

EXAMINATION OF STATE OF THE SCIENCE OF INTERVENTIONS  
DESIGNED TO INCREASE  
FARMERS' USE OF HEARING PROTECTION DEVICES

by

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## **DEDICATION**

My sincerest admiration goes to the health and safety professionals who strive to create a safe and healthy work environment, and to the workers who dedicate themselves to creating a better life for themselves and others, you have deepest my respect. This dissertation is dedicated to the memory of Kenneth Cox, Terry Stein, and Jay Wrobleski. You will be forever remembered.

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## **ABSTRACT**

### **Examination of State of the Science Interventions Designed to Increase Farmers’ Use of Hearing Protection Devices**

by

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Chair: Marjorie C. McCullagh

Among published interventions to increase farmers’ hearing protection device (HPD) use several methodological issues are of concern: use of theory, concepts, reliability of measures of self-report, and gender-related differences in predictors of HPD use.

Three papers were prepared to better understand use of HPDs among this group of workers and guide subsequent interventions: (a) a critical review of theory implementation in HPD use interventions among farmers, (b) a literature review and examination of the evidence of reliability of self-report as a measurement method, and (c) an examination of gender-related differences in predictors of HPD use among farm operators.

Theory examination identified five interventions and six theories (health belief model, transtheoretical model of change, health promotion model, social cognitive theory, PRECEDE-PROCEED, and theory of self-efficacy). While the studies employed health behavior theories to varying degrees, all intervention resulted in increased HPD use.

Kappa, correlations, sensitivity/specificity, positive/negative predictive validity, correlations, and logistic regression were used to assess concordance between self-report and non self-report methods. Kappa scores ranged from .01 to .89; sensitivity/specificity scores were 92% and 61% respectively; Pearson's  $r$ , Spearman's  $\rho$ , and Kendall tau-b were .89, .84, and .69 respectively; and odds ratios ranged from 1.4 to 19.42.

Concordance increased with use of daily activity cards, short time intervals between performance of the behavior and reporting, and limiting recall efforts to five days.

The Farmers' Predictors of Hearing Protection Device Use Model was used to examine gender-related differences in predictors of HPD use. Logistic regression identified different predictors for men (interpersonal support [OR = 2.00,  $p = .01$ ], situational influences [OR = 1.29,  $p = .02$ ], barriers [OR = .57,  $p < .001$ ] and women (self-efficacy [OR = 2.26,  $p < .001$ ], value [OR = 1.49,  $p = .04$ ]).

Implications for future research to promote the use of HPDs among farmers include further testing of the Farmers' Predictors of Hearing Protection Device Model, and revision and successive testing of self-efficacy and interpersonal influences scales. Interventionists seeking to increase HPD use should consider tailoring interventions to the unique gender-specific predictors of farmer men and women.

## **CHAPTER I**

### **EXAMINATION OF STATE OF THE SCIENCE INTERVENTIONS DESIGNED TO INCREASE FARMERS' USE OF HEARING PROTECTION DEVICES**

Millions of farmers in the United States are at risk for noise-induced hearing loss (NIHL), a condition that is 100% preventable with the use of hearing protection devices (HPDs) (Centers for Disease Control and Prevention [CDC], 2009; Rabinowitz & Rees, 2005). Farm operators are exposed to high noise levels while performing farm work and have low use of hearing protection and a high prevalence of hearing loss in both men and women farmers (Beckett et al., 2000; Carruth, Robert, Hurley & Currie, 2007; McBride, Firth & Herbison, 2003; McCoy, Carruth & Reed, 2001; Meeker, Carruth & Holland, 2002; Plakke & Dare, 1992; Reed, 2004; Schenker, Orenstein & Samuels, 2002; Tak, Davis & Calvert, 2009). Interventional research to increase farmers' use of HPDs is sparse, and among the published literature, several methodological issues warrant investigation.

For example, several different theories and combinations of theories have been used as frameworks for the interventions. There are similarities among the theory concepts as well as differences. An examination and critical assessment of theory application may be useful for informing and designing future interventions. The results are expected to provide new insights for the design of interventions to promote use of HPDs among farmers.

Another methodology concern in farmers' use of HPD interventions is reliance on self-report as an outcome measurement method. Conflicting views regarding the reliability of self-report warrant further investigation into this method.

Finally, although there are a much greater number of men than women farmers in the cumulative interventions, comparison studies have not been done to determine if there are gender-related differences in predictors of farmers' HPD use. Identification of gender-related differences in HPD use could inform future research to promote HPD use among this population.

Several terms are used throughout this research in reference to the population of study. For purposes of this paper, farm operators are defined as the individuals responsible for the day-to-day operation of the farm and active in farming activities; farmers are those individuals who perform farm work tasks and may or may not be farm operators; farm families consist of adult and child or adolescent members of a family who live and work on a farm. Collectively, the studies examined focus on the populations of farm operators, farmers, and farm families. Therefore, when making references to all of the identities above, the term farming community will be used.

The overarching question in this relatively young intervention research area is, "What is the current state of the science in research to promote HPD use among farm operators?" To address this question, the following research questions were presented:

- 1) Six behavior change theories were used in published intervention research to promote farmers' HPD use. How did each intervention design operationalize theory concepts? What were the concepts studied and how do the concepts from each of the theories compare to each other?

2) All outcomes from the intervention studies were self-reported. What is the current state of the science with regard to reliability of self-report in health protective behavior research?

3) Lastly, according to the most recent survey from the United States Department of Agriculture census published in 2007, from 2002 to 2007 there was an increase of women principal farm operators in the United States in almost every category of farm type. None of the published studies compared significant factors associated with HPD use between genders. Are there significant differences in predictors of HPD use between men and women? Differences could imply that gender may be a consideration in the design of future interventions to increase HPD use among farmers.

To better understand current collective knowledge and guide subsequent HPD use interventions three papers were prepared: (a) a review and examination of theory application in HPD use interventions among farmers, (b) a literature review and examination of the evidence of reliability of self-report as a behavior outcome measurement, and (c) an examination of gender-related differences in predictors of HPD use among farmers.

This research focused on the issue of interventions to promote HPD use in the farming community in the hope of prevention of NIHL. Although desirable, a meta-analysis of the theory-based interventions was not feasible due to heterogeneity among the interventions.

*Specific Aim 1*

To critically examine and compare theories guiding HPD use interventions among farm operators with a focus on application of theory concepts and identification of congruent concepts.

