Farm Presence and Factors Related to Women's Reproductive Health

Farm Residence, Local Farm Presence and Factors Related to Women's Reproductive Health

Myron R. Schwartz, M.A.
Instructor, Family and Community Medicine
Pennsylvania State University College of Medicine

Ginger D. Fenton, M.S.
Graduate Research Assistant, Veterinary and Biomedical Sciences
The Pennsylvania State University

George F. Henning, M.D., V.M.D.
Associate Professor, Family and Community Medicine
Pennsylvania State University College of Medicine

Please address all correspondence to:
George F. Henning, M.D.
Department of Family and Community Medicine H154
Pennsylvania State University College of Medicine
500 University Drive
Hershey, PA 17033

This research received support from the Pennsylvania Department of Agriculture, Agromedicine Program, Penn State College of Agricultural Sciences Seed Grant

Number of Tables: 5

Abstract

There are numerous potential hazards to pregnant women living or working on farms, including infectious agents, trauma, chemical and pesticide exposure, and compromised health care access. This study was designed to explore the correlates of pregnancy outcomes for women living and working on farms or in areas of high farm density. The first component of the research was a women's health survey distributed by mail to 3,709 dairy farm women in the Commonwealth of Pennsylvania. Five hundred ninety-eight completed surveys were analyzed. Survey questions included fertility history and pregnancy outcomes including abortive/preterm delivery. A second component of this study analyzed hospital discharge data. Diagnoses analyzed included multiple births, preterm labor/delivery, spontaneous abortion, diabetes, and hypertensive disorders. Models tested with these data included the effect of percent farm residence in the patients' ZIP Code of residence on pregnancy outcomes. Analyses of both data sources did not establish significant effects of farm residence on pregnancy outcomes. This information suggests that the conduct of more costly studies should be conducted only in the presence of additional evidence that may link farm residence to pregnancy outcomes. The researchers suggest that the methodologies employed here provide a cost efficient strategy to begin an investigation of the effect of farm residence and local farm presence on pregnancy outcomes.

Keywords: farm residence, pregnancy, reproductive health

Introduction

The role of women in Pennsylvania agriculture is increasing. While women have traditionally played a role as the "farmwife" or "farm helper," a role that typically included tending to young animals, gardening, caring for children, and food preparation; many are now taking on management roles or running their own farms. The number of female principal farm operators in Pennsylvania has increased by 21.4 percent between 1997 and 2002.[1] A total of 29,160 women were classified as farm managers or supervisors, agricultural product inspectors or graders, or miscellaneous agricultural workers.[2]

With more active involvement in the daily functions of the farm, women are exposed to certain risks that could affect their reproductive health or that of their unborn child. These risks may be associated with exposure to pesticides and insecticides,[3,4,5] physical injury,[6] zoonotic infectious agents including *Coxiella burnetti*, *Listeria monocytogenes*, *Leptospira interrogans*, and *Brucella abortus*,[7] exposure to gases such as carbon monoxide,[8] and handling veterinary obstetric drugs[9].

Several studies have examined the relationship between residing or working on a farm and infertility, yielding mixed results. Increased stillbirths were observed in an agricultural region in New Brunswick.[3] In one questionnaire-based case-control study, a significant increase in infertility among women who resided on farms or worked in agricultural-related jobs was reported.[4] An increased risk of limb defects was observed for maternal employment in agricultural fields.[5] However, another study reported that non-metropolitan residence was not significantly associated with an increased risk of neonatal mortality or low birth weights.[10] Greenlee et al. demonstrated that residence on a farm, ranch, or in a rural area had a protective effect against infertility.[11]

The existing evidence associating farm residence and employment with pregnancy outcomes is mixed, suggesting the need for further study. The objective of this research is to continue the investigation of that association.

Methods

In the absence of readily available individual-level, contemporaneous data that include both the clinical history of a pregnancy and the farm status residence of the individual, this research analyzed two alternative types of data. The first of these is survey data including retrospective fertility history of farm women. These data were obtained through a stratified, random sample survey of dairy farms in Pennsylvania, conducted with the cooperation of the Pennsylvania Field Office of the National Agricultural Statistics Service. The sample was stratified by dairy herd size. A total of 624 surveys were returned from an initial mailing of 3,709, resulting in a response rate of 17.8 percent; 598 of the respondents answered questions about fertility history.

