

HEARING STATUS AND USE OF PERSONAL
PROTECTIVE EQUIPMENT IN GRAIN AND SWINE WORKERS
PARTICIPATING IN A HEARING SURVEILLANCE PROGRAM

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Graduate Studies and Research
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Abstract

Grain and swine workers exposed to greater than 85 dB(A) are at risk for noise induced hearing loss. When hearing damage occurs is uncertain. Ensuing damage is irreversible. When the source of the noise cannot be eliminated, workers have to rely on hearing protection devices. Early identification of agricultural related hearing loss characteristics in a workers' career is critical. At present, little is known about the nature of hearing loss in agricultural industries.

The purpose of this study was to examine the state of hearing health and hearing protection usage in Saskatchewan grain and swine workers. Pender's Health Promotion model provided a conceptual framework for the research project by guiding the assessment of general hearing health characteristics and the development of discussion related to hearing protection use.

Method: A secondary analysis was conducted of data collected on 299 grain and 125 swine workers who were examined through an occupational health surveillance program between 2004 and 2009. A questionnaire was used to gather information on the use of hearing protection devices, noise exposure history, and variables associated with use of hearing protection devices. Hearing at 500, 1000, 2000, 3000, 6000 Hz was measured by an audiogram that was administered by a trained technician. Overall hearing loss was defined as any loss at any frequency in either ear at ≥ 25 dB from the results of the audiogram.

Statistical Approach: Means and standard deviations were used to express continuous variables and categorical variables were described with frequencies and percentages. Logistic regression models were used to assess the association between significant hearing losses and occupation, adjusting for other important variables. For all comparisons, the level of statistical significance was set at $(\alpha) = p < 0.05$.

Results: Years of employment were higher in the grain worker population. Hearing loss and ringing in the ears from a loud noise was observed in half of the worker population. The grain worker group showed a greater overall hearing loss (≥ 25 dB) compared to swine worker group. In fact, over 91% of those with a significant hearing loss were grain workers. Those workers with hearing loss were more likely to be older, male, and report current ringing in their ears. Grain workers wore hearing protection only half the time when in a noisy environment and swine workers almost consistently used hearing protection when in a noisy environment. General use of hearing protection in the workers was seen in only half of the worker population. Risk factors for ≥ 25 dB hearing loss in either ear at any frequency were age, male gender and being a grain worker.

Conclusion: In this study worker related hearing loss is a major health risk with 50 % of the study population experiencing a significant hearing loss. As a serious occupational hazard it appears to have a greater impact on grain workers as compared to swine workers. The results of this study will be used to identify strategies to promote the hearing health of grain and swine workers in Saskatchewan.

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Dedication

I would like to dedicate this thesis to my partner in life, my husband Murray Wiederhold and our son, Carson my greatest accomplishment and joy in life. Both have given me unconditional love and support throughout this journey and are the reason behind everything I do and strive for in life. To my parents and family, to whom I hope I have made proud by achieving this accomplishment. I love you all.

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Chapter 1: Introduction

1.1 Background to the Problem

Noise is a major occupational hazard and is the greatest single cause of preventable sensorineural hearing loss in the world (Alberti, 1998). Short term effects of noise exposure include temporary hearing loss, difficulty in verbal communication, and safety risks. A long term health effect of noise exposure is permanent hearing loss (Raymond & Lusk, 2006). There is no effective treatment for permanent hearing loss. Often a silent disease, the negative health outcome of noise induced hearing loss is gradual, it occurs without pain or the appearance of physical abnormalities (Raymond & Lusk, 2006).

Noise induced hearing loss has been recognized as one of the most common confirmed occupational diseases (El Dib, Verbeek, Atallah, Andriolo, & Soares, 2006). In 1996, the National Institute for Occupational Safety and Health identified that more than 30 million workers in the United States were exposed to harmful levels of noise on the job (Raymond & Lusk, 2006). Although there is no national registry of noise induced hearing loss, studies show that compliance with hearing protection devices in noisy environments is on average 77% compared to the 100% compliance required to prevent noise induced hearing loss (Lusk, Ronis, Kazanis, Eakin, Hong & Raymond, 2003). Ehlers and Graydon (2011) noted that in a farm family and health hazards survey conducted with New York, adult farmers and farm residents, 36% of the participants reported some difficulty in hearing.

There are very few Canadian published studies on hearing loss in farming related environments and no studies specific to the incidence of noise induced hearing loss in grain and swine workers in Canada. In the two Canadian articles reviewed where gender, age and hearing hazards on the farm were discussed (Reesal, Hagel, Pahwa, Domoney, McDuffie & Dosman,

1994 and Lupescu, Angelstad, Lockinger, McDuffie, Hagel, Dosman & Bidwell, 1999), it was shown that loss of hearing was more prevalent in males than females. As well, noise induced hearing loss in farming appeared to increase with years of working in the industry as a result of prolonged exposure (Reesal et al., 1994 and Lupescu et al., 1999). There are a small number of studies from the United States that examined farming and swine industry hearing hazards (Achutan, Chandran & Tubbs, 2007, Depczynsk, Franklin, & Challinor, 2005, Franklin, Depczynski, Williams & Fragar, and Humann, Donham, Jones, Chandran & Smith, 2005).

Noise induced hearing loss is a preventable condition. As a first line of noise control, it is mandated that the employer reduce noise levels to below 85 dB (A)* in all areas where workers may be required or permitted to work (Saskatchewan Labour: Occupational Health and Safety, 1997). However, noise level management is complex. Hass-Salvin, McColl & Pickett (2005) noted that reducing machine noise is often financially impractical and mechanically impossible. When the source of the noise cannot be eliminated due to the financial impact or mechanical impossibility, workers have to rely on administrated controls or hearing protective devices. Despite the positive effects of wearing hearing protection, such devices are infrequently used (Lupescu et al., 1999).

Improving the health behaviors of workers exposed to noise can be approached in different ways, including instituting a work place regulation of noise levels and training in hearing conservation. In Canada, workplace regulations vary between provinces. In Saskatchewan, the Health and Safety Division of the Provincial Ministry of Labour Relations and Workplace Safety legislates noise levels of 85 dB (A) in the work environment be used as the level for mandatory hearing testing of employees and implementation of a hearing conservation program

Footnote: (A) weighting

(Saskatchewan Labour, 1996), Federal Regulations legislates noise levels at 87 dB (A). A hearing conservation program includes training workers about the hazard of exposure to noise, providing environmental and engineering control measures where practical to reduce noise levels, and the provision of and proper use of hearing protection.

1.2 Purpose of the Study

The purpose of the study was to examine the state of hearing health and hearing protection usage in Saskatchewan grain and swine workers who participated in a hearing surveillance program conducted by the Canadian Centre of Health and Safety in Agriculture at the University of Saskatchewan between 2004 and 2009. The information from this study could be used to identify strategies to promote the sustainability and dissemination of evidence-based hearing protection programming. Further research and development of occupational hearing programs within these occupational industries can be undertaken to improve hearing health and protection.

Chapter 2: Literature Review

CINAHL and Medline (1990 – 2011) databases were used to search for primary research articles. The combined search terms included “noise induced hearing loss” and “prevention” and “control”. The combined search of CINAHL and Medline identified 1, 104 articles. The search was refined to “noise induced hearing loss” and “prevention” and “control” and “agriculture”; this resulted in 100 articles. The term agriculture was replaced with “farming” to result in 40 articles, and then replaced with “grain worker/swine worker” to result in 5 articles. The term “Pender’s Health Promotion Model” was added to the search and resulted in 6 articles. Abstracts of 111 articles were examined and 47 articles were chosen for review.

2.1 What is Noise Induced Hearing Loss?

Defined by the American College of Occupational and Environmental Medicine Evidence - based Statement, October 27, 2002:

“Noise induced hearing loss, as opposed to acoustic occupational trauma, is hearing loss that develops slowly over a long period of time (several years) as the result of exposure to continuous or intermittent loud noise. Occupational acoustic trauma is a sudden change in hearing as a result of a single exposure to a sudden burst of sound, such as a blast. The diagnosis of noise induced hearing loss is made clinically by a medical professional and should include a study of the noise exposure history”. (p.1)

Noise induced hearing loss can either be temporary or permanent. Hearing loss has no visual signs. There is no external damage to the ear, no bleeding and no noted pain unless the loss is due to severe acoustic trauma, pain would be acute. Noise induced hearing loss can be caused by trauma (acoustic) or repeated exposure to high noise levels over a period of time. Hearing loss results from the destruction of the cochlear hair cells in the inner ear (Hwang, Gomez, Sobotova, Stark, May, Hallman, 2001 and May, 2000). Hearing loss is gradual, and usually progresses over 10 -15 years of intensive noise exposure and then progresses more slowly thereafter (May, 2000) It is not until the speech frequencies (2000Hz) are affected that

the worker identifies a problem with their hearing.

Sound frequency is measured in cycles per second, commonly known as hertz (Hz). The human ear perceives sound in many frequencies in the range of 20 to 20,000 Hz. Noise induced hearing loss first becomes apparent at 4000 Hz, while 2000 Hz is the frequency at which conversational hearing becomes markedly impaired (Reesal et al., 1994). A loss of hearing can result in a several negative consequences including poor or missed communication with others, potential for increased safety risks because warning signals of impending danger are not heard, and social isolation because the person with the hearing loss cannot participate in or hear conversations where hearing is essential to the situation (Haas-Slavin et al., 2005).

Exposure to noise in the occupational environment is one of the hazards experienced by grain and swine workers. Hearing loss equals the loss of auditory sensitivity and can be measured by audiometric testing. An audiometer is an instrument used to measure the hearing threshold. It measures frequencies that include 500, 1000, 2000, 3000, 4000, 6000 and 8 000 Hz. Hearing loss will be represented on an audiogram as an increase in the hearing threshold levels.

2.2 Risk Factors for Hearing Loss on the Farming Environment

The cause of hearing loss has been linked to noise exposure related to the tasks and tools used by the worker (Kerr, McCullagh, Slavik & Dvorak, 2003). Both the swine and grain workers are exposed to noisy conditions that are not unlike those experienced by farmers. Noise induced hearing loss in farming appears to increase with years of working as a result of prolonged and accumulative effects of noise exposure (Depczynski, Franklin, Challinor, Williams & Frager, 2005). Hearing loss becomes a chronic condition that mainly affects the higher frequencies of one's hearing and the loss is shown to increase with age (Renick, Crawford & Wilkins, 2009). In farming activities, the most noted source of noise is from agricultural

equipment (Renick et al., 2009). Hazardous noise levels from activities on a farm, including the use of a tractor without a cab, chainsaw, workshop tools, and heavy machinery, can range from 86 dB(A) to 106 dB(A) (Renick et al., 2009). It is also recognized that working with livestock is a risk factor for developing noise induced hearing loss. Noise hazards in a swine confinement unit can be mechanical in nature (fans, automatic feeders, power washing equipment) or can come from the swine themselves (Humann et al., 2005). Noise hazards in the grain worker's job would be mechanical in nature and could include grain spilling from the truck box to the pit, workshop tools, a tractor without a cab, noise from rail cars as they move or are joined together, the opening of the car lids, and augers.

2.2.1 Age and Gender

Hearing loss due to aging and occupational hearing loss are seen as a major health issue (Lower, Fragar, Depczynski, Fuller, Challinor & Williams, 2010). As farmers age, their hearing sensitivity significantly declines compared to non-farming controls. Plakke and Dare in a study that compared non-farmer controls to farmers found that none of the members of the control group, who were white collar workers from three age categories (30's, 40's and 50's), had clinically significant hearing loss. However, the farming group showed a hearing loss of 10% at age 30, 30% at age 40, and 50% at age 50 (Plakke & Dare, 1992). In another study of farmers in Saskatchewan, average hearing losses among 51 to 60 year-old farmers was 50dB at 4000 Hz and 20dB at 2000Hz and those 61-70 years of age showed a hearing loss greater than the upper limit of 40 dB (Dosman, LaBrash & Ulmer, 2007). Reesal et al.(1994) also saw a progressive loss of hearing with the increase of age. When stratified by age, the hearing loss among farmers was more severe than that of the control population. In the United States, farming has the greatest prevalence of reported hearing impaired workers and most farmers can expect to experience

significant hearing loss by 50 years of age (Milz, Wilkins, Ames & Weatherspoon, 2008).

Presbycusis, or slow loss of hearing with age is found to be more prevalent in males (Hwang, Gomez, Sobotova, Stark, May & Hallman, 2001). It is uncertain at what age noise induced hearing loss begins but it could occur earlier within the farming population. In studies done by Ehlers and Graydon (2011), and Knobloch and Broste (1998) the prevalence of noise induced hearing loss was increased among male adolescents who lived and worked on a farm compared to non farming male adolescents. Ehlers and Graydon (2011) also noted that 25% of male farmers incur hearing handicaps by age 30 and 50% by age 50. Hwang et al. (2001) concluded that gender and age were both significant factors associated with hearing loss. They found significant differences in hearing sensitivity between men and women, and, with aging men's hearing declined faster than that of women (Hwang et al., 2001). The women in most studies relating to hearing loss and farming are the wives of farmers (Lupescu et al., 1999). In a study done by Lupescu et al. (1999) only 29% of their total study population (n = 1418) had normal audiograms. When broken down by gender, only 21% (n = 226) of male participants had normal audiograms as compared to 56% (n = 186) of the female participants. When further stratified by early loss and abnormal loss, the prevalence of abnormal loss was higher in the male population (Lupescu et al., 1999). Reesal et al. (1994) reported that, when comparing aged matched farming males to their female non-farming counterparts, males sustained 20 dB greater hearing loss than non-farming females.