*Specific Aim 2*

To examine the current state of the science of agreement of self-report and non self-report outcome measures in behavior change interventions.

*Specific Aim 3*

To analyze predictors of HPD use among farm operators to determine if there are gender-related differences.

The results of this study will be used to inform research in noise-induced hearing loss prevention and lead to the development of future interventions to promote the use of HPDs in the farming community.

### **Background and Significance of the Problem**

Sensorineural hearing loss occurs when the delicate sensory nerve hair cells in the cochlea of the ear sustain damage. Damage to these nerve cells can occur with trauma, exposure to ototoxic drugs, bacterial or viral infections, solvent exposures, and benign tumors - but most often occurs with prolonged exposure to high noise levels. The Occupational Safety and Health Administration (OSHA) mandates implementation of a hearing conservation program in regulated industries when noise exposure reaches an 8-hour time weighted average of 85 decibels. As a sound gets louder, less exposure time is necessary to result in damage. Damage to hearing due to noise is dependent on the duration and loudness of the exposure as well as other risk factors such as individual susceptibility, age, pre-existing ear disease, head and neck radiation, and orientation of

the ear in relation to the noise source (OSHA, 1999). With repeated loud noise exposure a temporary change in hearing ability occurs. Following loud noise exposure there is a temporary period of time when a person experiences a decreased ability to hear and perhaps ringing in the ears (tinnitus). After awhile, minutes to hours, “normal” hearing ability is restored. This is termed a temporary threshold shift. If the temporary threshold shift cycle is repeated over time the change or shift in hearing ability becomes permanent, progressive, and irreversible. This type of hearing loss is termed noise-induced hearing loss (NIHL).

### **Prevalence and Scope**

NIHL has been recognized as a work-related health concern since the 18th century (McCunney & Meyer, 1998). NIOSH (2009) estimates up to 30 million workers in the United States are exposed to hazardous noise. In a study on the global burden of NIHL, Nelson, Nelson, Concha-Barrietos, and Fingerhut (2005) identified occupations placing workers at risk for NIHL. These occupations include manufacturing, forestry, farming, construction, mining, textile, printing, music, airline pilots, mechanics, armed forces, and woodworkers. Men, women and children are affected by NIHL. Many women have taken on active farm task roles and it is not uncommon for young people to be exposed to farm noise while working along side their parent or grandparent farmers (Kidd, Reed, Weaver, Westneat & Rayens, 2003; Knobloch & Broste, 1998; Reed, 2004; Reed, Kidd, Westneat & Rayens, 2001).

## **Prevention of NIHL**

NIHL has a slow, often unrecognized onset. However, once the nerve cell damage occurs it cannot be reversed. Although NIHL is an irreversible, progressive, and permanent condition, with appropriate use of hearing protection, it is also 100 percent preventable (CDC, 2009; Rabinowitz & Rees, 2005). HPDs work by filtering sound as it travels through the ear canal, thus reducing the dose of noise. To be effective in preventing NIHL, HPDs must be worn 100% of the time when workers are exposed to loud noise, and be fitted and placed appropriately (National Institute of Health [NIH], 2011; Rabinowitz & Rees, 2005; Royster et al., 1996).

## **Quality of Life**

Loss of hearing has a negative impact on quality of life by causing difficulty with verbal communication, strain in personal relationships, increased risk of injury due to unheard warning signals, and contributes to feelings of isolation and depression (Carruth, Robert, Hurley & Currie, 2007; Choi et al., 2005; Sprince et al., 2002, 2003; Tambs, 2004; Wallhagen, Strawbridge, Shema & Kaplan, 2004; Wallhagen, Pettingill & Whiteside, 2006). The onset of NIHL is gradual and often goes unrecognized. The first clinical sign of NIHL is hearing loss at the 4000 – 6000 Hertz (Hz) frequency, which is just above the level of normal conversation ( $\leq 3,000$  Hz). Family members may complain that the person with NIHL is not listening, or the one with NIHL may perceive those with whom they are having conversations to be mumbling or not speaking clearly or loudly enough. The effects, just as the onset of NIHL, are gradual and progressive, and often a source of conflict or tension in familial and social settings (Arlinger, 2003; Dalton et al., 2003; Hass-Slavin, 2005; Tambs, 2004).

## **NIHL as a Priority Health Problem**

The U.S. Department of Health and Human Services (2010) has established objectives for improving the health of our nation. The most recent Healthy People 2020 agenda continues to include the prevention of NIHL as a research priority. Professional organizations such as American College of Occupational and Environmental Medicine (American College of Occupational and Environmental Medicine [ACOEM], 2012) and the American Association of Occupational Health Nurses (AAOHN, 2006) consider NIHL to be an important research issue. The World Health Organization has identified NIHL as a global priority health problem (ILO/WHO, 2003). At the Centers for Disease Control and Prevention (CDC), National Institute on Occupational Safety and Health (NIOSH, 2009) continues to identify workplace NIHL as a research priority, estimating more than 30 million workers are exposed to high noise levels resulting in hearing loss. NIOSH encourages further research to prevent this disease.

Also within the CDC, the National Occupational Research Agenda (NORA) has identified as a priority the need for interventions to reduce acute and chronic illnesses (NIHL is considered a chronic illness) and diseases among workers in the agriculture, forestry, and fishing industries (CDC, 2008). The National Institute on Deafness and other Communication Disorders (NIDCD) also considers NIHL to be a significant research area (NIDCD, 2011).

## **Hearing Conservation Legislation**

Federal and state health and safety regulators such as the Occupational Safety and Health Administration (OSHA) promulgated laws requiring employers with 11 or more non-family employees to institute a hearing conservation program to identify risk and

provide protection for workers exposed to loud noise (1999). Regulated employers are required to institute and enforce a hearing conservation program when noise exposures are above 85 decibels for an 8-hour time weighted average.

Manufacturing and construction are two such regulated industries. Employers in these industries are required to enforce the use of HPDs for workers exposed to high noise levels as defined above. Management personnel form health and safety committees who conduct compliance investigations, participate in work place health and safety research, initiate, and support hearing conservation programs. Workers' compensation insurance is the employer's funding source for pay loss and medical expenses including assistive devices for employees deemed to have workplace noise-induced loss of hearing. The OSHA 40 CFR Part 1928 exempts the agriculture industry from the occupational noise exposure standard, 29 CFR 1910.25, which was promulgated to protect exposed workers from NIHL.