The survey instrument included questions concerning respondent demographics, number of pregnancies, spontaneous abortions, stillbirths, and preterm deliveries. A modified version of the method described by Dillman[12] was employed and included an initial mailing, a reminder postcard, and a second mailing to those who did not respond to the initial mailing. Pregnancy outcome indicators for farm women derived from the survey were compared to available national indicators for an equivalent group.

The second data source was hospital discharge data obtained from the Pennsylvania Healthcare Cost Containment Council. These data described hospital discharges for calendar years 2005 and 2006 that included a pregnancy-related ICD-9 code in either the primary diagnosis code or one of the secondary codes. The discharge data included race, age, sex, and patient residential ZIP Code. There were 306,509 hospital discharges in Pennsylvania that included a pregnancy-related ICD-9 code. Of these, 169,860 were for patients residing in non-urbanized ZIP codes. Only rural (non-urbanized) discharge records were analyzed, since the inclusion of urban discharges would introduce a complex of confounding factors that would hinder proper model specification. Socio-economic data from the 2000 Decennial Census for ZIP Codes was matched to each record based on the residential ZIP Code of the patient. These data included percent farm residence, per-capita income, and percent poverty. The first of these was used as an independent variable in the analyses and the latter two as control variables. Binary logistic regression was used in the analyses of both data sources. A forward selection method was used to select variables for inclusion in the equations.

Results

Analysis of the Pennsylvania dairy farm survey was used to assess the factors associated with adverse pregnancy outcomes among farm women and to provide a comparison with national rates. Descriptive statistics for the survey data are presented in Table 1.

It should be noted that respondents included women who have completed their fertility and those who have not.Three pregnancy outcome indicators were derived from the survey data. The first (*Stillmiss*) is an indicator of whether the respondent had reported a stillbirth or at least one spontaneous abortion (32.1 percent). The second (*Preterm*) indicates if the respondent reported that they had at least one child who had been born prior to 37 weeks gestational age (16.7 percent). The final indicator (*Any Complication*) represents if the respondent reported any of the following: a spontaneous abortion, a stillbirth, a preterm baby, a post date baby, or a child with a birth defect (53.5 percent).

In Table 2, regression results for these three outcome measures are presented.

A binary logistic regression method employing a forward selection inclusion technique was used to estimate the equation. The variables considered for inclusion were: (1) number of pregnancies, (2) respondent's age, (3) respondent's education *(high school or less)*, (4) farm owner status, (5) years living on farm-to-age ratio index, (6) the presence of non-dairy animals on the farm, and (7) if the respondent was raised on a farm. The number of pregnancies should be considered an exposure variable and is of little substantive interest.

Of the seven indicators considered for inclusion in the three models, only two (in addition to the number of pregnancies) were significant, *Age* and *High School or Less*. The effect of *Age* was significant for *Premature* and *Any Complication*. On the basis of the regression equations, the probability of 30 year olds who had a preterm delivery during their fertility history was predicted to be about .07 greater than the same probability for 50 year olds (with control variables evaluated at their means). Similarly, the probability of 30 year olds experiencing any complication was predicted to be about .12 greater than 50 year olds. There are two reasonable explanations for these results. First, older women may underreport problems as a consequence of the passage of time, and secondly, the increasing role of women in farm activity may account for some of the difference.

The effect of *High School or Less* was significant for *Stillmiss* and *Any Complication*. On the basis of the regression equations, the probability of those with more than a high school education experiencing pregnancy loss during their fertility history was predicted to be about .14 greater than the same probability for those with a lesser education. Similarly the probability of those with a higher education experiencing any complication was predicted to be about .15 greater than those with a lesser education (with control variables evaluated at their means). These differences could potentially be a result of more frequent late-age parities for college educated women.