2.2.2 Use of Hearing Protection

The goal of hearing protection is to reduce the exposure of the ear to noise. Unprotected workers in high noise environments may experience more lost-time injuries, can be less productive, and may experience more problems in general (e.g. fatigue, headaches, etc.) than

those who work in lower noise environments (Milz et al., 2008). The barriers to workers accepting and wearing hearing protection devices include comfort, training on proper use of devices and communication while wearing hearing protection. For example, heat and humidity under the ear muff pose a discomfort to the worker, devices not fitted properly can also cause discomfort and the noise cancellation offered with hearing protection devices prevents workers from hearing safety signals or co worker's warning of danger. Suter (2009) noted the works of E.H. Berger (2003) cautioned that field tests showed that some hearing protection devices may not provide sufficient protection. In the absence of noise control, an over-reliance on hearing protection devices can also become an issue if the protection is insufficient (Suter, 2009).

Some workers are reluctant to implement the use of hearing protection devices if they already experience hearing loss, as it can further reduce speech perception, hearing of signals, etc. (Hass-Slavin et al., 2005). Family history of hearing loss and age were shown to lessen the likelihood to use or maintain use of hearing protection devices (Voaklander, Franklin, Depczynski & Frager, 2009). In a farm family, hearing loss may be seen as a natural consequence of the occupation; family awareness regarding prevention of hearing loss has been shown to be key in the use of hearing protection (Hass-Slavin et al., 2005 and Voaklander et al., 2009).

The wearing of hearing protection devices can be effective in reducing the exposure by as much as 30 dB or more (Michael, Tougaw, Wilkinson, 2011). This is dependent on many factors including the shape and/or size of the ear, motivation to wear a hearing protection device, and continuance of wearing the hearing protection device for the entire work shift (Michael et al., 2011). While fit testing for hearing protection devices is important to ensure that the device can be worn effectively, it does not guarantee that the worker will wear the device appropriately and

for the entire work shift (Michael et al., 2011).

2.2.3 Exposure Levels of Noise

Agricultural workers, particularly grain and swine workers, have the potential for regular exposures to levels of noise above 85 dB(A) (Dosman et al., 2007). There are different weighing scales used when measuring sound which filter out sound at different frequencies. The A-weighting scale excludes some low and some very high frequencies sound, and is closest to the frequency response of the human ear (Hass-Slavin et al., 2005 and Voaklander et al., 2009). The A-weighting scale is expressed as “A” after the decibel level (e.g. 85 dB(A)).

Prolonged exposure to noise levels in excess of 80 to 85 dB(A) may result in hearing loss of the worker. In the grain and swine industry a task-based approach can be used in assessing noise levels. In Saskatchewan, the Occupational Health and Safety Act (1993) states that 85 db is the average acceptable noise level for an 8 hour day without any hearing protection. This time frame of noise exposure by a worker is not to be exceeded without wearing hearing protection. For every 3 dB increase in average daily noise exposure, the safe maximum daily exposure time is halved. Many of the noise exposures in the agricultural environment, which are task-based or machinery related exposures, exceed the recommended 85 dB(A). Such exposures include but are not limited to: tractors, augers, grain dryers, feed processors, aeration fans, tools, pressure washers, castration of pigs, breeding of pigs, snout snaring and ear clipping (Dosman et al., 2007, Depczynski et al., 2005 and Achutan et al., 2007).

2.2.4 Previous and Concurrent History of Hearing Exposures

It is important to look at the previous and current hearing exposure history of the agricultural worker. Workers may in fact be employed in other occupations or have recreational hobbies where they may have additional noise exposures. Previous exposure or recreational

noise exposure would put these individuals at a greater risk for noise induced hearing loss (Plakke & Dare, 1992). Non occupational exposure to impulse noise (sudden or explosive peaks of noise), such as hunting, and prolonged exposure to activities such as snowmobiling or loud music, all increase an individual's risk for noise induced hearing loss (Dennis & May, 1995). When assessing hearing history in the occupational environment, a thorough questionnaire should include questions specific to non-occupational noise exposure.

2.3 Prevalence of Hearing Loss in the Agricultural Sector

In the last two decades, research on noise induced hearing loss and its consequences from long-term exposure have increased as tools for hearing measurement have improved (Voaklander et al., 2009). Several studies noted the consequences of noise exposure among the farming population putting farmers at a higher risk for noise induced hearing loss than non-farmers (Hass-Slavin et al., 2005, Plakke & Dare, 1992 and Voaklander et al., 2009). It was also noted that most of the hearing loss among farmers is in the higher frequency tones which affects the understanding of verbal communication (Hass-Slavin et al., 2005).

Farming Population

Plakke and Dare (1992) compared the hearing of male farmers whose exposure was only from farming, to a control group of age-matched white collared workers with no noise exposure. With 10 persons in each age group (ranges of age were: 25-34, 35-44 and 45-54), subjects were tested at 500, 1,000, 2,000, 3,000, 4,000, 6,000 and 8,000Hz. The averages for 500-3,000 Hz and 2,000 – 4,000 Hz were examined for comparison of hearing loss between groups. In the 25-34 age group, differences were not statistically significant but, there was a trend for farmers' hearing sensitivity to be poorer than that of non-farmers when comparing the threshold averages at 2000 – 4000 Hz and 500- 3000 Hz. The 35-44 age group had similar thresholds at the low and

mid frequencies (500 – 2,000 Hz) and had significantly different thresholds at the high frequencies (3,000Hz – 8,000Hz) ($p < 0.05$). The farmers in the 45-54 age group had statistically significant high-frequency hearing loss compared to the controls ($p < 0.05$) (Plakke & Dare, 1992).

In 1994, Reesal et al. conducted audiograms in a Saskatchewan farming community to determine if hearing loss in male and female farmers/farmer labors (grouped as “farmers”) differed from non-farmers of similar age. Results showed that farmers were more likely to experience a progressive loss of hearing with age. Hearing loss in both ears also increased with age and exposure to farm machinery. A greater loss of 10 dB in the left ear was detected and attributed to the use of heavy machinery such as tractors, as the left ear would have more exposure to greater decibels due to right ear advantage. Right ear advantage is the difference in noise exposure of the right and left ear due to the head of the worker creating a shadow which partially protects the one ear (Kerr et al., 2003). Example of right ear advantage are having the driver’s window open in a truck, looking over one’s right shoulder when driving a tractor which has trailing equipment behind and shooting right handed exposes the left ear to more noise (Kerr et al., 2003).

Lupescu et al. (1999) found that farmers at an earlier age than non-farmers had higher rates of noise induced hearing loss as a result routine of noise exposure greater than 85db. The Agricultural Health and Safety Network, a program sponsored by the rural municipalities and the Centre for Agricultural Medicine, currently the Canadian Centre for Health and Safety in Agriculture provided a screening and educational program in order to promote hearing conservation in farming populations. Out of a sample of participants ($n = 1418$), 29% had normal audiograms (participant hears all frequencies within the range of 0-25dB), 31% were

categorized as early loss index (notch or dip of at least 15db at 3000, 4000, and/or 6000 Hz, the bottom notch is found at $\geq 20\text{dB}$) and 39% were categorized as abnormal (assigned for significant hearing loss or when the configuration suggests that hearing loss may be unrelated) (Lupescu et al. 1999). Within the study, males were referred twice as often as females for further hearing examination and testing and 21% of males had normal audiograms as compared to 56% of females (Lupescu et al. 1999).

Kerr et al. (2003) conducted a hearing screening program using two convenient samples of construction workers and farmers (reference). Construction workers (53%) and farmers (67%) had thresholds of greater than 25 dB, in either ear (Kerr et al., 2003). Results showed that farmers had a higher rate of hearing loss, overall. Noise induced hearing loss was indicative at 4,000 Hz. Both groups had a right ear advantage which is explained by the differential noise exposure of the right and left side (Kerr et al., 2003).

Hearing loss among Ohio farm youth was compared to that of a national sample by Renick et al. (2009). Baseline data was collected on the farm youth (1994-1996) and then followed up (2003-2004), which also included audiometry testing. When compared to the national sample, the farm youth displayed a higher occurrence of hearing loss. At 6,000 Hz, nearly half of farm youth displayed some degree of hearing loss at baseline (Renick et al., 2009).

A qualitative study was conducted by Slavin et al. (2005) to examine the challenges and coping strategies experienced by 13 dairy farmers with a hearing loss and communication impairment. This study also looked at the needs for hearing protection, hearing conservation programs, educational training regarding hearing loss awareness, and noise control/management of the noise (Hass-Slavin et al, 2005). Four themes emerged including: 1. “A familiar but private problem” where the farmer was aware of the hearing loss, but preferred to deal with it as

a private or personal matter. 2. “Communication difficulties” which restricted social engagement, led to miscommunication, or embarrassment and stress. 3. “Safety and risk management” which could have led to posting of visual signs to compensate for audible signal to prevent injury or 4. “Complex noise management solutions” could have been undertaken such as machinery modification made to decrease noise emissions and the prevention of further hearing loss by using hearing protection devices (Hass-Slavin et al, 2005).

In summary, the studies reviewed have shown that farmers have a higher prevalence of hearing loss compared to non-farmers. As farmers age, their hearing also declines with exposure to noise. There are significant differences in hearing sensitivity between men and women and as they aged men’s hearing declined faster than that of women. Farmers face challenges when communication is impaired from a hearing loss that impacts their quality of life and safety. Evidence from the literature indicates that prolonged exposure to on-farm noise hazards results in hearing damage. Noise management strategies such as machine modification and the use of hearing protection devices are preventative measures that could be undertaken to prevent or decrease noise injury among farmers.

2.4 Sources of Noise and Agricultural Sector Exposure

Studies have shown that continuous exposure to harmful noise levels over extended periods of time can contribute to noise induced hearing loss. Farm equipment produces high levels of noise emission. Growing numbers of studies have indicated that agricultural workers are experiencing noise induced hearing loss due to their exposure to high noise levels (Dennis & May, 1995, Depezynski et al., 2005 & Humann, et al., 2005).

Dennis and May (1995) looked at a random sample of dairy farmers who wore noise dosimeters and recorded their activities for a full day of work. This group was exposed to noise

levels longer than 8 hours despite the typical eight (8) hour work day in other industries (Dennis & May, 1995). The 8-hour time weighted averages (TWA) of 86 dB(A) were found above U.S. Occupational Safety and Health Administration (OSHA) action level. The predominant source of noise exposure came from mechanical equipment (Dennis & May, 1995). Sources of noise exposures above 85 dB(A) included tractor noise at 90 dB(A) [once the throttle was engaged the noise level increased to a mean of 92 dB(A)], chain and buzz saws noises at 102 dB(A), and noise from bedding choppers at 95 dB(A) (Dennis & May, 1995). Another study done on the dairy industry by Beckett et al (2000) also found similar results with regards to noise exposures,

Three swine production facilities were sampled four times using a personal noise dosimeter and sound level meter in a study by Hummann et al. (2005). They found that workers had an overall exposure greater than 85 dB(A) (8 hour TWA). Specific tasks such as piglet processing and heat checking were the major sources of high noise exposure [(90.9 dB(A) and (92.1 dB(A), respectively] (Hummann et al., 2005). Other noise hazards were noted, including fans, feeding delivery systems, rattling noise generated by the steel crates, gates and pens, but these were not evaluated.

Depczynski et al (2005) used a snowball sampling method to access farmers from northern New South Wales and southern Queensland representing a variety of farming productions (dairy, grain, horticultural, mixed grain/cotton, livestock and sugar). Farm visits were made to 48 farms to collect noise exposure via a questionnaire and assess noise levels of the machines. The highest noise exposure was attributed to firearms (140 dB(A)). Other notable sources of noise emissions were chainsaws (106 dB(A)), augers (93 dB(A)), and tractors without cabs (92dB(A)) (Depczynski et al., 2005).

Achutan and Tubbs (2007) examined task based exposure levels at a small scale swine

operation at a community college. The purpose of this study was extrapolate these exposures to show potential maximum daily exposure levels as if the tasks were carried out for 8 hours, thereby making the findings more relevant for employees who work at a large scale swine confinement operations. These three tasks: power washing, snout snaring and ear tagging exceeded the 100% daily dose recommended by National Institute for Occupational Safety and Health (NIOSH) criterion for the time period worked (Achutan & Tubbs, 2007).

A cross-sectional survey done by Firth, Herbison and McBride (2006) on farmers in Southland, New Zealand included daily noise and dust exposure measurements and an assessment of farm buildings. Results showed that one third (35%) of the farmers were exposed to total daily noise exposure levels above the New Zealand workplace exposure limits of 85 dB(A), few of these farmers wore hearing protection (Firth et al., 2006). One fifth had hearing loss recognized by the Occupational Safety and Health (OSH) (Firth et al., 2006).

Miltz et al. (2008) conducted a pilot project to evaluate noise exposure with three farm families. Adult noise exposures on the farm for an 8 hour time weighted average ranged from 46.1 – 89.6 dB(A) when using Occupational Safety and Health Administration action level guidelines. When using the National Institute for Occupational Safety and Health /American Conference of Governmental Industrial Hygienists guidelines the noise exposures ranged from 62.6 to 92.1 dB(A) (Miltz et al., 2008). The results of the project indicated that noise exposures for farm families exceeded recommended levels.

In summary, these studies have shown that farmers are exposed to high noise levels from the use of task based equipment and from animals. Source of noise exposures identified in the farming sector were above 85 dB and were mainly machinery related. This was also identified in the swine operations, noise exposure exceeded 85 db based on tasks carried out in some

operations. As well, the source of noise exposures in swine operations included both mechanical and animal sources. The source of noise in the grain workers industry was not identified in the literature. The sources of noise in the grain industry are not well studied, are mechanical in nature and potential sources could include: grain spilling from the truck box to the pit, workshop tools, tractor use without a cab, rail cars as they move or join together, and augers used in the loading and unloading of grain. Many of the tasks conducted in swine facilities and with grain workers are similarly found in farming. Most farmers experience noise exposure at the workplace longer than 8 hours per day, which may not be typical of these other industries. The length of an exposure, its frequency and intensity are all factors that can make noise a hazardous agent in the workplace.