### **Treatment of NIHL**

Correction of this unseen sensory loss with the use of hearing aids or hearing assistive devices is expensive and not covered by most health insurance plans. Moreover, the use of assistive devices often causes people to feel stigmatized, and the device may be difficult to use, so it is not worn (Wallhagen, Pittingill & Whiteside, 2006). Hearing aids amplify sound vibrations as they enter the ear. Hair cells detect the larger vibrations and convert them into neural signals that are passed along to the brain (NIDCD, 2011). If damage to the inner ear is so severe that there are not enough functional hair cells remaining to respond to even the amplified sound, the device will be ineffective for increasing hearing ability. Hair cell damage and subsequent nerve fiber degeneration is a

result of noise exposure and leads to NIHL (NIDCD, 2011, Rabinowitz & Rees, 2005). Because treatment for NIHL is so highly unsatisfactory, primary prevention of the condition is highly preferred.

### **Significance to Nursing**

The information obtained from this research will be used to clarify nurses' and other health and safety professionals' understanding of what is known and unknown regarding the theoretical basis of interventions to increase the farming community's use of HPDs, evaluate the reliability of self-report as an outcome measure in behavior change interventions, and determine if there are statistically significant gender-related differences in predictors of HPD use. This knowledge will advance the development of evidence-based nursing and be useful in informing future interventions to promote HPD use among the farming community.

### **Hearing Conservation Research in General Industry**

Many studies of hearing loss and use of HPDs have been conducted with workers in general industry and construction. Federal regulations have been promulgated for the mandatory use of HPDs in certain situations with the intention of preventing NIHL among workers in general industry and construction. Research and intervention initiatives and systems in place in general industry have demonstrated some success in preventing NIHL among manufacturing workers (NIOSH, 2009). However, these initiatives and regulations have not produced 100% use of HPDs among regulated, high noise exposed workers. The majority of participants in hearing conservation research were men, most likely due to the nature of the work in manufacturing and construction.

However, more women are entering the farming industry in roles as producers. Greater details of the literature findings on gender are discussed later in this dissertation.

### **Hearing Conservation Research in the Farming Industry**

The non-corporate farming industry differs from general industry and construction in that it is exempt from federal and state health and safety regulations, surveillance activities and resources common in the manufacturing industry with regard to noise exposure and hearing loss prevention (OSHA, 2011). The independent farm owner-operator carries the financial as well as health and safety responsibilities for the business (farm) and its workers. The 2007 United States Agriculture Census reported there are over 1.2 million farms in the United States, almost 1 million farmers identify themselves as the principal operator of a farm, and 1.5 million agricultural workers are exposed to noise levels at or above the hazardous level identified by OSHA standards (Tak, Davis & Calvert, 2009).

It is important to understand some common attitudes and perceptions of these entrepreneurial workers. A qualitative study by Amshoff and Reed (2005) identified several characteristics of farm operators that demonstrate a “different perspective from the general population on what constitutes work” (p.305). Seventy percent of the farm operators interviewed reported a great deal of personal satisfaction from doing farm work, half of the farm operators said they did not plan on stopping farm work at some point in their life or retiring. On average, farm operators reported performing 11.1 different job tasks in the previous 12 months. Farm operators in the same study defined good health as the ability to work. At the same time, they reported having numerous

health conditions such as back problems, diabetes, skin cancer, arthritis, rheumatism, hypertension, and hearing problems.

McCullagh (2000) reported some farm operators defined “health” as the absence of pain and the ability to work, which supports earlier work by Wadud, Kreuter, and Clarkson (1998). Hearing loss is neither painful (physically) nor is it physically disabling in that it does not prevent farmers from performing farm work functions. Some sources would argue that hearing loss is a disability (i.e. the Americans with Disabilities Act, some Workers’ Compensation Laws, other medical-legal entities). However, researchers have demonstrated the farm operator with hearing loss believes he/she is still able to perform the physical and mental functions of the job, and continues to do so (Amshoff & Reed, 2005; Carruth, Robert, Hurley & Currie, 2007). Sample statements from farm operators in the Amshoff and Reed (2005) study provide some insight into farm operators’ attitudes about work and health. “No matter how sick you get...you just do what you have to do.” Some reported they felt they “would die if they did not work” (p. 307).

Carruth, Robert, Hurley, and Currie (2007) examined farm operators’ and farmers’ families’ perceptions and attitudes about hearing loss in a descriptive correlational study. The results indicated 21% of those surveyed (N=30) agreed to the statement “if you are a farmer, hearing loss is unavoidable” (p. 231). Hass-Slavin, McColl, and Pickett (2005) identified emotional, social, and practical consequences of hearing loss.

## **Review of the Literature**

### **Noise, Hearing Loss, and HPD Use Among Farmers**

Noise exposure is defined as the dose of unwanted sound pressure (Sataloff & Sataloff, 2006). Farmers are exposed to varying levels of noise while performing usual farm work throughout the workday. Beckett et al. (2000) reports farm area and equipment noise level measurements (decibels) from tractors (m=90.7), feeding areas (m=90.4), milking areas (m=80.2), and choppers (m=93). These noise levels are in the range of concern for hearing damage. Other noise level reports indicate farm noise frequencies ranging from 77 decibels to 140 decibels (Broste, 1989; Holt, Broste & Hansen, 1993; Jones & Oser, 1968; McBride, Firth & Herbison, 2003). Noise level measurements and their sources are important to know for the development of interventions designed to protect farmers' hearing. Farm noise exposure is the primary cause of sensorineural hearing loss among farmers (Ehlers et al., 1993; Meeker, Carruth, & Holland, 2002; Reed, 2004).

Thelin, Joseph, Davis, Baker, and Hosokawa (1983) conducted audiograms on farmers and found high rates of hearing loss. Despite efforts to promote hearing conservation, there continues to be a high prevalence of hearing loss and low use of HPDs among the farming population (McCullagh, Lusk, & Ronis, 2002; McCullagh, 2010, Meister, Hest, & Burnett, 2010; Williams, Purdy, Murray, LePage, & Challino, 2004).