The data from the survey permit an estimation of the fetal loss rate (sum of spontaneous abortions and stillbirths / number of pregnancies) for the sample. The sample estimate for this rate is 14.0 percent. An appropriate national comparison rate should be based on the historical period in which the fertility occurred for the sample and should demographically approximate the sample. Since the average age of the sample was 47 years and the age at first parity is approximately 25 years; the majority of the fertility for the sample would have taken place between 1985 and 1995. The sample also is almost entirely white. Consequently, the national comparison used here is the fetal loss rate for non-Hispanic white women for 1990. This rate is 16.4 percent.[13] Considering the probability of underreporting from the sample data, the farm women sample is very similar to an equivalent national rate.

Overall, farm structure, farm role, and farm background factors were not significantly associated with adverse pregnancy outcomes. However, two socio-demographic factors, age and education were. Age was a measure of age of the respondent and not an indicator of age at parity.

Hospital discharge data was the second data source used in this research. These data included descriptions of Pennsylvania hospital discharges for pregnancy-related ICD-9 codes for calendar years 2005 and 2006. Only discharges in non-urbanized ZIP Codes were used in the analyses. Table 3 presents a description of the variables used in the analyses and their short names. Table 4 presents the univariate statistics for the variables used in the analyses.

Nine pregnancy outcome indicators were used in the analyses. Four hypertension related indictors (*Prehp, Prehp2, Transienthp,* and *Clampsia*), one delivery term indicator (*Preterm*), two birth status indicators (*Stillbirth* and *Multiple*), and one diabetes variable (*Gestational Diabetes*). Control variables used in the regression analyses included two patient demographic variables (*Age* and *Race*) and two ecological variables describing the wealth of the patient's ZIP Code (*PC Income* and *Percent Poverty*). Since personal income data were unavailable, the latter were included to better isolate the direct effect of the independent variable of interest, *Percent Farm. Percent Farm* is best understood as a "local farm presence" variable describing the residential location of the patient and not an indicator of farm residence proper or farm employment.

Results of binary logistic regressions using forward selection inclusion procedures for each of the nine pregnancy outcome measures are presented in Table 5. All models were significant, however, the models explained very little variation in the outcome indicators (all Cox & Snell R-squareds were less than .01).

The effects of local farm presence on pregnancy outcomes were marginal. The effect parameter was only significant for three of the nine outcome indicators. For *Stillbirth*, the greater the local farm presence, the higher the probability of reporting a stillbirth; however the effect was minimal. Evaluating all other variables in the equation at their mean (except race=white), the probability of a stillbirth was only .003 greater for those who resided in a ZIP Code with no residential farm population when compared to those who resided in a ZIP Code with a farm population of 10 percent. For eclampsia/preclampsia *(Clampsia)*, the greater the local farm presence, the lower the probability of an eclampsia/pre-eclampsia diagnosis. This effect was also quite small. The probability of an eclampsia/pre-eclampsia diagnosis was only .005 less for those who resided in a ZIP Code with no residential farm population than the same probability for those who resided in a ZIP Code with a farm population of 10 percent.

The effects of the control variables in the equations estimated exhibited a mixed consistency with past research. Age was (generally) positively associated with an increase in adverse pregnancy outcomes, local per-capita income was (generally) negatively associated with adverse pregnancy outcomes, local poverty rate was (generally) negatively associated with adverse pregnancy outcomes (weak and inconsistent), and non-white status effects were mixed.

Discussion

Although in a few instances, a local farm presence effect on pregnancy outcome was statistically significant; these effects were substantively small and inconsistently patterned. Consequently, the researchers offer the following provisional conclusion: No substantively important epidemiological pattern exists that associates local farm presence with pregnancy outcomes. This conclusion is offered provisionally, since the measurement of farm presence employed was, in many respects, an indirect indicator. Farm presence was measured as the percent of the population in the subject's ZIP Code who were living on a farm. It did not account for geographic proximity of the subject to a farm, actual farm residence, or the mix of farm types in the local area.