2.5 Legislation

Swine operations would be under Saskatchewan Labour legislation whereas grain workers are federally legislated regarding acceptable noise levels. These levels at 87 dB appear to be similar to those found for Saskatchewan workers. In Saskatchewan the Occupational Health and Safety Act, 1993 states that 85 db is the average acceptable noise level for an 8 hour day without hearing protection. This time is not to exceed without the use of hearing protection. Saskatchewan Labour, Occupational Health and Safety Division, Audiometric Testing in Saskatchewan (October, 1998) outlines noise control and hearing conservation regulations for the employer to implement in the workplace as the following:

“*General duty*” which includes: reasonable measures are in place to reduce noise (elimination, quieting, enclosure of noise source, and installing barriers to noise). “Noise reduction through design, construction of buildings” in order to meet the lowest practical noise level, alterations or modification to equipment and/or implementation of new equipment with

lowest practical noise level.

“Measurement of noise” in areas where workers are required to work and that noise levels may often exceed 80 db. Noise measurements must be re-measured when renovating, altering, repairing the place of employment or replacing equipment. The employer must maintain a record of the noise measurements. The worker may request a copy of any noise measurements done. Signage will be posted clearly on areas with noise levels greater than 80 db.

“Daily noise exposure between 80 dBAL_{ex} and 85 dBAL_{ex}” (dBAL_{ex} “the level of a worker’s total exposure to noise, in dBA, average over an entire workday and adjusted to an equivalent eight-hour exposure”) will be reported to the worker by the employer, the worker may request hearing protection, hearing protection must be made available to the worker, and the worker will be trained on the selection, use and maintenance of the hearing protection.

“Daily noise exposures greater than 85 dBAL_{ex}” the employer will inform the worker of the hazards of occupational noise exposure, reduce noise levels where the worker is required to work as practical, minimize workers exposure where practical and document these steps. If these steps are not practical, the employer must document why. Where noise reduction is not practical, the employer must provide hearing protection to the worker and the worker will be trained on the selection, use and maintenance of the hearing protection. The worker is to have at least one audiometric test every 24 months.

“Hearing conservation plan” will be developed by the employer. The plan will include assessment of the occupational noise, methods of noise control, selection, use and maintenance of hearing protection, training of workers regarding noise hazards, noise controls, and hearing protection, maintaining records of exposure, audiometric testing and requirements, and review of the hearing conservation plan. A copy of the hearing conservation plan must be available to the

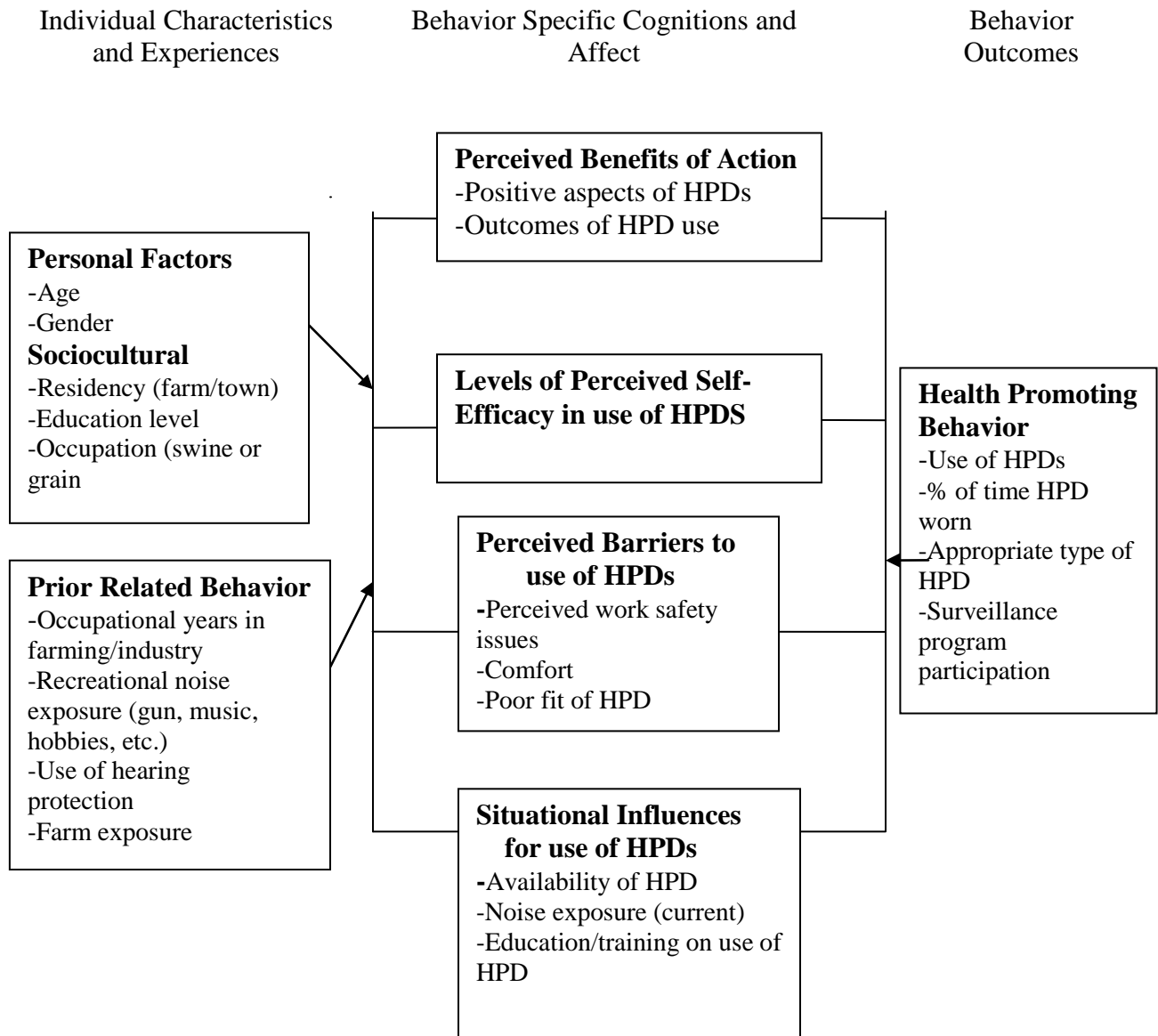
workers (*Saskatchewan Labour, Occupational Health and Safety Division, Audiometric Testing in Saskatchewan, -Appendix 2 (October, 1998)*).

2.6 Summary

Noise in the farming environment is an occupational hazard. Many of the activities performed on the farm are task based and involve the use of equipment that emits noise greater than 85 dB(A). In the swine industry, noise exposure can be mechanical or due to the swine themselves, both have with noise emissions great than 85 dB. Agricultural equipment is a recognized source of noise emissions. Exposure to this type of noise over a period of time can lead to noise induced hearing loss. Assessment of the extent of noise exposure in those who work in agriculturally related industries is still not well understood. There are very few Canadian studies published that are recent or that specifically address noise levels and hearing loss in the grain and swine industry workers. Although there are some studies that have assessed the hearing and hearing hazards in the swine industry, none have assessed hearing loss in the grain industry. The literature only refers to “farming”, “dairy farming” or “swine farming/industry”. Noise remains to be one of the lesser recognized hazards in the industry. The effects of significant exposure to this hazard are permanent. The most frequent and dangerous effect is the loss of hearing is at the higher frequency tones. This frequency affects the understanding of verbal communication; therefore, the worker may not hear a warning signal for danger from a co-worker or device. This could serious consequence as a near fatal or fatal injury.

2.7 Conceptual Model

Application of Pender's Health Promotion Model for Behaviours Associated with the Use of Hearing Protection Devices (HPDs) with Grain or Swine Worker Industries



Revised Health Promotion Model (Pender, 1996)

The Health Promotion Model developed by Pender can be used as a framework for development of educational interventions related to general hearing health, safe noise level exposure, and the proper use of hearing protection devices. Pender postulates that the modifying factors such as: perceived benefits of action, perceived self-efficacy, perceived barriers, and situational influences can influence cognitive perceptual factors, which in turn influence health-promoting behaviors (Lusk, Ronis, & Kerr, 1995). The Health Promotion Model was used to examine the variance in hearing protection use among individuals and provided data describing factors that influence this behavior. This model has been identified in research studies regarding hearing protection and health promoting behaviors (Gates & Jones, 2007; Kerr, Lusk, & Ronis, 2002; Lusk et al., 2003; McCullagh, 2010; McCullagh & Robertson, 2009; McCullagh, Lusk, & Ronis, 2002). Pender's Model has been used in the farming industry, automotive industry, migrant workers at a garment plant, and the construction industry (Gates & Jones, 2007; Kerr, Lusk, & Ronis, 2002; Lusk et al., 2003; McCullagh, 2010; McCullagh & Robertson, 2009; McCullagh, Lusk, & Ronis, 2002). In each of these industries the model is relevant to the development of interventions to increase the use of hearing protection and decrease the rate of hearing loss due to noise exposure.

Research has shown that the behavior specific cognitions and affect (beliefs, interpersonal influences, barriers and situational influences) were significantly related to the protective behaviors (Gates & Jones, 2007; McCullagh et al., 2002; McCullagh, 2010). In a study done by McCullagh & Robertson (2009) the understanding of the workers experience was essential in developing educational interventions to increase the use of hearing protection devices. In 2010, McCullagh's intervention was focused in modifying farmers' attitudes and beliefs and showed that the farmer's use of hearing protection devices was influenced by their

perceived barriers and availability of hearing protection devices. The use of hearing protection devices was statistically significant when hearing protection devices were made available to farmers. Kerr et al. (2002) also found that behavior specific cognitions and affect has a direct relationship to the health promoting behavior of increased use of hearing protection devices.

In this Model, health-related behaviors are divided into two categories: (a) individual characteristics and experiences, and (b) behavior specific cognitions and affect. These variables directly influence health-related behaviors.

Individual characteristics and experiences

Individual characteristics and experiences consist of prior related behaviors and personal factors (Sakraida, 2002). These factors include: age, gender, residency (farm or town), work and recreational noise exposure history, hearing history, and use of hearing protection. In the literature, it was noted that personal factors affect noise exposure. For example, age (young adults) impacted the value of hearing protection use, and gender (female) impacted perceived self-efficacy and perceived health (Lusk, Ronis, Hogan, 1997).

Prior related behavior was shown to be dependent on situational factors, e.g. availability of hearing protection (McCullagh & Robertson, 2009 and McCullagh, 2010). The selection of hearing protection devices described in the literature is highly individualized and is based on noise exposure as well as personal perception of comfort. When looking at perceived health, farmers appear to be aware of hearing loss in relation to noise and may disregard their need for hearing protection citing their well established hearing loss as to be expected in the farming business (McCullagh & Robertson, 2009). As a result, the selection of hearing protection by the individual may not always meet their needs for protection. It is unlikely that just one type of hearing protection is suitable for all tasks.

Behavior specific cognitions and affect

Behavior specific cognitions and affect are variables that relate to motivation to make changes for health protection. These variables are the major determinants of health-promoting behavior. Factors of importance are perceived benefits of action, perceived self efficacy, perceived barriers and situational influences (Sakraida, 2002). These three variables can be measured by the use of hearing protection devices. It is assumed that people will take action if the expected positive outcomes (benefits) of the action outweigh the expected negative outcomes (barriers) (Ronis et al., 2005).

Situational influences could include the availability or accessibility of hearing protection devices and the recognition of exposure to high levels of noise. In the farming industry, there are few reports to indicate interventions to increase the use of hearing protection devices. Farmers are aware of noise, but lack labour organizations advocating for hearing protection usage (McCullagh, 2010). For this reason, implementing interventions is challenging. Barriers to the use of hearing protection devices include: developing methods to ensure convenient access by having hearing protection devices available in areas with noise hazards, developing strategies on how to adapt to alternative techniques for monitoring equipment, and relying on other senses such as vision and awareness of movement (vibrations) that may signal equipment malfunction (McCullagh & Robertson, 2009). It is thought that legislation related to mandatory hearing protection use (enforcement) could control for physical or social influences affecting health behavior with farming practice (Kerr et al., 2002).

Behavior Outcomes

Behavioral outcomes are the likelihood of using hearing protection. The loss of hearing has effects on verbal communication and normal work and personal life function. Modeling or

influencing others in the workplace by describing how another individual or situation influenced a workers decision to wear hearing protection are described by McCullagh and Robertson (2009). The researchers mentioned other recognized health benefits of wearing hearing protection devices, these included reduction in fatigue, headaches, and noise annoyance.

By examining information from the swine and grain workers occupational health surveillance program (CANWORKSAFE), one could develop educational interventions to increase the use of hearing protection devices and provide recommendations regarding access to hearing protection devices and noise levels abatement. Such interventions can be shared with employers, employees and industry in general.

2.8 Research Questions

Based on the review of the literature and the data available through the hearing surveillance program conducted by the Canadian Centre of Health and Safety in Agriculture at the University of Saskatchewan between 2004 and 2009, the research questions to be addressed by this study are:

1. What are the hearing characteristics of swine and grain workers and is there a difference in the hearing loss between grain and swine workers?
2. Does the use of hearing protective devices differ between grain and swine workers?

2.9 Significance of the Study

The information obtained from this study can be used to identify strategies to promote the sustainability and dissemination of evidence-based hearing programming. Findings can be applied to the current grain and swine workers hearing surveillance program, and to further identify research in the development of occupational hearing programs that could enhance and promote the hearing health of workers in Saskatchewan.