A national database for surveillance and injury reporting specific to the farming industry does not exist. Consequently, an accurate, industry-specific measurement of economic burden for hearing loss among farmers is not available. The indirect cost of

hearing loss-related injuries is significant and important. In a case control study of Iowa farmers, those with self-reported hearing loss were 80% more likely to sustain a fall related injury than those not reporting hearing loss. Farmers who wore a hearing aid were 2.4 times more likely to be injured on the job. Animal-related injuries for farmers reporting wearing a hearing aid were 5.4 times more likely and 4.4 times more likely for machine related injuries of farmers reporting hearing aid use (Sprince et al., 2003).

Engineering and administrative controls to mitigate noise is the preferred method to decrease noise exposure. However, costs to retrofit engineering changes to equipment, or purchase new, quieter equipment may be cost prohibitive and, for many farm operators, not feasible. Implementation of administrative controls to reduce noise exposure, such as changing work assignment or work hours, is also not feasible for the independent farm operator. Depending on the nature of the work, farmers may have frequent exposure to other hazardous noise less amenable to engineering and administrative controls, such as livestock (Beckett et al. 2000; Goldcamp, 2010; Reed, 2004).

### **Hearing Protector Device Use Among Farmers**

Although there is known resistance to HPD use among the farming population, use of HPDs to mitigate noise exposure is the best solution when engineering and administrative controls are not reasonable or feasible (Murphy, 1992; NIOSH, 2009). This resistance may largely be due to beliefs held by farmers about hearing loss and hearing loss prevention. Researchers have examined farmers' beliefs about hearing loss and prevention and/or use of HPDs. Findings include beliefs such as the noise did not bother them, therefore they did not need to use hearing protection (Wadud, Kreuter &

Clarkson, 1998), or their noise exposure was not enough to warrant wearing HPDs (Meister, Hest, & Burnett, 2010; McCullagh, 2010). Some participants expressed the belief that hearing loss is unavoidable in farmers, it takes too much time to use HPDs, use is inconvenient and dirty, and hearing loss is a normal effect of aging. Farm operators also expressed a concern that with the use of hearing protection they might not be able to hear subtle sounds from their equipment; potential indicators of a problem either with the equipment or in the vicinity of the equipment. Not identifying an equipment problem early can result in damaged equipment or personal injury to the user or someone nearby, as well as substantial monetary loss to the farm operator (Amshoff & Reed, 2005; Hass-Slavin, McColl, & Pickett, 2005; McCullagh, 2010; Carruth et al., 2007).

Using Pender's Health Promotion Model and work previously performed by Lusk, Kerr, Ronis, and Eakin (1999), McCullagh, Lusk, and Ronis (2002) identified predictors of HPD use among farm operators. McCullagh revised and tested Pender's Health Promotion Model for use in identifying predictors of HPD use among farm operators. The significant predictors included perceived barriers to HPD use, perceived situational factors influencing HPD use, and gender. Other barriers and situational factors limiting use of HPDs included discomfort and unclean HPDs, not the right type available and difficulty communicating with other farm operators. Women farm operators were less likely than their counterparts (men) to use HPDs when in high noise exposure areas (McCullagh, 1999).

### **HPD Use Interventions Among Farmers**

A review of the interventional research literature for the promotion of the use of HPDs among the farming community revealed a paucity of published papers. Long-term

(one to four years) school based educational interventions demonstrated a positive impact on increased use of HPDs (Kidd, Reed, Weaver, Westneat, & Rayens, 2003; Knobloch & Broste, 1998; Reed & Kidd, 2004; Reed, Kidd, Westneat, & Rayens, 2001) and resulted in increased use of HPDs among the students' parents (Knobloch, 1999). This discovery could have implications for the effect on other family members in the study of behavior change and may warrant consideration in the design of future HPD use behavioral interventions.

Interventions among adult farmers resulted in an immediate increase of use of HPDs (Gates & Jones, 2007; Jenkins, Stack, Earle-Richardson, Scofield, & May, 2007; McCullagh, 2010). However, long-term follow-up for sustained HPD use was not reported. The intervention participants were predominately male and all outcomes were self-reported. Pender's Health Promotion Model was used in part or modified to guide most of the adult HPD use intervention studies (McCullagh, 2010; McCullagh, Lusk & Ronis, 2002). Gates (2007) combined the health belief model with Pender's health promotion model and social learning theory, and Jenkins and colleagues (2007) designed an intervention combining the social leaning theory with PRECEDE-PROCEED. The transtheoretical model of change guided interventions conducted among youth by Kidd et al. (2003) and Reed & Kidd (2002). A comparison and analysis of health behavior change models in HPD use interventions was warranted. The three papers in this dissertation, along with specific aims and research questions are described below.

### **Intervention Theory Concept Comparison (Paper One)**

Theory provides the basis on which to develop, execute, and evaluate interventions. Of the published literature on interventions to promote the use of HPDs in

the farming community, seven articles (five interventions) identified a theoretical basis. The objectives of this paper are to comprehensively review the health behavior theories and theory concepts used in interventions to promote the use of HPDs in the farming community, examine theory application and identify relevant concepts. These theories include: (a) health belief model, (b) transtheoretical model of change, (c) PRECEDE-PROCEED, (d) Pender's health promotion model, (e) social cognitive theory, and (f) theory of self-efficacy. The specific aims of this paper were to critically examine and compare the theories and concepts used in HPD use interventions in the farming community, but more importantly, examine application of the theory concepts guiding the interventions and identify shared concepts. The following research questions were addressed:

- 1) How do the concepts in each of the theories compare?
- 2) How did the intervention operationalize theory concepts?
- 3) Which concepts contributed significantly to the outcomes?

Criteria for considering interventions for this review included the following: the intervention focused on a population of farmers, the aim was to promote HPD use, HPD use was the dependent variable or included in the dependent variable, the report was written in English, and it identified a theory or distinct theory concepts. There were no specific exclusion criteria. Methodological quality, statistical procedures, summarization, and discussion of findings are reported and compared. The following theories were included in the analysis.

## **Theories Applied in HPD Use Intervention Studies of Farmers**

***Health Belief Model.*** The health belief model (HBM), developed by Becker (1974), was created to explain preventive or health protecting behavior. The HBM includes concepts of perceived susceptibility, perceived severity, perceived benefits, cues to action, and self-efficacy. This model has been used with interventional research to increase use of HPDs, but has not sufficiently explained or predicted outcomes among farmers.

***Transtheoretical Model of Change.*** The transtheoretical model of change (TTM) has been used to understand how behavior change is initiated, how it progresses, and finally how the new behavior is maintained (Prochaska & DiClemente, 1982). The model includes five central concepts: stages of change, processes of change, decisional balance, confidence, and temptation.