The absence of a verification of any substantively significant association between local farm presence and pregnancy outcomes suggests, that when considering research costs, it may be prudent only to continue the investigation of these matters in the presence of other information that may suggest an association between a specific farm environment factor and pregnancy outcomes or epidemiological patterns that may suggest the need for an important public health intervention. The research conducted here was conducted with the support of limited research funding. It was accomplished using an add-on module to a survey conducted for other purposes and the analysis of archival data. The researchers suggest that such an approach may serve as a cost-effective strategy to explore the need for more costly investigations.

The absence of consistent epidemiological patterns does not imply that continued vigilance with respect to matters of farm safety be relaxed. In individual instances, exposure to potentially harmful environmental factors and farm work may have serious consequences for pregnant women, but the frequency of these occurrences is not sufficient to establish strong epidemiological patterns.

References

1. United States Department of Agriculture National Agricultural Statistics Service (USDA-NASS). 2004. 2002 Census of Agriculture. Available at: http://www.nass.usda.gov/census/. Accessed 9/20/06.

2. PA Department of Labor and Industry. 2000. US census labor force data by gender for farming, fishing, and forestry occupation in Pennsylvania for 2000. Available at: http://www.paworkstats.state.pa.us. Accessed on 9/13/06.

3. White, FMM, Cohen, FG, Sherman, G, McCurdy, R. Chemicals, birth defects and stillbirths in New Brunswick: associations with agricultural activity. Can Med Assoc J. 1988 Jan;138:117-

4. Fuortes, L, Clark, MK, Kirchner, HL, Smith, EM. Association between female infertility and agricultural work history. Am J Ind Med. 1997;31:445-51.

5. Engel, LS, O'Meara, ES, Schwartz SM. Maternal occupation in agriculture and risk of limb defects in Washington State, 1980-1993. Scand J Work Environ Health. 2000 Jun;26(3):193-8.

6. National Coalition for Agricultural Safety and Health. Agriculture at Risk: A Report to the Nation, Institute of Agricultural Medicine and Occupational Health, Editor. 2001, The University of Iowa: Iowa City, Iowa.

7. Langley, RM, Morrow, WEM. Zoonotic hazards in humans in agriculture, forestry, and fisheries. In Langley, RM, McLymore, RL, Meggs, WJ, Robertson, GT editors. Safety and health in agriculture, forestry, and fisheries. Rockville, MD: Government Institutes; 1997. p. 127-41.

8. Donham, KJ, Thelin, A. Agricultural medicine: occupational and environmental health for health professionals. Ames, Iowa: Blackwell Publishing; 2006.

9. Wilkins III, JR, Bowman, ME. Needlestick injuries among female veterinarians: frequency, syringe contents and side-effects. Occup Med. 1997;47(8):451-7.

10. Larson, EH, Hart, LG, Rosenblatt, RA. Is non-metropolitan residence a risk factor for poor birth outcome in the U.S.? Soc Sci Med. 1997;45(2)171-88.

11. Greenlee, AR, Arbuckle, TE, Chyou, P. Risk factors for female infertility in an agricultural region. Epidemiology. 2003 Jul;14(4):429-36.

12. Dillman, DA. Mail and internet surveys: the tailored design method. New York, NY: John Wiley and Sons, Inc;2000.

13. Centers for Disease Control and Prevention. Trends in pregnancies and pregnancy rates by outcome: estimates for the United States 1976-96. Series 21, No. 56. Jan 2000. HHS,CDC:Hyattsville, MD.