Chapter 3: Methodology

3.1 Research Design

This study is a secondary analysis of data collected as part of a screening program of workers in swine and grain industries. The study population included all grain and swine workers who participated in the CANWORKSAFE program and had first-time hearing evaluations conducted between the years 2004 and 2009.

3.2 Sample and Setting

The CANWORKSAFE program of the Canadian Centre for Health and Safety in Agriculture was contracted to undertake hearing surveillance activities for Saskatchewan grain and swine companies between the years 2004 and 2009. CANWORKSAFE provides occupational services to persons in the agricultural industries. The goal is to promote employee wellness through spirometry and audiometry, hazard evaluation, and health education.

The original data base consisted of 445 participants. Those grain workers who had missing hearing data and those tested in 1995 for the longitudinal surveillance program with no follow up testing were deleted from the data base (n=19). Two swine workers were also deleted from the data base due to no hearing data. The total sample of workers available for analyses was 424. Of these, 299 were grain workers and 125 were swine workers.

All testing was conducted during the work day of the worker. The testing was conducted on the 299 grain workers at a health facility close to the work location of the study participants. The grain workers traveled from their place of employment to a designated health facility location. The 125 swine workers were tested at the manager's house or office area on-site at the swine barn location.

3.3 Data Collection and Instruments

Each worker completed a hearing questionnaire. Both swine and grain worker questionnaires can be found in Appendix A. The questionnaire was followed by a nurse administered audiogram (see audiogram record, Appendix B).

Questionnaire

The Noise Exposure Information Questionnaire consisted of two sections and was administered by the nurse who conducted the screening. Section one contained demographic data related to the grain and swine worker. Section two contained data on the grain and swine worker's hearing health history. The questionnaire included questions on demographic characteristics, years in the industry, prior noise exposures, current noise exposures, ear-related illnesses and injuries, noise related conditions, and hearing protection questions. Prior to assessing exposure to noise, a noisy environment was defined with subjects during questionnaire administration as "a situation in which you are standing three feet away from an individual and you have to raise your voice in order to be heard".

The Noise Exposure Information questionnaire has been utilized since 1995 when it was first designed and used in the Agriculture Health and Safety Network as part of an educational and screening program to promote respiratory health and hearing conservation among farm operators (Lupescu et al., 1999). It has been used extensively in agriculture surveillance programs through the Canadian Centre for Health and Safety in Agriculture. There is no data assessing the reliability and validity of the questions or the questionnaire.

Hearing Assessment

Audiometric exams were undertaken on each individual, using the EMI (Electro-medical Instrument, Co.) GSI 17 and RA 300 models which have insert headphones. There were a

greater percentage of swine workers (74%) tested on the GSI 17 however, there were a greater percentage of grain workers tested on the RA 300 (61%). For the study, it was assumed that the sensitivity was equal between the two types of equipment. The equipment was maintained as per the guidelines from Saskatchewan Labour: “audiometric testing should be conducted with an audiometer that is constructed, used, maintained and calibrated in accordance with the requirements contained in: Canadian Standards Association publication, CAN 3-Z107.4-M86 *Pure Tone Air Conduction Audiometers for Hearing Conservation and for Screening.*”

All persons conducting the testing were certified audiometric technicians. Insert headphones were used on site during the testing as a sound booth was unavailable. All testing took place in a quiet room.

3.4 Operational Definitions

3.4.1 Dependent Variables

Hearing Loss

Audiometric evaluations were undertaken on each study subject and were used to evaluate hearing loss. Measurements of hearing threshold levels (in decibels) were taken at 500, 1000, 2000, 3000, 4000, and 6000 Hz. Baseline audiograms or the workers first audiogram were administered for each subject. According to Saskatchewan Labour an abnormal baseline audiogram was defined as: “an audiogram produced from a baseline audiometric test in which the hearing threshold, in either ear, averages 25dB or more at 500 to 6000 Hz”. The above information is found at: (<http://www.labour.gov.sk.ca/safety/audiometric>). For this study a significant hearing loss was defined as an abnormal audiogram result at any of the measured frequencies in either ear of ≥ 25 db.

3.4.2 Independent variables

All independent variables were obtained from the interviewer administered questionnaire.

Noise Exposure and hearing protective devices

1. Noise exposure:

“Are you exposed to noisy environments at your grain/swine workers job?” (yes: no)

2. Hearing protection use:

“What type if hearing protection do you wear?”

3. Group

Swine worker: currently employed in a swine confinement unit

Grain worker: currently employed as a worker in a grain handling facility

Hearing Protection Use

Hearing protection use was identified by the following question: “Do you wear hearing protection when working in a noisy environment?” (yes/no)

Other variables assessed:

4. Parental hearing loss

“Parent with a hearing loss before 50?” (yes: no)

5. Sibling hearing loss

“Sibling with a hearing loss before age 50?” (yes: no)

6. Hearing health history:

Questionnaire reporting of the following: History of broken eardrum, vertigo, ear surgery, ear injury, head injury, hearing loss/ringing in the ears from infection or hearing loss/ringing in the ears from a loud noise? (yes: no)

7. Current ringing in ears

“Do you have ringing in the ears?” (yes: no)

8. Ill today

“Were you ill on the day of testing?” (an indication of “yes” by the worker to the question “do you have a cold, flu or allergy problems today”)

9. Years in current employment

3.5 Procedure

During the surveillance program and prior to the audiogram a brief health history was taken, examination of the outer ear was performed, and an otoscopic exam was conducted. Hearing threshold levels were recorded in decibels for the right and left ear at 500, 1000, 2000, 3000, 4000, and 6000 Hz. Following the audiogram, workers were counseled regarding their hearing health and noise exposure. Workers who had audiograms categorized as “abnormal” or ‘early loss index” were advised to have further assessment and referrals were made.

3.6 Ethical Considerations

Ethical approval for the original study was obtained July 14, 2011. For this secondary analysis of the data, ethical approval was obtained from the University of Saskatchewan Advisory Committee in Behavioral Science Research on September 8, 2011 (Appendix C). All data provided to the researcher was de-identified prior to release to the researcher by the principal investigator. Grain/swine companies or towns were not reported.

3.7 Data Entry and Cleaning

Data was entered by a research assistant using the data entry software of the Statistical Package for Social Sciences IMB Version 19 (IBM SPSS 19.0) at the Canadian Centre for Health and Safety in Agriculture. All personal identifiers were removed prior to the student analysis. The data was further cleaned by the student using frequencies, sorting, listing, and

crosstabs. Any queries in data were identified and sent to the research assistant for the surveillance program or the principal investigator who provided clarification/correction of data as required to the data base using the original questionnaires. A new data file was then provided to the student.

3.8 Methods of Analysis

SPSS was used to manage data obtained from the research study questionnaire and hearing tests to conduct the statistical analysis. Level of significance was set at $\alpha \leq 0.05$. Descriptive analysis was performed on the data using frequencies, percentages and crosstabs for categorical variables. Means and standard deviations were used to express continuous variables. Logistic regression models were used to assess the association between significant hearing losses (greater than 25dB in either ear at any hearing level (Hz), and industry group (grain or swine worker)). The final model assessing any hearing loss and industry group also included sex, hearing protection usage, age, years of employment, ringing in ears, and current illness. Chi-square tests were used to look at differences between groups and use of hearing protection devices in noisy environments.

Chapter 4: Results

4.1 Study Population

The study population included grain and swine workers who participated in the CANWORKSAFE program and had hearing evaluations between the years 2004 and 2009. The original data base contained 445 participants. There were 424 participants with adequate questionnaire and hearing data. Participants who were missing hearing data were removed from the data set. From the 424 participants, 299 participants were grain workers and 125 participants were swine workers.

General Characteristics of the Study Population

The mean age of the total population was 36.0 (10.6 standard deviation, SD) years. The study population was not evenly distributed with regards to gender, with 337 males (79.5%) and 87 females (20.5%). There were more grain workers than swine workers in this study (70.5% and 29.5%, respectively). In this study 4% had experienced an eardrum injury, 5.4 % experienced vertigo, 4.2% had prior ear surgery, 3.3% had a direct injury to the ear, 12.5% had a previous head injury and 18.4% had experienced some form of hearing loss in the past. Family history of a hearing loss before the age of 50 was reported by 8.0% of the study population having a parent with a hearing loss and 3.3% having a sibling with a hearing loss. On the day of the surveillance 5.7% reported experiencing ringing in the ears while 33.7% reported a history of being ill today which included having a cold, allergies or cough. In this population 26.2% reported a history of being exposed to a noisy environment today.

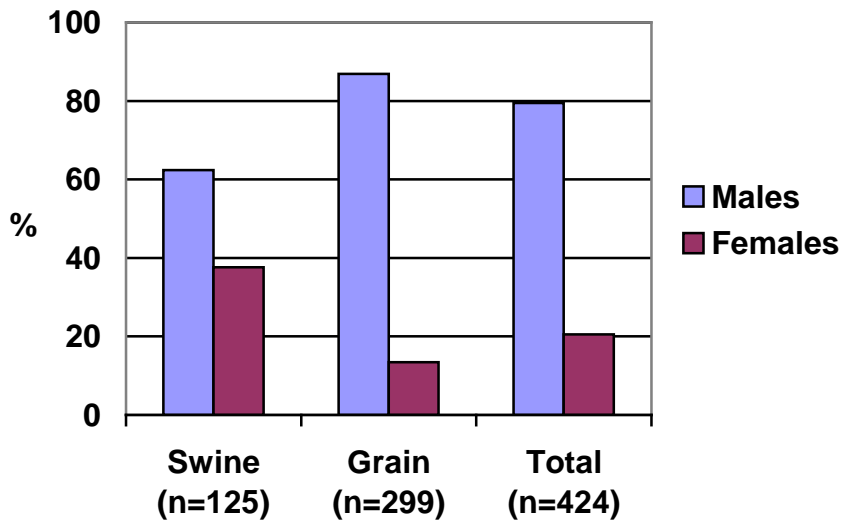
Comparison of swine and grain workers demographics are shown in Table 4-1 and Figure 4-1. The mean age of the grain worker population was 36.9 (9.9SD), the mean age of the swine worker population was 33.7 (11.9SD) which was significantly different between groups ($t_{198.8} =$

-3.19, $p < 0.01$). Years of employment between the two groups differed and were only available for 400 individuals. Swine workers were employed for an average of 2.5 years and grain workers were employed an average of 12.2 years and this difference was statistically significant ($t_{398} = -9.72$, $p < 0.001$). Overall in swine and grain worker groups there were significantly more males than females (see Figure 4-1).

Table 4-1 Swine and grain workers demographics

| | Swine n=125 | Grain n=299 | Total n=424 |
|-----------------------------|----------------|----------------|----------------|
| | mean (SD) | mean (SD) | mean (SD) |
| Years Employed ¹ | 2.48 (4.12) | 12.20 (9.20) | 9.21(9.16) |
| Age (Years) | 33.72(11.87) | 36.91(9.85) | 36.0(10.58) |

¹ data was missing for 24 participants



*p<0.05 for all comparisons

Figure 4-1 Sex of swine and grain workers

4.2 Research Question #1

What are the hearing characteristics of grain and swine workers and is there a difference in the hearing loss between grain and swine workers?

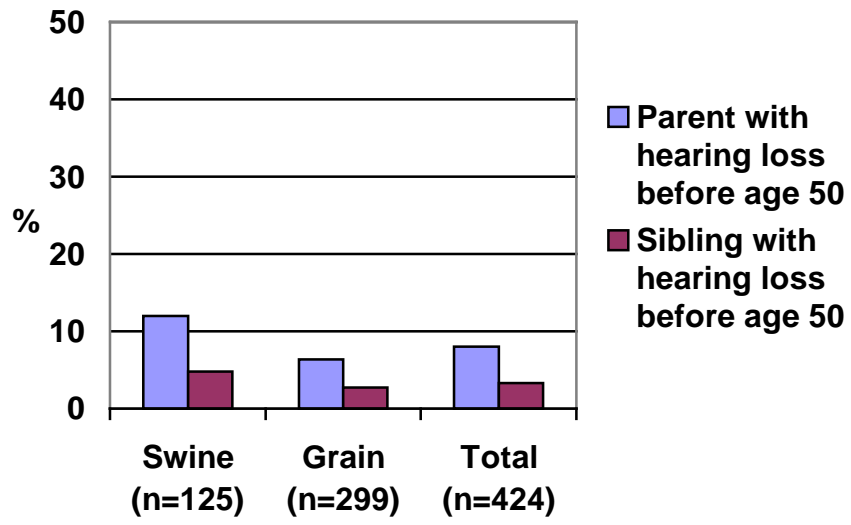
4.2.1 Hearing Characteristics and Hearing Health of Swine and Grain Worker Populations

Comparison of grain and swine workers' family history of hearing loss is shown in Figure 4-2. Thirty-four of 424 participants (8.0%) reported a history of a parent with hearing loss before age 50. Of these, 15 (12%) were swine workers and 19 (6.4%) were grain workers. Also, 14 of 424 participants (3.3%) reported a sibling with hearing loss before age 50. Of these, 6 (4.8%) were swine workers and 8 (2.7%) were grain workers. Findings for family history of hearing loss (siblings or parent) were not significantly different between workers groups.

Table 4-2 represents the comparison of hearing health history between swine and grain workers regarding pre-existing hearing health problems. A broken eardrum was reported by 17 of 424 (4.0%) workers. Of these, 6 (4.8%) were swine workers and 11 (3.7%) were grain workers. Vertigo was reported by 23 of 424 (5.4%) workers. Of these, 7 (5.6%) were swine workers and 16 (5.47%) were grain workers. Ear surgery was reported by 18 of 424 (4.2%) workers. Of these, 8 (6.4%) were swine workers and 10 (3.3%) were grain workers. Ear injury was reported by 14 of 424 (3.3%) workers. Of these, 6 (4.8%) were swine workers and 8 (2.7%) were grain workers. Head injury was reported by 53 of 424 (12.5%) workers. Of these, 12 (9.6%) were swine workers and 41 (13.7%) were grain workers.