***PRECEDE-PROCEED.*** PRECEDE-PROCEED is a comprehensive framework for assessing health and quality of life needs, and designing, implementing, and evaluating health promotion programs (Greene & Kreuter, 1999). This model takes both individual and environmental factors into consideration and includes the participants in the development and evaluation of the intervention. The acronym PRECEDE represents predisposing, reinforcing, and enabling concepts in educational diagnosis and evaluation at the individual level. There is an emphasis on identifying educational deficits, referred to as the diagnoses, and developing methods to change environmental and social influences on health behaviors in populations. PROCEED focuses on influences outside of the individual, and represents policy, regulatory and organizational concepts in educational and environmental development.

***Health Promotion Model.*** Pender's health promotion model (HPM) was first introduced in 1987, as a behavior change model for health promotion. Three major components form the basis for the HPM: (a) cognitive/perceptual or psychological elements that determine health-promoting behaviors, (b) modifying circumstances that influence cognitive/perceptual factors and so indirectly influence health-promoting behaviors and, (c) the likelihood of action leading to enhancing or maintaining well being. Cognitive/perceptual factors include items such as importance of health, definition of health, perception of health, self-efficacy, health status, benefits, and barriers to health-promoting behavior. Modifying factors include demographic and biological characteristics, interpersonal influences, and situational and behavioral factors.

***Social Cognitive Theory.*** Social cognitive theory (SCT) is a learning theory based on the premise that people learn behaviors by observing others with whom they have a connection. Environmental, social, and cognitive factors are considered in this theory.

*Vicarious learning* is the essence of social cognitive theory. Simply stated, it is the process of learning a new behavior by watching another person perform that behavior. According to Bandura, it is also one of the four main ways self-efficacy is attained.

*Identification* with the individual demonstrating the desired behavior is an important aspect of the social cognitive theory. The greater the connection or identification between the observer and modeler, the more likely it is that a change in behavior will occur.

*Self-efficacy* is the core component within social cognitive theory and has been a concept in all other theories described in this paper. However, the concept of self-

efficacy has also been used independently. HPD use interventions have used self-efficacy as a theory in intervention implementation. So, for purposes of this paper, it will be explained as an independent theory.

***Theory of Self-efficacy.*** Although self-efficacy is a major concept in Bandura's social cognitive theory (1977), Bandura himself refers to self-efficacy as a theory (Bandura, 1982). Simply stated, self-efficacy is the belief in one's own competence to perform in a certain way to attain a certain goal or set of goals - if an individual has confidence or belief in their ability to perform in a certain way, they will. The greater the self-efficacy of a behavior, the more likely will be performance of the behavior and goal attainment. According to Bandura, there are four ways to increase self-efficacy (a) vicarious learning, (b) mastery experience, (c) improving physical and emotional states and, (d) verbal persuasion.

Using the above listed research questions as a framework, theories guiding the HPD use interventions within the farming community were systematically reviewed and compared, with a focus on application of theory and significant overlapping concepts.

## **Reliability of Self-Report (Paper Two)**

Self-report of outcome measures is the most common means of data collection in the farming community HPD use intervention studies. There are several potential reasons for concern regarding reliability of self-report of protective behaviors such as recall bias, social desirability, and lack of motivation. Many general population behavior change interventions use self-report as an outcome, such as seatbelt use, smoking, alcohol consumption, physical activity level, and nutrition intake. It is important to understand the current state of the science in terms of concordance of self-report with non self-report

outcomes. The specific aim of this paper was to present a review of the literature with regard to concordance of self-reported outcome measures compared to non-self reported measures. Five research questions guided the paper:

- 1) What studies have been published regarding concordance of protective health behaviors comparing self-report measures with non self-report measures?
- 2) When and with what populations have researchers used self-report as an outcome measure and other measurement methods?
- 3) What are the comparative benefits and limitations of self-reported outcome measures?
- 4) Does the outcome of the evaluation support or refute self-report as a reliable outcome measure as it relates to farmers' use of HPDs and other protective behaviors?
- 5) How can this information inform future intervention research among the farming community with regard to HPD use and other protective behaviors?

A comprehensive, computerized data base search was conducted using search terms of self-report outcomes, non self-report outcomes, observed outcomes, occupation, personal protective equipment, farmer, farmers, construction, construction workers, concordance, agreement, reliability, health behavior change, interventions, and any other terms found useful to identify studies for evaluation. The search focused on, but was not limited to, occupations similar to farming (i.e. variable noise levels, mostly unsupervised workers, non-regulated). The study was included in the evaluation if it described a comparison of self-reported outcomes with non self-reported outcomes and an analysis of results. Initially, the search was limited to years 2002 to the present. However the

limitation resulted in too few publications, therefore year of publication limitation was abandoned. Results of the overall search are described and evaluated for utility of self-report as an outcome measure.

### **Gender Differences in HPD Use Predictors (Paper Three)**

According to the United States Department of Agriculture census (2007), there has been an increase of women principal farm operators in the United States in almost every category of farm type (e.g. equine, dairy, wheat) from 2002 to 2007. The census reports there are 306,209 U.S. farms with a woman as principal farm operator. This is an increase of 68,390 over 5 years. The number of women principal farm operators also increased during the same time span by farm size on farms ranging from 1 to 500 or more acres. Farm ownership by women also increased during the same 5-year time span by 60,719 farms. The United States Census Bureau (2007) indicates women comprise 30% of total farm operators. Farm operators are defined in the census as the person who either does the work or makes day-to-day decisions on the farm.

### **Roles of Women on the Farm**

The woman's role on the farm has changed over time. Larger farm sizes and the reduction of hired workers have encouraged a trend for the woman on the farm to take on a larger role in farm production work. Although the division of labor on farms varies by region, group and family, Reed et al. (1999) reported that 46% of women who characterized themselves as homemakers regularly engaged in farm work such as work with animals, field irrigation, farm equipment operation, and management. Other studies have shown that women perform many regular and intermittent farm activities that

expose them to mechanical and environmental risk hazards such as machinery, equipment, chemicals, and livestock (McCoy, Carruth & Reed, 2001; Carruth, McCoy & Reed, 2001; Reed, 2004). Reed (1999) suggests that because of the woman's self-identity as homemaker and possibly intermittent exposures, she may not see herself at risk for injury due to farm hazards.