Table 1: Univariate Statistics for Farm Survey Data

	N	Percent		N	Percent
Number of Pregnancies			**Stillmiss***		
0	62	10.4	No	337	67.9
1	31	5.2	Yes	159	32.1
2	97	16.2	Total	496	100.0
3	140	23.4			
4	93	15.6	**Premature****		
5	55	9.2	No	425	83.3
6	44	7.4	Yes	85	16.7
7	17	2.8	Total	510	100.0
8	17	2.8			
9	12	2.0	**Any Complication*****		
10	11	1.8	No	215	46.5
11	6	1.0	Yes	247	53.5
12	7	1.2	Total	462	100.0
13	2	.3			
14	1	.2	**Number of Premature Babies**		
16	2	.3	0	425	83.3
17	1	.2	1	65	12.7
Total	598	100.0	2	13	2.5
			3	5	1.0
Number of Miscarriages			4	1	.2
0	346	68.9	6	1	.2
1	94	18.7	Total	510	100.0
2	33	6.6			
3	10	2.0			
4	13	2.6			
5	2	.4			
6	1	.2			
9	1	.2			
10	2	.4	**Variables Used as Independent Variables**		
Total	502	100.0			
			High School or Less	63.8	(Percent)
			Farm Owner	41.1	(Percent)
			Other Livestock****	21.3	(Percent)
			Farm Years/Age	.62/.10	(Mean/Index)
			Raised on Farm	55.4	(Percent)
			Age	47.1	(Mean)
			Pregnancies (at least one)	4.2	(Mean)

* Yes if any pregnancy resulted in a stillbirth or miscarriage and No if pregnant and none of the above
** Yes if any pregnancy resulted in premature delivery and No if pregnant and none were premature
*** Yes if any miscarriage, premature, overdue, stillbirth, or birth defect and No if pregnant and none of the above
****Yes if non-dairy animals raised on farm and No if not

Table 2: Results of Binary Logistic Regressions for Survey Data (Forward Selection Method)

	Odds Ratio (Significance)						
Dependent Variable	**Number of Pregnancies**	**High School or Less**	**Age**	**Farm Owner, Years on Farm/Age Index, Other Livestock, Raised on Farm**	**Cox & Snell R-Squared**	**Model Chi-Square**	**Model Significance (N)**
Stillmiss	1.727 (.000)	.503 (.007)		None met forward selection criteria for any equation	.219	109.520	.000 (443)
Premature	1.187 (.000)		.977 (.035)		.043	21.256	.000 (488)
Any Complication	1.535 (.000)	.534 (.004)	.975 (.004)		.159	76.903	.000 (443)

Table 3: Description of Variables Used in Hospital Discharge Data

Variable	**Description** (ICD-9 Codes in parentheses)
Problem	Indicated if positive on stillbirth, hypertension variables, clampsia, diabetes, or preterm (1 if indicated, 0 otherwise)
Prehbp	Indicated if benign essential hypertension (642.0) and hypertension w/clampsia overlaid (642.7) (1 if indicated, 0 otherwise)
Prehbp2	Indicated if benign essential hypertension (642.0) only (1 if indicated, 0 otherwise)
Transienthbp	Indicated if transient hypertension (1 if indicated, 0 otherwise)
Preterm	Indicated if preterm delivery—includes only discharges with a delivery (1 if indicated, 0 otherwise)
Stillbirth	Indicated if stillbirth code indicated on V type ICD-9 code (1 if indicated, 0 otherwise) (Includes only discharges w/delivery)
Clampsia	Indicated if pre-eclampsia or eclampsia (642.4 thru 642.7) (1 if indicated, 0 otherwise)
Gestational Diabetes	Gestational diabetes (648.8) (1 if indicated, 0 otherwise)
Multiple	Indicated if multiple birth (regardless of live or not) (1 if indicated, 0 otherwise) (Includes only discharges w/delivery)
Age	Age of patient
Race	Race of patient (white=0, nonwhite=1)
PC Income	Per-capita income for ZIP Code of patient (in thousands)
Percent Farm	Percent farm residence in ZIP Code of patient
Percent Poverty	Percent less than 200% poverty in ZIP Code of patient