Hearing loss/ringing in ears from a past history of infection, illness, injury or medication were reported by 78 of 424 (18.4%) workers. Of these, 24 (19.2%) were swine workers and 54 (18.17%) were grain workers. Nearly half of the workers (n=211 or 49.8%) reported a hearing

loss or ringing in the ears from a loud noise. Of these, 58 (46.4%) were swine workers and 153 (51.2%) were grain workers. The results reported above were not statistically significant.



All comparisons not significant

Figure 4-2 Swine and grain workers family history of hearing loss

Table 4-2 Swine and grain workers¹ hearing health history

| | Swine n=125 n(%) | Grain n=299 n(%) | Total n=424 n(%) |
|---|------------------------|------------------------|------------------------|
| Broken Eardrum | | | |
| yes | 6 (4.8) | 11 (3.7) | 17 (4.0) |
| no | 119(95.2) | 288 (96.3) | 407 (96.0) |
| Vertigo | | | |
| yes | 7 (5.6) | 16 (5.4) | 23 (5.4) |
| no | 118 (94.4) | 283 (94.6) | 401 (94.6) |
| Ear Surgery | | | |
| yes | 8 (6.4) | 10 (3.3) | 18 (4.2) |
| no | 117 (93.6) | 289 (96.7) | 406 (95.8) |
| Ear injury | | | |
| yes | 6 (4.8) | 8 (2.7) | 14 (3.3) |
| no | 119 (95.2) | 291 (97.3) | 410 (96.7) |
| Head injury | | | |
| yes | 12 (9.6) | 41 (13.7) | 53 (12.5) |
| no | 113 (90.4) | 258 (86.3) | 371 (87.5) |
| Hearing loss/ringing in ears from infection, illness, injury or medication | | | |
| yes | 24 (19.2) | 54 (18.1) | 78 (18.4) |
| no | 101 (80.8) | 245 (81.9) | 346 (81.6) |
| Hearing loss/ringing in the ears from a loud noise | | | |
| yes | 58 (46.4) | 153 (51.2) | 211 (49.8) |
| no | 67 (53.6) | 146 (48.8) | 213 (50.2) |

¹n.s. for all comparisons by worker group

Information about a current hearing problem was gathered through the questions assessing hearing symptoms and the otoscopic exam. Comparison of swine and grain workers hearing symptoms and test results are shown in Table 4-3. Overall, 24 of 424 (5.7%) workers have experienced ringing in the ears and 143 of 424 (33.7%) were ill on the day of testing (an indication of “yes” by the worker to the question “do you have a cold, flu or allergy problems today”). Otosopic exams were conducted on both the left and right ear prior to the hearing test. Results were reported as either “clear” or “other”. Other was noted as: wax in the ear canal or abnormal descriptions of the eardrum. Following the exam, 51 of 424 (12%) workers were referred to their family physician for follow up. Hearing testing results showed that of the total population, 8 (1.9%) workers were referred for further audiology assessment.

Table 4-3 Comparison of swine and grain workers hearing symptoms and exam results on test day

| | | Swine | Grain | Total |
|-------------------------|-------|------------|------------|------------|
| | | n=125 | n=299 | n=424 |
| | | n(%) | n(%) | n(%) |
| <hr/> | | | | |
| Variable | | | | |
| Ringing in the ears now | | 4 (3.2) | 20 (6.7) | 24 (5.7) |
| Ill today | | 50 (40.0) | 93 (31.1) | 143 (33.7) |
| Otoscope L | Clear | 105 (84.0) | 240 (80.3) | 345 (81.4) |
| | Other | 20 (16.0) | 59 (19.7) | 79 (18.6) |
| Otoscope R | Clear | 108 (86.4) | 243 (81.3) | 351(82.8) |
| | Other | 17 (13.6) | 56 (18.7) | 73 (17.2) |
| Otoscope referral | | 14 (11.2) | 37 (12.4) | 51(12.0) |
| Referral | | 8 (6.4) | 0 (0)* | 8 (1.9) |

* p < 0.001

4.2.2 Comparison of Hearing Loss between Swine and Grain Workers Group

Hearing thresholds (decibels) were measured for 500 Hz to 6000 Hz for the left and right ear in the swine and grain worker population (Table 4-4). Swine workers showed greater mean hearing loss ($p < 0.05$) in the right ear at both the 1,000 Hz and 2,000 Hz frequencies, whereas grain workers had greater mean hearing loss in the left ear at 4,000 Hz ($p < 0.05$), and greater mean hearing loss in both ears at 6,000 Hz ($p < 0.05$) (Figure 4-3 and Table 4-4).

When hearing loss was categorized as a loss ≥ 25 dB in any ear at any frequency, 201 (47.4%) had significant hearing loss. Table 4.5 presents the characteristics of the study population by hearing loss status. Those with a significant hearing loss were more likely to be older, to be males, and to report ringing in their ears. Those with a significant hearing loss were also more likely to have worked longer with their employer. More grain workers than swine workers had a significant hearing loss ($p < 0.001$). Table 4.6 presents the mean hearing levels by industry group for the 201 subjects (42 swine workers and 159 grain workers) with significant hearing loss ≥ 25 dB in either ear at any hearing threshold. Generally at the lower frequencies swine workers had a greater mean hearing threshold values while at the higher frequencies this pattern was reversed with grain workers having higher mean hearing threshold values.

Multivariable logistic regression analyses were conducted to assess significant hearing loss (25 dB or greater at any hearing level, Hz) in a model that included worker group (swine vs. grain), hearing protection use, age and sex, having an illness on day of surveillance and current ringing in ears. Results of the univariate and multivariate logistic regressions are found in Table 4-7. Compared to swine workers, being a grain worker was a significant risk for a hearing loss. Being male, of older age were also risk factors, and having ringing in the ears on the day of testing was also associated with a hearing loss ≥ 25 dB. Notably the use of a hearing protection

device was not associated with less likelihood of a hearing loss. Years with employer was no longer significant in the multivariable model.

Table 4-4 Comparison between groups of mean hearing thresholds (decibels) and range for 500 Hz to 6000 Hz for right and left ear of all participants

| | | Swine | Grain | Total |
|--------|-------|------------------------|---------------------|-----------------------|
| | | n = 125 | n = 299 | n = 424 |
| | | mean±SD (min, max) | mean±SD (min, max) | mean±SD (min, max) |
| 500Hz | Right | 11.40±10.23 (-5, 65) | 10.38±7.99 (0, 50) | 10.68±8.71(-5, 65) |
| | Left | 10.96±10.03 (-5, 65) | 11.65±9.57 (0,95) | 11.44±9.70 (-5, 95) |
| 1000Hz | Right | 11.32±10.20 (-10, 65) | 8.28±7.85(0, 55) †† | 9.17±8.71 (-10, 65) |
| | Left | 10.12±10.56 (-5, 65) | 10.13±10.17 (0, 90) | 10.13±10.28 (-5, 90) |
| 2000Hz | Right | 11.00±11.73 (-10, 65) | 8.34±8.36 (0, 55) † | 9.13±9.54 (-10, 65) |
| | Left | 10.52±12.095 (-10, 70) | 10.84±11.72 (0, 90) | 10.74±11.82 (-10, 90) |
| 3000Hz | Right | 13.08±13.81(-5, 65) | 11.09±12.90 (0, 80) | 11.67±13.19 (-5, 80) |

| | | | | |
|--------|-------|-----------------------|------------------------------------|------------------------|
| | Left | 13.04±13.78 (-5, 80) | 14.73±16.74 (0, 100) | 14.23±15.93 (-5, 100) |
| 4000Hz | Right | 9.60±15.81(-10, 70) | 11.54±13.96 (0, 85) | 10.97±14.54 (-10, 85) |
| | Left | 10.20±15.39 (-10, 90) | 15.99±19.55 (0, 100) ^{††} | 14.28±18.59 (-10, 100) |
| 6000Hz | Right | 10.44±16.04 (-10, 75) | 21.07±15.36 (0, 85) ^{††} | 17.94±16.28 (-10, 85) |
| | Left | 10.36±16.27(-10, 90) | 25.79±20.55 (0, 110) ^{††} | 21.24±20.61 (-10, 100) |

*p<0.05

† p<0.01

†† p<0.001

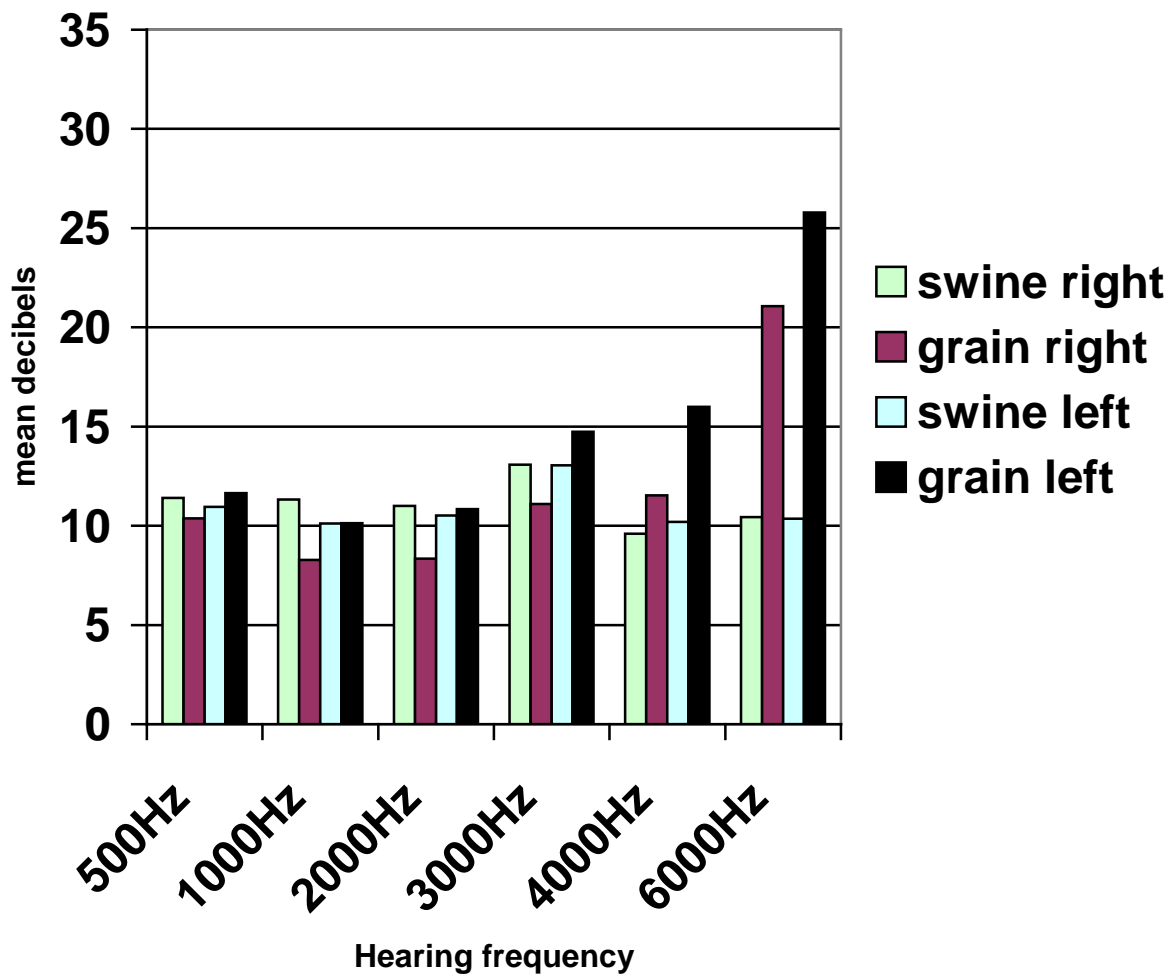


Figure 4-3 Mean hearing thresholds (decibels) greater than baseline for 500 Hz to 6000 Hz for right and left ear of participants

Table 4-5 Characteristics of the Study Population with Hearing Loss <25 db and ≥25db

| | <25db | ≥25db | |
|-----------------------|-------------|--------------|----------|
| | n=223 | n=201 | p. Value |
| | m(sd) | m(sd) | |
| Age (yrs) | 32.0 (9.20) | 40.4 (10.22) | p<0.001 |
| Years with Employer | 7.0 (7.73) | 11.6 (9.96) | p<0.001 |
| | n(%) | n(%) | |
| Group | | | |
| Grain | 140 (62.8) | 159 (79.1) | p<0.001 |
| Swine | 83 (37.2) | 42 (20.9) | |
| Sex | | | |
| Male | 156 (70.0) | 181 (90.0) | p<0.001 |
| Female | 67 (30.0) | 20 (10.0) | |
| Hearing Problem | | | |
| Yes | 139 (62.3) | 114 (56.7) | n.s |
| No | 84 (37.7) | 87 (43.3) | |
| Ill Today | | | |
| Yes | 74 (33.2) | 69 (34.3) | n.s |
| No | 149 (66.8) | 132 (65.7) | |
| ringing in Ears Today | | | |
| Yes | 4 (1.8) | 20 (10.0) | p<0.001 |
| No | 219 (98.2) | 181 (90.0) | |
| Referred to Physician | | | |
| Yes | 5 (2.2) | 3 (1.5) | n.s |
| No | 218 (97.8) | 198 (98.5) | |

Table 4-6 Mean hearing thresholds (decibels) and range for 500 Hz to 6000 Hz for right and left ear of study subjects with >25 dB hearing loss in any ear at any frequency

| Frequency | Ear | Swine | Grain |
|-----------|-------|--------------------|--------------------|
| | | n = 125 mean±SD | n = 299 mean±SD |
| 500Hz | Right | 16.90±13.39 | 12.86±9.13 |
| | Left | 17.62±12.84 | 14.37±11.40 |
| 1000Hz | Right | 17.02±13.66 | 10.66±9.24 |
| | Left | 17.50±13.80 | 13.08±12.40 |
| 2000Hz | Right | 19.29±14.96 | 11.13±9.71 |
| | Left | 19.52±15.84 | 15.16±13.95 |
| 3000Hz | Right | 24.64±17.29 | 16.98±14.45 |
| | Left | 24.88±17.05 | 22.92±18.77 |
| 4000Hz | Right | 23.93±18.82 | 18.27±15.77 |
| | Left | 24.05±18.45 | 25.97±21.97 |
| 6000Hz | Right | 25.60±16.97 | 29.56±16.02 |
| | Left | 26.31±17.07 | 37.77±21.19 |

Table 4-7 Univariate and adjusted logistic regression results [odds ratios with 95% confidence intervals (CI)] assessing associations between industry variables and having a hearing loss of 25 dB or greater.

| | Univariate | Multivariate |
|-------------------------|---------------------|---------------------|
| Variable (referent) | Odds ratio (95% CI) | Odds ratio (95% CI) |
| Group (swine) | 2.24 (1.45-3.47) | 2.31 (1.20-4.42) |
| Hearing protection (no) | 0.80 (0.54-1.17) | 1.21 (0.73-2.01) |
| Age | 1.09 (1.07-1.11) | 1.10 (1.07-1.13) |
| Sex (female) | 3.89 (2.26-6.69) | 3.37 (1.77-6.42) |
| Years with employer | 1.06 (1.04-1.09) | 0.97 (0.93-1.01) |
| Ill today | 1.05 (0.70-1.58) | 1.33 (0.81-2.16) |
| Ringling in ears | 6.05 (2.03-18.02) | 6.88 (1.87-25.34) |

4.3 Research Question #2:

Does the use of hearing protective devices differ between grain and swine workers?