### **Susceptibility to Noise-induced Hearing Loss**

Although the research is somewhat ambiguous, there is some evidence that women may be more vulnerable to hearing loss than men, even at noise level exposures below 83 dB, a level lower than the 8-hour time weighted average exposure limit set by OSHA (Szanto & Ionescu, 1983). In a sample of 126 factory workers proportions of hearing loss between men and women were similar (67% and 62%), although men had longer noise exposure than women in the study (Westbrook, Hogan, Penney & Legge, 1992). Other studies have indicated that as they age, hearing sensitivity declined faster in men than in women (Pearson et al., 1995).

### **Gender and Health Behaviors**

Research has demonstrated that marriage and other social relationships are associated with lower morbidity and mortality (Berkman & Syme, 1979; House, Robbins & Metzner, 1982; House, Landis & Umberson, 1988; Wallston, Alagna, Devilis & Devillis, 1983) and the health benefits from these relationships seem to be greater for men than women (House, Landis & Umberson 1988; Schumaker & Hill, 1991; Umberson, 1992). Women also tend to be more knowledgeable about health issues, adhere to health care recommendations and monitor and influence preventive health behavior of others

(Lewis & Lewis, 1977; Briscoe, 1987; Nathanson, 1977). Harris and Guten (1979) and Mechanic and Cleary (1980) found the strongest predictor of preventive health care is female gender. Further research demonstrated that men are 2.7 times more likely to be influenced by women in health seeking behaviors (Norcross, Ramirez, & Palinkas, 1996).

There is ample evidence in the literature that women have a strong influence on health practices of men, specifically their husbands, and that health behavior interventions have an effect on other family members. Considering the increasing and expanding role of women and farm work, an examination of HPD use and understanding the predictors of HPD use among women farm operators could yield important information in the development of interventions to increase the use of HPDs among farm operators of both genders.

The specific aim of this paper was to analyze data from two previous studies (McCullagh et al., 2002, 2010) of predictors of HPD use among farm operators to determine if there are gender-related differences. Three research questions guided this paper.

- 1) What are the significant predictors of use of HPDs among women farm operators from the combined studies?
- 2) Are there differences in significant predictors of HPD use between men and women farm operators?
- 3) What are the implications of the results for future HPD use intervention research, policy, and practice?

## **Setting and Subjects**

A secondary analysis was conducted to examine gender differences in predictors of HPD use among farm operators. This study tested the Farmers' Use of Hearing Protection Model (McCullagh, 2010) derived from Predictors of Workers' Use of Hearing Protection Model (Lusk, Ronis, Kerr, & Atwood, 1994). Combining two parent studies (McCullagh, 2002 & 2010) provided a sample size of 173 women and 513 men. The first (2002) study was conducted with a convenience sample of farmers attending a regional farm show in the Midwest. The second (2010) study was a cross-sectional study using telephone surveys of a random sample of Midwest farm operators to identify factors related to their use of HPDs. Pender's Health Promotion Model guided both studies.

## **Measures**

Variables for the parent studies were based on the Farmers' Use of Hearing Protection Model (McCullagh, 2010) derived from Predictors of Workers' Use of Hearing Protection Model (Lusk, Ronis, Kerr, & Atwood, 1994). This model hypothesized that cognitive and affective factors influence use of HPDs among farmers. The variables were divided into two categories, 1) behavior-specific cognitions and affects and 2) individual characteristics and experiences. Variables in each of the studies included: perceived value of use of HPDs, perceived barriers to use of HPDs, self-efficacy in use of HPDs, perceived situational factors influencing the use of HPDs such as availability of HPDs, perceived interpersonal influences influencing the use of HPDs which includes subscales of perceived interpersonal norms for HPD use, perceived modeling of HPD use, and perceived interpersonal support for HPD use. Demographic

characteristics included age, gender, farm products produced, and occupational role (e.g., owner, paid worker). The dependent variable was use of HPDs measured by self-report.

### **Instruments**

Instrument reliability was tested prior to use in the parent studies; Cronbach's alpha coefficients measured .70 or greater in all but one of the instruments. The Farmer's Perceived Interpersonal Modeling Instrument demonstrated a reliability of .49, most likely due to a low number (n=4) of items comprising the instrument. Behavior-specific independent variables included interval-level measures of perceived benefits of use of HPDs, perceived barriers to action, self-efficacy in use of HPDs, and perceived situational factors influencing use of HPDs. Farmers' perceived interpersonal influences on HPD use were also measured; these included three subscales: Farmers' Perceived Interpersonal Norms of HPD Use, Farmers' Perceived Interpersonal Modeling of HPD Use, and Farmers' Perceived Interpersonal Support for HPD Use. Demographic factors included age, gender, and race. The dependent variable was use of hearing protection devices when in high noise areas, measured by self-reported percent of time of use while in high noise work areas (e.g., barn, field, grain handling system, and shop).

### **Data Analysis**

Data analyses of the combined data sets included descriptive statistics, logistic regression, comparisons of means and medians, and chi-square analysis. The combined data sets from parent studies were tested for collinearity and reliability. Data sets were analyzed with SPSS software, Version 17.1 (SPSS Inc., Chicago, IL). Each parent study, and the combined data sets, were tested for significant differences in predictors of HPD

use between genders. The results of this study are expected to strengthen the development of interventions to increase the use of HPDs among men and women farmers.

### **Summary**

To examine the state of the science of interventions to promote the use of HPDs among farmers three papers comprise this dissertation. Chapter II is a comprehensive review and comparison of application of theory concepts implemented in interventions to increase farmers' use of HPDs. Chapter III is a literature review and analysis of self-report as an outcome measure. Chapter IV is a statistical analysis of gender-related differences in predictors of HPD use among farm operators. The findings from this study will inform the body of knowledge related to interventions to promote HPD use in the farming community.

## **CHAPTER II**

### **COMPARISON OF THEORY CONCEPTS GUIDING INTERVENTIONS DESIGNED TO PROMOTE THE USE OF HEARING PROTECTORS AMONG FARM OPERATORS**

A small number of studies, guided by various theories, have tested interventions to increase hearing protector device (HPD) use among farmers. While there are certainly some similarities among the theory concepts, there are differences as well. Because intervention research to promote HPD use among farmers is still developing, an examination and critical assessment of theory application will be helpful for informing and designing future interventions, and may provide new insights into methods of increasing HPD use among farmers (Rogers, 1989). This report sought to (a) compare guiding theories and theory concepts in farmers' HPD use intervention research, (b) examine how the interventionists applied theory, and (c) identify which concepts are associated with significant positive outcomes based on reported results. The purpose of this paper was to examine and compare application of theories and concepts in farmers' HPD use interventions, and to identify parallel meanings among the collective studies.