Table 4: Univariate Statistics for Variables Used in Hospital Discharge Analyses

	Number of Respondents	Percent		Number of Respondents	Percent
Problem			**Stillbirth**		
Not Indicated	145,092	85.4	Not Indicated	148,865	99.4
Indicated	24,768	14.6	Indicated	901	0.6
Total	169,860	100.0	Total	149,766	100.0
Prehbp			**Clampsia**		
Not Indicated	167,549	98.6	Not Indicated	164,210	96.7
Indicated	2,311	1.4	Indicated	5,650	3.3
Total	169,860	100.0	Total	169,860	100.0
Prehbp2			**Gestational Diabetes**		
Not Indicated	168,120	99.0	Not Indicated	165,640	97.5
Indicated	1,740	1.0	Indicated	4,220	2.5
Total	169,860	100.0	Total	169,860	100.0
Transienthbp			**Multiple**		
Not Indicated	165,243	97.3	Not Indicated	148,885	99.4
Indicated	4,617	2.7	Indicated	835	.6
Total	169,860	100.0	Total	149,720	100.0
Preterm					
Not Indicated	139,6379	93.2			
Indicated	10,129	6.8			
Total	149,766	100.0			
Race			**Age**	(Mean)	27.98
White	149,234	87.9	**Percent Farm**	(Mean)	1.10
Not White	20,626	12.1	**Pct. Poverty**	(Mean)	25.30
Total	169,860	100.0	**PC Income**	(Mean)	20,591

Table 5: Results of Binary Logistic Regressions for Pregnancy Outcomes for Hospital Discharge Data (Forward Selection Method)

	Odds Ratio (Significance)						
Dependent Variable	**Age**	**Race**	**Per-Capita Income**	**Poverty**	**Percent Farm**	**Model Chi-Square***	**Model Significance**
Problem	1.022(.000)		.986(.000)	.995(.000)		372.572	.000
Prehbp	1.116(.000)		.981(.000)			939.403	.000
Prehbp2	1.117(.000)		.987(.002)			729.339	.000
Transienthbp	1.008(.001)	.719(.000)				56.252	.000
Preterm	.991(.000)	1.230(.000)	.981(.000)	.996(.039)		139.659	.000
Stillbirth		1.427(.000)		1.007(.039)	1.038(.015)	23.140	.000
Clampsia	1.005(.024)		.981(.000)	.994(.009)	.983(.002)	25.009	.000
Gestational Diabetes	1.092(.000)	.739(.000)	.987(.004)	.986(.000)		1277.625	.000
Mutiple	1.060(.000)		1.031(.001)	1.014(.013)		119.295	.000

*All Pseudo R-squareds less than .01

VITA

Ginger D. Fenton

Education:

Ph.D.	2009	The Pennsylvania State University	Pathobiology
M.S.	2005	The Pennsylvania State University	Food Science
B. S.	1999	Edinboro University of Pennsylvania	Environmental Science/Biology

Awards and Honors

- First Place in the Penn State University Graduate Exhibition –Life and Health Sciences Division in 2008
- First Place in the Gamma Sigma Delta College of Agriculture Graduate Poster Exhibition in 2008

Publications

Fenton, G. D., K. J. Brasier, G. F. Henning, R. B. Radhakrishna, and B. M. Jayarao. 2009. A Survey of Selected Occupational Health Characteristics of Women Working on Dairy Farms in Pennsylvania. Journal of Agromedicine 14(4):___.

Fenton, G. D., K. J. Brasier, G. F. Henning, R. B. Radhakrishna, and B. M. Jayarao. 2009. Occupational Health-related Behaviors and Habits of Women Working on Dairy Farms in Pennsylvania. Journal of Agromedicine 14(4):___.

Fenton G. D., R. B. Radhakrishna, and C. N. Cutter. 2009. Participation in 'Handwashing University' Promotes Proper Handwashing Techniques for Youth. Journal of Extension. Accepted.

Fenton G. D., L. F. LaBorde, R. B. Radhakrishna, J. L. Brown, and C. N. Cutter. 2006. Comparison of Knowledge and Attitudes Using Computer-based and Face-to-face Personal Hygiene Training Methods in Food Processing Facilities. Journal of Food Science Education 5:45-50.

Grants

2006-2007 Penn State College of Agricultural Sciences Seed Grant: A Comprehensive Survey of Zoonotic Occupational Health Risks of Women in Animal Agriculture, $14,500

Master's Thesis

Comparison of Computer-based and Face-to-face Personal Hygiene Training Methods in Food Processing Facilities. Advisors: Catherine N. Cutter and Luke F. LaBorde