Table 4-8 summarizes the workers exposure to noise and hearing protection use. Of the 424 study participants nearly 80% (n=335) of workers reported exposure to a noisy environment at work. Although most workers experienced a noisy environment (having to raise their voice to be heard when standing three feet away from an individual in the work environment), more swine workers (97%) than grain workers (70%) experienced noisy environments ($\chi^2 = 36.94$, $df=1$, $p < 0.001$) during work. Exposure to a noisy environment on the day of testing was experienced by a quarter of the workers (26.2%). Of these, swine workers were more likely than grain workers to have reported exposure on the day of surveillance (61.6 % and 11.4%, respectively, $\chi^2 = 115.08$, $df=1$, $p < 0.001$). There were 59.7% of all workers who reported the use of hearing protection when in a noisy environment. Significantly more swine workers (91.2%) than grain workers (46.5%) reported hearing protection use in a noisy environment ($\chi^2 = 77.23$, $df=1$, $p < 0.001$). General use of hearing protection among swine and grain workers was 55.4%. There was no difference by worker group for general use of hearing protection. Figure 4-4, present the sex and hearing protection use of those with ≥ 25 dB hearing loss. There was significantly more males in the grain industry compared to the swine industry that had a hearing loss over 25 dBs ($p < 0.02$). As well grain workers were less likely to wear hearing protection in a noisy environment ($p < 0.001$).

Table 4-8 Swine and grain workers exposure and hearing protection use

| | Swine n(%) | Grain n(%) | Total n(%) |
|---|---------------|---------------|---------------|
| Exposed to a noisy environment | | | |
| yes | 122 (97.6) | 213 (71.2) | 335 (79.0) |
| no | 3 (2.4) | 86 (28.8) | 89 (21.0) |
| Wear hearing protection when in a noisy environment | | | |
| yes | 114 (91.2) | 139 (46.5) | 253 (59.7) |
| no | 11 (8.8) | 160 (53.5) | 171 (40.3) |
| Exposed to a noisy environment today | | | |
| yes | 77 (61.6) | 34 (11.4) | 111 (26.2) |
| no | 48 (38.4) | 265 (88.6) | 313 (73.8) |
| Workers overall hearing protection usage | | | |
| yes | 72 (57.6) | 163 (54.5) | 235 (55.4) |
| no | 53 (42.4) | 136 (45.5) | 189 (44.6) |

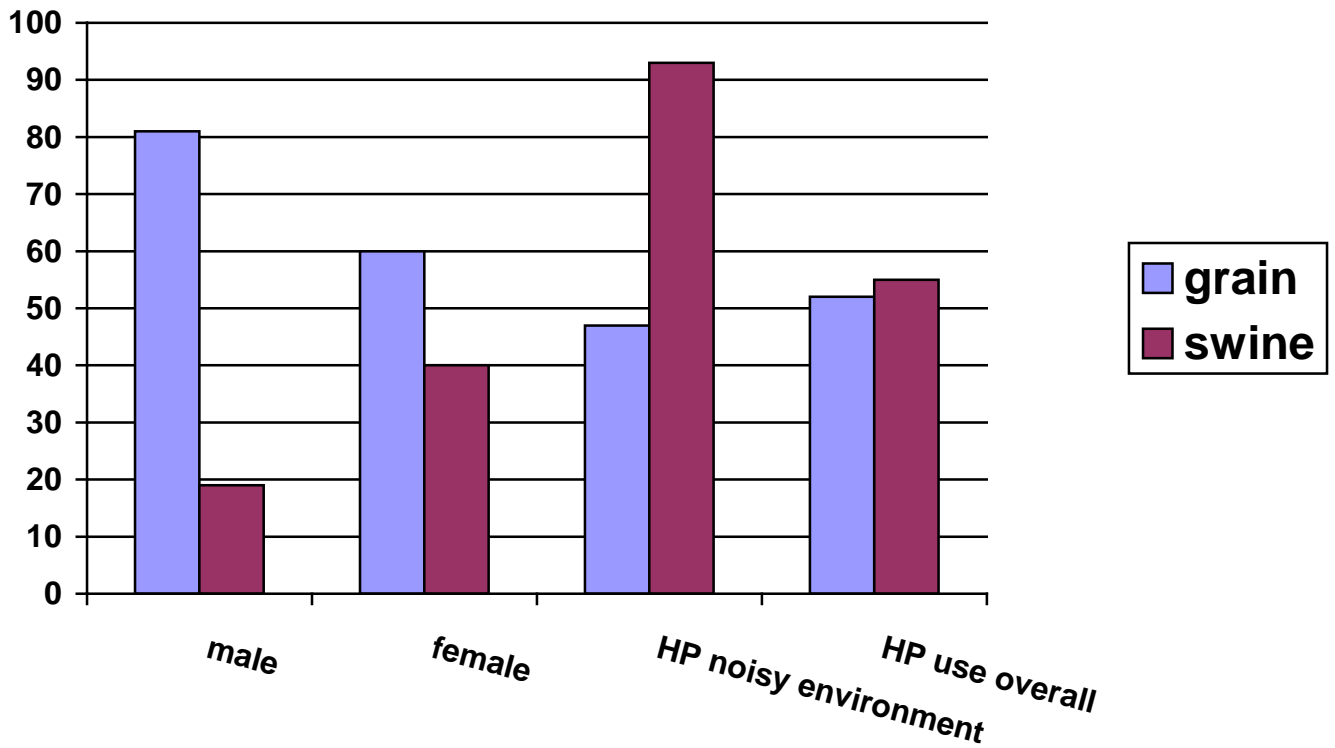


Figure 4-4 Distribution for sex and hearing protection (HP) usage by group for those participants with 25 dB or greater hearing loss in either ear at any frequency.

4.4 Summary

In this study population of 424 swine and grain workers who participated in the CANWORKSAFE program between the years 2004-2009:

- Grain workers were significantly older than swine workers and in both industries more males than females were employed.
- Years of employment varied between the two groups. Grain workers were employed the longest in the industry at 12.2 years. This was not associated with a hearing loss in the multivariable model.
- Hearing loss/ringing in the ears from a loud noise were seen in half of the worker population.
- Swine workers showed greater mean hearing loss than grain workers in the right ear at 1000 Hz and 2000 Hz.
- Grain workers showed significantly greater mean hearing loss as compared to swine workers in the left ear at 4000 Hz and in both ears at 6000Hz.
- Of the 424 participants, nearly 50% had a hearing loss of ≥ 25 dB in either ear at any hearing threshold.
- Grain workers were at a greater risk of a significant hearing loss (≥ 25 dB) overall.
- Most participants experienced noisy environments in the workplace. Grain workers reported wearing hearing protection in a noisy environment only half of the time (46.7%), while swine workers almost consistently used hearing protection in a noisy environment (91.2 %). General hearing protection was similar amongst groups.

Chapter 5: Discussion

The purpose of this research was to examine the state of hearing health and hearing protection usage in Saskatchewan swine and grain workers who participated in a hearing surveillance program conducted by the Canadian Centre of Health and Safety in Agriculture at the University of Saskatchewan between 2004 and 2009. Hearing protection device use, noise exposure history, and audiometric hearing results were assessed.

5.1 Major Findings

This study showed that major risk factors for greater than 25dB hearing loss in either ear in any frequency were working in the grain industry, older age, male sex and ringing in the ears at time of assessment. Although hearing protection was generally used, about 50% of the time in both groups, swine workers were significantly more likely to use hearing protection when in noisy environments. These findings for grain workers have not been reported before. Noise exposure over time and aging have been shown to contribute to hearing loss (Gomez, Hwang, Sobotova & Stark, 2001).

The role of presbycusis is well known and reported in the literature. Presbycusis, or slow loss of hearing with age is also found to be more prevalent in males (Hwang, Gomez, Sobotova, Stark, May & Hallman, 2001). Presbycusis coupled with noise exposure, occupational or other, contributes to the greater hearing loss as one ages. Research by Plakke and Dare (1992) shows that as a farmer ages, their hearing sensitivity is poorer than that of a control group. Their research also indicated that hearing sensitivity becomes progressively worse in the third decade of farming (Plakke & Dare, 1992).

Gender differences in hearing loss are found to be significant in men and women as they age (Hwang et al., 2001). Typically, hearing in men declines faster than that of women (Hwang

et al., 2001). The literature describes a statistically significant difference between males and females (Reesal et al., 1994 and Lupescu et al., 1999). Reesal et al. (1994) found an average loss in age-matched males was 15 db greater than in women, and males were referred to a physician for audiology assessment twice as often as females. Lupescu et al. (1999) also reported that twice as many males than females were referred for further testing and examination following participation in a hearing screening program. Being a male in this study was a significant risk factor for any significant hearing loss of greater than 25 db.

Females in this study were more likely to use hearing protection, than males. It was also noted in this study that in the grain industry, there were significantly more males and overall participants who did not wear hearing protection when compared to the workers in the swine industry. In the literature, findings are conflicting regarding gender and the use of hearing protection. In a secondary analysis of a clinical trial, Raymond and Lusk (2006) looked at interventions that would increase use of hearing protection. This analysis showed that a large proportion of females compared to males were reported to have changed their behavior to increase the use of hearing protection devices, and they maintained this behavior compared to their male counterparts (Raymond & Lusk, 2006). In a study done by Lupescu et al. (1999), males self reported wearing hearing protection 47% of the time when exposed to noise as compared to their female counter parts who reported wearing hearing protection only 18% of the time. Dennis and May (1995) also reported similar results. They found males exposed to noisy environments wearing hearing protection 18-25% of the time, as compared to females who wore hearing protection in noisy environments 9-15% of the time. It was also noted that the female's exposure levels were lower than those experienced by the males.

Length of occupational exposure over time to noise greater than 85 dB in an 8 hour day

may have an impact on hearing outcomes. Noise induced hearing loss with prolonged exposure to noise greater than 85 dB (A) results in the destruction of the cochlear hair cells (Depczynski, et al.,2005). The cochlear nerve cells do not have sufficient time to recover when exposed to excessive noise levels (Hwang, 2001). Given that noise levels in a medium size swine barn at feeding have been measured at 100 dB, this equates to a permissible daily exposure of 30 minutes without hearing protection (Kristensen & Gimsing, 1988). Similarly, another task based assessment was done looking at pressure washing in the swine barn; the daily exposure limit without hearing protection was calculated at 15 minutes of exposure time (Kristensen & Gimsing, 1988). Most often swine workers were likely to have some hearing loss at any of the hearing frequencies tested. However, only grain workers showed significant hearing loss greater than 25 dB at 6000. Humann et al. (2005) analyzed the frequency distribution of noise in the swine confinement units. They found that the most prominent noise frequencies found by an octave band analysis were in the ranges of 2000 Hz – 5000 Hz. This observation corresponds to the frequencies 3000 Hz – 6000 Hz where hearing loss is prominent in male farmers (Humann et al., 2005). Swine workers showed greater hearing loss in the right ear at both the 1,000 Hz and 2,000 Hz frequencies, whereas grain workers had greater hearing loss in the left ear at 4,000 Hz, and greater hearing loss in both ears at 6,000Hz. No information in the literature was available on the noise levels at different frequencies observed for grain workers.

5.2 Research Question #1

What are the hearing characteristics of grain and swine workers and is there a difference in the hearing loss between grain and swine workers?

Some types of hereditary hearing loss may not appear later in life, and family history at times may not be helpful in ruling out an alternative diagnosis to noise induced hearing loss

(May, 2000). In this study, a comparison was done looking at grain and swine worker's family history of hearing loss of a parent and sibling with a hearing loss before age 50. This comparison was not found to be significantly different between groups.