#### **Noise and Hearing Loss**

Noise induced hearing loss (NIHL) occurs when the delicate sensory nerve hair cells in the cochlea of the ear sustain damage, usually attributed to prolonged exposure to high noise levels. Cell and ultimately nerve damage is dependent on the duration and loudness of the noise exposure as well as other risk factors such as individual

susceptibility, age, preexisting ear disease, and orientation of the ear in relation to the noise source (Occupational Safety and Health Administration [OSHA], 1999). Initially, high noise exposure results in a temporary change in hearing ability (temporary threshold shift) that resolves within minutes to hours after removal from the exposure. If this cycle is repeated over time, the change in hearing ability becomes permanent, progressive, and irreversible (Better Hearing Institute [BHI], 2011; National Institute on Deafness and other Communication Disorders [NIDCD], 2011).

Several terms were used throughout this paper in reference to the population of study. Farm operator refers to the individual responsible for the day-to-day operation of the farm and may be involved in farm work. The term farmer was used to refer to an individual who performs farm work, this individual may or may not be a farm operator. Farm family refers to all members of a family, adults and children, who live and work on a farm. Lastly, the term, farming community refers to the collective terms as described above.

Farmers are exposed to high noise levels daily in their work. Noise measurements associated with common farm tasks range from 77 decibels (dB) to 140 dB (Beckett et al., 2000; Holt, Broste & Hansen, 1993; Jones & Oser, 1968; McBride, Firth & Herbison, 2003). Although farmers often do not recognize noise as a health hazard, even when provided with objective findings, farm noise exposure is the primary cause of sensorineural hearing loss among this population of workers (Broste, Hansen, Strand & Stueland, 1989; Ehlers et al., 1993; Meeker, Carruth & Holland, 2002; Reed, 2004; Reed, Westneat, Browning & Skarke, 1999; Reed & Claunch, 1998).

On family owned farms, children are often exposed to high noise while working along side parents or grandparents. Research provides evidence of NIHL among these young farmers (Broste, Hansen, Strand & Strueland, 1989; Kidd et al., 2003; Knobloch & Broste, 1998; Franklin, Challinor, Depczynki & Frager, 2002; Reed, 2004; Reed, Kidd, Westneat & Rayens, 2001). There is a need for interventions to provide farm operators with the tools they need to protect their own hearing health as well as the hearing health of other farm workers.

### **Prevention of NIHL**

NIHL is insidious, progressive, irreversible, and permanent. Yet, with appropriate use of hearing protection devices (HPDs), it is also 100% preventable (Centers for Disease Control and Prevention [CDC], 2008; Dobie, 1995). HPDs reduce the dose of noise by filtering sound as it travels through the ear canal. Appropriate use of HPDs means they are worn correctly (i.e., fitted and placed properly) 100% of the time when workers are exposed to loud noise (Royster et al., 1996). Even a 10% decrease in time of HPD use will negatively impact effectiveness (Arezes & Miguel, 2002). Interventions to increase and promote HPD use are important in the prevention of NIHL (American College of Occupational and Environmental Medicine [ACOEM], 2012; CDC, 2008; National Institute of Health [NIH], 2011).

### **Noise, Hearing Loss, and Quality of Life**

The gradual and progressive onset of NIHL can be a source of conflict or tension in familial and social settings (Arlinger, 2003; Hass-Slavin, 2005; Tambs, 2004). Since early NIHL commonly affects conversation frequencies, 500 Hertz (Hz) to 3,000 Hz,

misunderstandings and tensions can occur when the person with NIHL is perceived as not listening or paying attention, or the speaker is accused of mumbling or speaking too quietly. Difficulty with verbal communication, strain in personal relationships, increased risk for injury, and feelings of isolation and depression are some of the quality of life issues associated with loss of hearing (Carruth, Robert, Hurley, Currie, 2007; Dalton et al., 2003; Tambs, 2004; Wallhagen, Strawbridge, Cohen & Kaplan, 1997).

### **NIHL as a Priority Health Problem**

Many governmental and professional organizations consider the prevention of NIHL a priority. These include the U.S. Department of Health and Human Services, Healthy People 2020 (2010), the International Labor Organization/World Health Organization (ILO/WHO, 2003), and the Centers for Disease Control and Prevention (2008). The National Institute for Occupational Safety and Health (NIOSH, 2009) estimates more than 30 million workers are exposed to high noise levels resulting in hearing loss. The National Institute on Deafness and other Communication Disorders (NIDCD, 2011) and the American College of Occupational and Environmental Medicine (ACOEM, 2012), also consider NIHL to be a significant research area.

### **Hearing Conservation Legislation**

The Occupational Safety and Health Administration (OSHA) mandates employers with 11 or more non-family member employees to identify risks and provide protection for workers exposed to loud noise (1999). These employers are required to institute a hearing conservation program when noise exposures are above 85 decibels for an 8-hour time weighted average. The OSHA standard, 29 CFR 1910.25, was promulgated to

protect exposed workers from NIHL. The standard includes noise level monitoring, employee and supervisor training on use of HPDs, yearly noise-induced hearing loss education, HPD use, audiometric examinations, available supply of HPDs, and medical follow-up of standard threshold shifts in employees exposed to high noise levels as defined by the standard. However, another standard, OSHA 40 CFR, Part 1928, exempts the agriculture industry, which includes the farming community, from the occupational noise exposure standard.

### **Treatment of NIHL**

Noise induced hearing loss is irreversible. The current treatment for NIHL is a hearing assistive device or hearing aid. Hearing assistive devices work by amplifying sound before it reaches the inner ear. If damage to the inner ear is so severe that nerve cells cannot respond to the amplified sound, the device will not improve hearing ability. Assistive devices are expensive, often not covered by health insurance plans, and many people feel embarrassed or self-conscious wearing the device. There is also some difficulty in physically wearing hearing aids, so many people who have them, don't use them (Wallhagen, Pettingill & Whiteside, 2006). In a survey of 3,174 hearing aid owners (Kochkin, 2010), researchers found that 29.7% of owners were either dissatisfied with their hearing aid or leave their hearing aid in a drawer (i.e., do not use it). Primary prevention of NIHL is highly preferred over treatment for the condition.