Hearing health history collected on swine and grain workers serves as an assessment to identify any hereditary or underlying pre-existing health problems that can contribute to hearing loss. Non-occupational risk factors, such as the use of ototoxic medications, head trauma, infections, and hereditary disorders, can contribute to hearing loss (May, 2000). Sensorineural hearing loss can be hereditary. This type of hearing loss would be identified in the higher frequencies (3,000 Hz, 4,000 Hz, 6,000 Hz). The workers were assessed for ringing in the ears and illness on the day of the exam (an indication of "yes" by the worker to the question "do you have a cold, flu or allergy problems today"). Otoloscopic exams were conducted in both ears prior to the hearing test. The otoscopic exam results reported as either clear or other. Workers were referred to their family physician for follow up were 12% (n= 51). In this study being ill today was not associated with a hearing loss overall or between groups.

Pre-existing health problems, such as broken eardrum, vertigo, ear surgery, head injury, hearing loss/ringing in ears from infection, and hearing loss/ringing in the ears from a loud noise were assessed. Workers seldom present with primary complaints of hearing loss. Most often the worker will report ringing in the ears, shouting to communicate with co-workers following exposure to loud noise (May, 2000). The possibility of hearing loss is one that should be considered by the examiner when pursuing the hearing history of the worker. Questions should include a family history of hearing problems, childhood health, head trauma, history of ear infections can all contribute to hearing loss and should be examined (May, 2000). In this study the workers answered yes or no to pre-existing health problems which included: broken ear

drum, vertigo, ear surgery, ear injury, head injury, hearing loss/ringing in ears from infection, illness, injury or medication, and hearing loss/ringing in the ears from a loud noise. In the worker population of grain and swine workers, the hereditary health problems were evenly distributed and not significant.

One of the most significant findings within this study was the high prevalence of hearing loss above threshold in both swine and grain workers. Of note, half of the workers (211 of 424, 49.8%) reported a hearing loss/ringing in the ears from a loud noise, suggesting that the affected population of swine and grain workers might have been exposed to a loud noise where hearing protection was not available or not used. This could be at their grain or swine workplace, prior employment, or recreational exposure. Depczynski et al. (2005) reported that the highest exposure level on farms were related to firearms, where a single shot is equivalent to almost a full week of continuous exposure at 90 dB. Dennis and May (1995) also reported that prolonged exposure to hunting, snowmobiles and loud music are likely to further increase an individual's risk to noise induced hearing loss. It also draws attention to the worker's beliefs about noise exposure, their personal experiences with hearing loss and their frequency of use of hearing protection when exposed to noise (Gates & Jones, 2007). Hwang et al. (2001) reported that more research needs to be done on non-farming occupational and recreational noise exposures and how they contribute to hearing loss. This conclusion is valid and would confirm how recreational noise exposure impacts hearing loss.

Of the 424 participants, 201 had hearing loss of greater than 25 dB in either ear at any frequency. Furthermore, when a significant hearing loss (≥ 25 dB) was evaluated, over 90% of those so affected were grain workers. After adjusting for length of time in industry, hearing related symptoms, age and sex, grain workers continued to be more at risk for a hearing loss than

swine workers. In this study it is difficult to determine if length of time in the industry was a factor in the findings of hearing loss by worker group. In this study length of employment in the industry was limited to current employment and may not have represented overall exposure in the industry by those workers. Clearly the grain worker's environment requires further exploration for the nature of this hearing loss.

Swine workers showed hearing loss significantly greater than grain workers in the right ear at 1000 Hz and 2000 Hz. Grain workers showed significantly greater hearing loss as compared to swine workers in the left ear at 4000 Hz and in both ears at 6000Hz. As reported earlier in this study, Humann et al. (2005) analyzed the frequency distribution of noise in the swine confinement units. They found that the most prominent noise frequencies found by an octave band analysis were in the ranges of 2000 Hz – 5000 Hz. This observation corresponds to the frequencies 3000 Hz – 6000 Hz where hearing loss is also prominent in male farmers (Humann et al., 2005). Dennis and May (1995) also reported hearing losses in the 2000Hz – 4000 Hz range were present in twice as many farmers as compared to the non-farming controls. This was also seen in this study population.

5.3 Research Question #2

Does the use of hearing protective devices differ between grain and swine workers?

Occupational hearing loss remains prevalent. In most industries noise control efforts are in place but hearing protection is still required to lower the noise exposure to a safe level (Michael et al., 2011). Workers continue to experience hearing loss because they do not wear hearing protection effectively and for the duration of the noise exposure (Michael et al., 2011). A high percentage of workers in both groups reported exposure to a noisy work environment (97.6%). However, their use of protective devices differed when exposed to a noisy

environment. In this study it was noted that 91.2% of the swine workers wore hearing protection in a noisy environment as compared to only 46.5% of the grain workers.

In the grain industry there was significantly more males and individuals overall that did not wear hearing protection as compared to those in the swine industry. This was inconsistent with the literature. Two studies which included males and females looking at use of hearing protection and when grouped by sex, males showed a higher use of hearing protection. Lupescu et al. (1999) showed that 47% (n=506) of males self reported to wear hearing protection compared to their female counterparts who wore hearing protection 18% (n=58) during noise exposure. Dennis and May (1995) also found similar results that there is only a minority of farmers who wear hearing protection. When broken down by group, they found males wore hearing protection 18 to 25% of the time as compare to females who wore hearing protection 9 to 15% of the time.

Although noise induced hearing loss can be prevented by using hearing protection, a little over half of the grain worker population do not wear hearing protection in noisy environments. Swine workers can be assigned dedicated tasks that they perform throughout the day or for many days. For example, power washing pens, snout snaring and ear tagging has been classified as high noise exposure in a swine operation (Achutan & Tubbs, 2007). Humann et al. (2005) identified piglet processing, by which the worker picks up the piglet to their chest to administer vaccinations and other procedures. This task causes significant excitement which leads to squealing in the swine. This noise hazard has been measure at 90dB. As well, the orientation of the workers head placement while holding the squealing piglet lends to high exposure. This is an apparent/continuous noise exposure; thereby the swine worker would be more apt to wear hearing protection when exposed to these types of environments. Grain workers, on the other

hand, may have a variety of different tasks during the day where noise levels associated with these tasks may not be apparent to the worker. Sbihi, Teschke, Macnab and Davies (2009) findings were also consistent with the findings by Humann et al. (2005) stating that exposure levels influenced the using of hearing protection among workers.

Evidence in an agricultural hearing program from Australia showed that prolonged exposure to noise greater than 85 dB is indicative of noise induced hearing loss (Depczynski, et al. 2005). Hass-Slavin (2005) reported that farmers indentified that hearing loss is a familiar problem in the farming community. Gates and Jones (2007) report that day to day jobs task become normalized and workers lose their relationship with feelings of susceptibility. They also reported that the participants indicated that they “never thought it was necessary”, “they were not exposed for long period of time”, and “I didn’t think I needed to use it” (Gates & Jones, 2007) as reasons for not wearing hearing protection.

Noise does more harm to workers than hearing loss (Alberti, 1998). Even if the workplace noise levels are low enough not to damage hearing, they may interfere with communication, warning signals and contribute to stress (Alberti, 1998). Therefore, it is important to look closely at how best to make workers aware of the problem of noise. As mentioned previously, Gates and Jones (2007) report that day to day jobs task become normalized and workers lose their relationship with feelings of susceptibility to noise induced hearing loss. In this study it is shown that both worker populations report wearing hearing protection a little over half of the time (55.4%). This finding is also consistent with the literature where Hwang et al. (2001) reports that if people start using hearing protection once they notice a hear loss, they would not improve their current state of hearing, but may only prevent further hearing loss.

Hearing protection devices are an important part in hearing conservation. In the hierarchy of controls it has been said by Suter (2009) that it should be third, after engineering and administrative controls. The comfort of wearing hearing protection devices also needs to be considered. A protection device that is uncomfortable is unlikely to be worn, or worn effectively (Tougaw, 2011).

5.4 Pender's Model Application

Pender postulates that the modifying factors such as perceived benefits of action, perceived self-efficacy, perceived barriers, and situational influences can influence cognitive perceptual factors, which in turn influence health-promoting behaviors (Lusk, Ronis, & Kerr, 1995). The Health Promotion Model was used to examine the variance in hearing protection use among individuals and provided data describing factors that influence this behavior. Positive association between length of exposure/employment, use of hearing protection, gender and age contribute to hearing loss. Results of these assessments can be used in Pender's Health Promotion Model to educate workers on the maintenance of their hearing and prevention of noise induced hearing loss. Educational messages regarding overcoming barriers and encouraging hearing protection use to maintain hearing as one ages and to prevent noise induced hearing loss based on attitudes, beliefs, habits, behavior history, and personal factors can be used as a predictor of hearing protection devices (McCullagh, 2010).

When applying Pender's Health Promotion Model one could look at all of the above predictors when exposed to noise. Are the workers aware of the noise hazards above 85 dB at their work site? Are the workers likely to ignore the use of hearing protection at noise levels below 85 dB as they don't believe they are exposed to noise levels that can cause hearing difficulty? Are there barriers related to the use of the hearing protection devices? Are they

readily available to the workers? Have they been trained on the proper use of the hearing protection devices or is there a comfort issue with the hearing protection devices? Interventions can be based on these common concepts. As postulated by Gates & Jones (2007) a framework can be built around persons wanting to wear hearing protection if it is readily available, if it is perceived to have significance to their lives, when hearing protection is reinforced and when they are motivated to do so because of the impact a hearing loss would have on their personal life.

In a recent Cochrane meta analysis of interventions used to promote the use of hearing protection in the work environment concluded that tailored interventions (interventions that are specific to individual or groups and are aimed to change behaviour) were more effective when compared to a non-intervention group (El Dib, Mathew & Martens, 2012)

5.5 Potential Limitations and Bias

The analysis for this thesis was done on data collected for a health surveillance program and therefore certain limitations were encountered. There was missing data and non-responses to questions for some subjects and therefore not all questions related to hearing health or protection were available in all subjects for analysis. Although many of the questions on the swine and grain questionnaires were identical some of the more useful questions related to hearing protection were not available for both groups (types of hearing protection). Attempts were made to limit noise as much as possible in the environment where audiometric screening was conducted, background noise may have been present during the testing and could have affected testing results. Workers from both groups came for testing directly from the work site. Prior exposures to noise on the day of testing were reported by 26.2% of the total worker population and could have interfered with hearing assessment. As well, 33.7% of the total worker population reported being ill on the day of testing. Being ill on the day of testing included any of

the following: a head cold, flu, and allergies. Exposure to loud noise on the day of testing could cause a temporary hearing loss (Schulz, 2011). Being sick on the day of testing could also cause hearing loss due to middle ear pressure (Beckett, et al, 2000). The questions related to hearing loss, or ringing in an ear caused by an infection, injury, illness or medication did not take into account sensorineural defects from a variety of other etiologies that could have influences the findings for hearing loss due to the work environment. These etiologies may include viral, vascular, or other causes of inner ear damage such as: infections (mumps, meningitis, lyme disease, syphilis, scarlet fever, and measles), neurological disorders (multiple sclerosis), Meniere's disease, and head trauma (skull fracture) (May, 2000).

Audiometric exams were undertaken on each individual, using the EMI (Electro-medical Instrument, Co.) GSI 17 and RA 300 models which have insert headphones. There was a greater percentage of swine workers (74%) tested on the GSI 17 however, there was a greater percentage of grain workers tested on the RA 300 (61%). For the study, it was assumed that the sensitivity was equal between the two types of equipment. The questionnaire although subjective in nature was administered by a healthcare professional. Reporting bias could not be completely ruled out. Workers may have felt the need to over report the use of hearing protection use and under report symptoms, a possible source of response bias. Also, the surveillance program is provided to the workers through their employer. The employer would receive information regarding the results of the hearing surveillance program. A fear of a negative response from the employer regarding the lack of use of hearing protection devices could result in the workers over reporting the use of hearing protection devices while working in a noisy environment. Lastly, the health surveillance questionnaire used in this study has not been validated and there is no information on how the questions were derived. However, objective measures regarding hearing loss and

audiometry were also available.

5.6 Future Research

More research is needed in the area of the impact of non-occupational noise exposure and recreational exposures contributing to the hearing loss of workers in grain and swine industries. Noise exposure is cumulative. Working in the grain and swine industry, having other exposures to an agricultural/ non-agricultural job simultaneously and recreational exposures currently or in the past may increase the risk of noise induced hearing loss. Another study to include this other environmental exposure data is required to identify if this has had an impact on the worker's hearing. As well, while there is useful data on noise exposure levels in various task assignments in the swine industry, no such information is available in the grain industry. Further study of these levels of grain worker environments is needed.

This study also highlights potential areas for future research regarding barriers to hearing protection use by using Pender's Health Promotion model. An in depth look at the beliefs of the workers in with regards to noise exposure and hearing protection use is needed. Focus groups could explore perceived self efficacy, what health means to the worker and their description of health status, perceived benefits of using hearing protection devices, and potential barriers of using hearing protection devices. Results from this study could be used to form educational tools to be used in the Surveillance Program. One of these tools could be a fit testing audit. A fit testing audit leads to follow up in order to ensure that workers are wearing hearing protection devices properly, using hearing protection when required (e.g. identifying noise hazards), wearing the correct hearing protection, and training workers regarding hearing loss prevention.

5.7 Conclusion

Noise induced hearing loss is a serious occupational hazard. We have seen that gender,

age, and type of worker are a risk factor for ≥ 25 dB hearing loss. Gender differences, presbycusis and noise exposure in the worker population is consistent with findings in the literature in relation to hearing loss. Length of the occupational exposure over time to greater than 85 dB may have an impact on hearing and hearing outcomes. Grain workers reported wearing hearing protection in a noisy environment only half of the time. The type of task exposure may also impact hearing loss. This may have contributed to the ≥ 25 dB hearing loss seen in the grain workers, as compared to the swine workers.

Both worker groups identified that they were exposed to working in a noisy environment. When exposed to noise in the work place, swine workers almost always wore hearing protection as compared to the grain worker population who wore hearing protection for half the time. This could be attributed to the different tasks performed by each of the worker groups, and perhaps influencing their use of hearing protection. It also identifies that day to day tasks may have become routine thereby the worker cannot distinguish noise as a hazard.

Noise exposed workers receive information regarding noise exposure and hearing thresholds through the occupational health surveillance program. The assumption is that this information is beneficial. It is important for the nurse working in the surveillance program to be aware of the risks of prolonged exposure to noise in excess of 80 to 85 dB which may result in hearing loss. The risk factors seen in this study with regards to age, gender and being a grain worker should be taken into consideration.

Noise induced hearing loss is a preventable condition. It requires commitment and collaboration between the employer and employee groups. The employer should monitor the noise exposure in work environments and continuously review interventions (mechanical or removal of the worker from the exposure) to decrease noise generation. The employee needs to

remain responsible for their hearing health by recognizing areas of high noise exposure and using hearing protection devices when working in this environment. Re evaluation of current hearing programming and hearing protection practices will help to reinforce that hearing loss in the work place is largely a preventable condition. This should be done through teaching and involvement of the worker regarding use of hearing protection devices. Nursing interventions should focus on increasing hearing protection awareness, identifying potential sources of noise working collaboratively with employers and employees in reducing hearing loss in the workplace. The beliefs of the worker regarding occupational noise hazards and their use of hearing protection are key to adopting self protective behaviors in response to exposure to hazardous noise. Special attention needs to be given to those groups identified as high risk, such as the two groups understudy in this research project.

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APPENDIX A

Grain Worker Noise Exposure Questionnaire

Noise Exposure

Section 1

CONSENT

I voluntarily agree to participate in this health program. I understand that the specific results of this questionnaire and examination will be held in confidence. I understand that only statistical information will be shared with my employer.

I understand that depending upon the results of the testing I may be referred for further assessment.

Signature of Participant _____

Witness (print) _____

Witness (signature) _____

GENERAL INFORMATION (Please Print)

1. Name: FIRST _____ LAST _____

2. Address _____

Postal Code _____

3. Phone Number: _____

4. Date of Examination: _____

5. Family Physician _____

6. Sex: Male _____ Female _____

7. Date of Birth: Month Day _____ Year _____

8. Employer: _____

9. Employed for _____ years and _____ months with this employer.

Section 2

HISTORY

For the purposes of this questionnaire, “noise” or “noisy environment” is defined as:

A situation in which you are standing three feet away from an individual and you have to raise your voice In order to be heard.

1. Are you exposed to noisy environments?

a) At your grain workers job? Not Applicable____ YES ____ NO ____

b) Other employment? Not Applicable____ YES____ NO____

2. Do you wear hearing protection when working in a noisy environment? YES____ NO____

If YES;

-what percentage of the time do you wear hearing protection in a noisy environment?

| | | | |
|--------------|-----------|------------------------|------------|
| Grain worker | a) <25% | other work _____ | a) <25% |
| | b) 25-49% | (specify type of work) | b) 25-49% |
| | c) 50-74% | | c) 50- 74% |
| | d)>75% | | d)>75% |

What type of hearing protection do you wear?

a) Ear Plugs____ b) Ear muffs____ c) Other (Please explain) _____

3. Have you EVER had?

a) Broken ear drum? YES____ NO____

b) Vertigo (severe dizziness)? YES____ NO____

c) Ear surgery? YES____ NO____

d) Ear injury? YES___ NO___

e) Head injury? YES___ NO___

f) Hearing loss, or ringing in an ear YES___ NO___

Caused by an infection, injury, illness or medication? YES___NO___

If YES, how long did it last? _____

g) A parent with a hearing loss YES___ NO___

Before the age of 50 years? YES___ NO___

h) A sibling with a hearing loss YES___ NO___

Before the age of 50 years? YES___ NO___

4. Have you ever experienced hearing loss, or ringing in an ear? YES___ NO___

Caused by a loud noise? YES___ NO___

5. If you hunt or shoot, from which shoulder do you shoot? RIGHT___ LEFT___

6. Do you have ringing in your ears now? YES___ NO___

7. Do you have a cold, flu or allergy problems today? YES___ NO___

8. Were you exposed to a noisy environment today? YES___ NO___

If YES, for how long? _____ Hours_____ minutes

Did you use hearing protection? YES___ NO___

Section 3

FOR OFFICE USE ONLY

RESULTS OF OTOSCOPIC EXAM:

Right:

Left:

AUDIOGRAM: (to be attached)

Done by: _____

Audiometer: _____

Calibrated: _____

Sound booth: YES _____ NO _____

Comments/Referrals:

Swine Worker Noise Exposure Questionnaire

Noise Exposure

Section 1

CONSENT

I voluntarily agree to participate in this health program. I understand that the specific results of this questionnaire and examination will be held in confidence. I understand that only statistical information will be shared with my employer.

I understand that depending upon the results of the testing I may be referred for further assessment.

Signature of Participant _____

Witness (print) _____

Witness (signature) _____

GENERAL INFORMATION (Please Print)

1. Name: FIRST _____ LAST _____

2. Address _____

Postal Code _____

3. Phone Number: _____

4. Date of Examination: _____

5. Family Physician _____

6. Sex: Male _____ Female _____

7. Date of Birth: Month Day _____ Year _____

8. Employer: _____

9. Employed for _____ years and _____ months with this employer.

Section 2

HISTORY

For the purposes of this questionnaire, “noise” or “noisy environment” is defined as:

A situation in which you are standing three feet away from an individual and you have to raise your voice in order to be heard.

1. Are you exposed to noisy environments?

a) At your swine workers job? Not Applicable____ YES ____ NO____

b) Other employment? Not Applicable____ YES____ NO____

2. Do you wear hearing protection when working in a noisy environment? YES____ NO____

If YES;

-what percentage of the time do you wear hearing protection in a noisy environment?

| | | |
|----------------------|------------------------|------------|
| Swine worker a) <25% | other work _____ | a) <25% |
| b) 25-49% | (specify type of work) | b) 25-49% |
| c) 50-74% | | c) 50- 74% |
| d)>75% | | d)>75% |

What type of hearing protection do you wear?

a) Ear Plugs____ b) Ear muffs____ c) Other (Please explain) _____

3. Have you EVER had?

a) Broken ear drum? YES____ NO____

b) Vertigo (severe dizziness)? YES____ NO____

c) Ear surgery? YES____ NO____

d) Ear injury? YES____ NO____

- e) Head injury? YES___ NO___
- f) Hearing loss, or ringing in an ear YES___ NO___
- Caused by an infection, injury, illness or medication? YES___ NO___
- If YES, how long did it last? _____
- g) A parent with a hearing loss YES___ NO___
- Before the age of 50 years? YES___ NO___
- h) A sibling with a hearing loss YES___ NO___
- Before the age of 50 years? YES___ NO___
4. Have you ever experienced hearing loss, or ringing in an ear? YES___ NO___
- Caused by a loud noise? YES___ NO___
5. If you hunt or shoot, from which shoulder do you shoot? RIGHT___ LEFT___
6. Do you have ringing in your ears now? YES___ NO___
7. Do you have a cold, flu or allergy problems today? YES___ NO___
8. Were you exposed to a noisy environment today? YES___ NO___
- If YES, for how long? _____ Hours___ minutes
- Did you use hearing protection? YES___ NO___

Section 3

FOR OFFICE USE ONLY

RESULTS OF OTOSCOPIC EXAM:

Right:

Left:

AUDIOGRAM: (to be attached)

Done by: _____

Audiometer: _____

Calibrated: _____

Sound booth: YES _____ NO _____

Comments/Referrals:

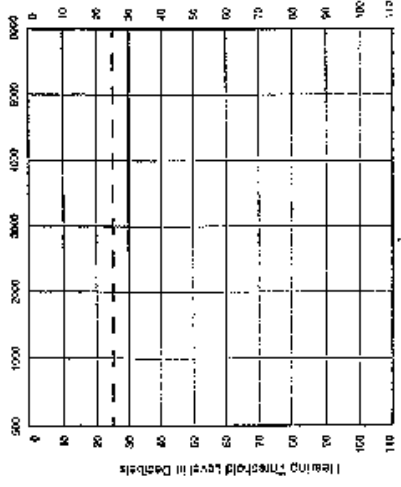
APPENDIX B

AUDIOGRAM

GSI 17
 RA 300
 Other _____

Name _____ No. _____ Ser. No. _____
 Age _____ Sex _____ Time _____ Job _____ Location _____
 Date _____

Examiner _____
 Signature _____



SYMBOLS

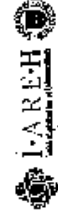
| Ear | Response | No Response | Phone |
|-------|----------|-------------|-------|
| Left | Y | X | Plus |
| Right | O | 0 | Red |

COMMENTS

- Normal Results
- Early loss index. Some noise-related Hearing loss, left/right ear. You need to use hearing protection to prevent further loss.
- Abnormal: Please see a physician or Audiologist for further assessment.
- Have your doctor wash you left/right ear.

Test Reliability:

| | Yes | No |
|---------------------------------------|-----|----|
| 1. Noise exposure for last 18 hours | | |
| 2. Ear, nose, throat problems | | |
| 3. Ambient noise during test | | |
| 4. Difficulty establishing thresholds | | |
| 5. Proper test technique followed | | |



CanWorkSafe

Institute of Agricultural, Rural and Environmental Health (I.A.R.E.H.)
 Centre for Agricultural Medicine, University of Saskatchewan
 103 Herriot Drive, Saskatoon, SK S7N 0W8 Telephone: (306) 966-4205 Fax: (306) 966-3795

APPENDIX C



Biomedical Research Ethics Board (Bio-REB)

Certificate of Approval

| | | |
|--|--|-----------------|
| PRINCIPAL INVESTIGATOR Donna Rennie | DEPARTMENT Canadian Centre for Health and Safety in Agriculture | Bio # 11-176 |
|--|--|-----------------|

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT
University of Saskatchewan
Saskatoon SK

STUDENT RESEARCHER(S)
Lynn Dwerynchuk

FUNDER(S)
INTERNALLY FUNDED

TITLE
Protocol : Hearing Status and Use of Personal Protective Equipment in Grain and Swine Workers

| | | | |
|-------------------------------------|----------------------------|--|----------------------------|
| ORIGINAL REVIEW DATE 08-Sep-2011 | APPROVED ON 09-Sep-2011 | APPROVAL OF Application to Access Existing Health Data (14-Jul-2011) | EXPIRY DATE 08-Sep-2012 |
|-------------------------------------|----------------------------|--|----------------------------|

Delegated Review: Full Board Meeting:

CERTIFICATION

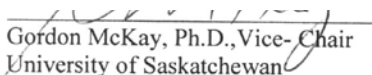
The study is acceptable on scientific and ethical grounds. The Bio-REB considered the requirements of section 29 under the Health Information Protection Act (HIPA) and is satisfied that this study meets the privacy considerations outlined therein. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research study, and for ensuring that the authorized research is carried out according to governing law. This approval is valid for the specified period provided there is no change to the approved protocol or consent process.

FIRST TIME REVIEW AND CONTINUING APPROVAL

The University of Saskatchewan Biomedical Research Ethics Board reviews above minimal studies at a full-board (face-to-face) meeting. Any research classified as minimal risk is reviewed through the delegated (subcommittee) review process. The initial Certificate of Approval includes the approval period the REB has assigned to a study. The Status Report form must be submitted within one month prior to the assigned expiry date. The researcher shall indicate to the REB any specific requirements of the sponsoring organizations (e.g. requirement for full-board review and approval) for the continuing review process deemed necessary for that project. For more information visit http://www.usask.ca/research/ethics_review/.

REB ATTESTATION

In respect to clinical trials, the University of Saskatchewan Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the Food and Drug Regulations and carries out its functions in a manner consistent with Good Clinical Practices. This approval and the views of this REB have been documented in writing. The University of Saskatchewan Biomedical Research Ethics Board has been approved by the Minister of Health, Province of Saskatchewan, to serve as a Research Ethics Board (REB) for research projects involving human subjects under section 29 of The Health Information Protection Act (HIPA).


Gordon McKay, Ph.D., Vice-Chair
University of Saskatchewan
Biomedical Research Ethics Board

Please send all correspondence to:

Research Ethics Office
University of Saskatchewan
Box 5000 RPO University
1607 – 110 Gymnasium Place
Saskatoon, SK Canada S7N 4J8



Certificate of Re-Approval

PRINCIPAL INVESTIGATOR: Donna Rennie; DEPARTMENT: Canadian Centre for Health and Safety in Agriculture; Bio #: 11-176; INSTITUTION: University of Saskatchewan; STUDENT RESEARCHER(S): Lynn Dwerynchuk; FUNDER(S): INTERNALLY FUNDED; TITLE: Hearing Status and Use of Personal Protective Equipment in Grain and Swine Workers; RE-APPROVED ON: 20-Aug-2012; EXPIRY DATE: 19-Aug-2013

Full Board Meeting []
Delegated Review [x]

CERTIFICATION

The study is acceptable on scientific and ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research study, and for ensuring that the authorized research is carried out according to governing law.

FIRST TIME REVIEW AND CONTINUING APPROVAL

The University of Saskatchewan Biomedical Research Ethics Board reviews above minimal studies at a full-board (face-to-face meeting). Any research classified as minimal risk is reviewed through the delegated (subcommittee) review process.

REB ATTESTATION

In respect to clinical trials, the University of Saskatchewan Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Part 4 of the Natural Health Products Regulations and Division 5 of the Food and Drug Regulations and carries out its functions in a manner consistent with Good Clinical Practices.

Gordon McKay, PhD., Chair
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Biomedical Research Ethics Board

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