## **Methods**

### **Selection of Studies for Analysis**

To identify interventional research for the promotion of HPD use among farmers, four computerized databases were searched: CINAHL, PSYCINFO, PubMed, and Google Scholar. Additionally, articles were selected using an ancestry approach. The following key words or search terms were used: hearing protection device use, ear muffs, ear plugs, intervention, hearing loss prevention, farmers, and farm operators. For inclusion in this analysis, the report must (a) describe a research intervention conducted among farmers to promote HPD use, (b) included HPD use as a dependent variable, (c) be written in English, and (d) identify a theory or identifiable theory constructs. Studies were not restricted by dates and there were no specific exclusion criteria.

### **Selected Studies**

A total of seven reports representing five interventions met the selection criteria (Table II.1). There were a total of 1,891 adolescents and 266 adults in the combined studies. Within these seven reports, six theories appeared, in whole or in part.

### **Analysis**

Each report was examined for operationalization of theory concepts cited by the authors and listed the concepts according to theoretical term and its conceptual definition. Some definitions were ambiguous, but each of the definitions provided in this paper were either derived from content in the article, or traced back to the theorist's definition.

**Table II.1**

## Studies Aimed at Promoting Hearing Protector Use Among Farmers

Author, Date	<i>N</i>	Design	Theory*	Intervention Methods
Gates, 2007	25	Quasi experimental, two-group comparison	HPM, TTM, PP	Noise assessments with information on results, HPDs, family inclusion
Jenkins, 2006	209	One-group post-test	PP, HBM, SCT	Audiometric screening, modeling, support
Kidd, 2003; Reed, 2001, 2004	1,138	Two-group quasi experimental	TTM	Role play, cues, classroom, hands-on
Knobloch, 1998	753	Two-group quasi experimental	HBM, TSE	Classroom instruction, demonstrations
McCullagh, 2010	32	One-group, pre- posttest	HPM	Mailed HPDs with manufacture's instructions for use

\* HBM- health belief model; TTM- transtheoretical model of change; PP- PRECEDE-PROCEED; HPM- health promotion model; SCT- social cognitive theory; TSE- theory of self-efficacy

Common or similar definitions across studies were grouped together to identify and eliminate duplication. For example, several theories named self-efficacy as a concept, so it was counted as one concept. Perceived susceptibility and threat to health were listed as two concepts, but conveyed similar operational definitions, so were grouped into one concept. Environmental reevaluation, which is the realization of how one's unhealthy behaviors affect another, was counted as one concept since the meaning was not shared by any other concept.

This process continued with each concept until groupings of all concepts were accomplished. After eliminating duplicate or very similar meanings and grouping into concepts, 11 distinct concept groups were identified among the six theories (Table II.2)

## **Results**

### **Summary of Intervention Studies**

#### **Interventions to Increase HPD Use Among Farm Youth**

Knobloch & Broste (1998) conducted an education-based, pre and posttest intervention with 753 students over a four-year period, aimed at increasing HPD use. Guided by the health belief model and theory of self-efficacy, the researchers implemented a hearing conservation program similar to those in general industry. The program included educational components, hearing tests, availability of HPDs, and noise assessments. Researchers measured use and intention to use HPDs at various times during the intervention.

Kidd and colleagues (Kidd et al., 2003; Reed & Kidd, 2004; Reed et al., 2001) conducted a two-group crossover, pre-post test design study in a school-based

intervention involving 1,138 agricultural students and 21 schools. Guided by the transtheoretical model of change, the aim was to determine if an intervention could move an adolescent from the stage of contemplating a safety behavior, to acting on that behavior. Students participated in interactive simulations and exercises focused on prevention of disabilities from accidents and exposures related to work behaviors.

### **Interventions to Increase HPD Use Among Adult Farmers**

Guided by components of the health belief model, Pender's health promotion model, and social learning theory, Gates and Jones (2007) designed a quasi-experimental intervention that included an intervention group ( $n = 8$ ) and a comparison group ( $n = 17$ ). Researchers used education about hearing loss and hearing loss prevention, noise assessments, a supply of HPDs, and instructions on HPD use to increase HPD use among the farmers. One booster encouraging HPD use, and the prevention of noise induced hearing loss was mailed to participants approximately half way through the three-month program. The booster was described by the authors as "a colorful brochure" and served as a reminder to use HPDs. The mailing also allowed the participants to request additional HPDs if needed.

Incorporating components of the health belief model, social cognitive theory, and PRECEDE-PROCEED model, Jenkins and colleagues (2007) designed a one-group post-test intervention to reduce respiratory and hearing exposures. The hearing aspect of the intervention included 209 farmers or farm family members. Researchers conducted audiometric tests and provided educational information about noise exposure, hearing loss, and HPD use with the participants. Participants were asked to commit to using HPDs for three weeks.

Guided by Pender's health promotion model, McCullagh (2010) tested the feasibility of using a mailed intervention to increase HPD use among farmers ( $N=32$ ). In this one-group pre- and post-test design study, farmers were first contacted by telephone and asked to participate. Those who agreed were asked to use, and provided with, various types of HPDs, along with manufacturers' instructions for use. Approximately two to three months following the mailing, the researcher measured HPD use by self-report and associated attitudes and beliefs (McCullagh, 2002).

### **Theoretical Foundations Guiding the HPD Use Intervention Studies**

The following theories were used exclusively or in combination in the selected interventions: (a) health belief model (HBM); (b) transtheoretical model of change (TMC); (c) Pender's health promotion model (HPM); (d) PRECEDE-PROCEED; (e) social cognitive theory (SCT), and (f) theory of self-efficacy (TSE). Each of the theories and corresponding concepts are illustrated in Figure 2-1. A brief description of each of the theories and operational definitions follows.

***The health belief model.*** The HBM was used in the studies by Knobloch (1998) and Jenkins (2007). Developed to explain why people do or do not engage in health-related behavior at the individual decision-making level, it serves as a model for explaining and predicting a person's use of health care recommendations. This model predicts the likelihood of an individual to perform a certain action or adopt a certain behavior to avoid acquiring an illness, or return to their prior state of wellness (Rosenstock, 1966).

Derived from psychological and behavioral theories, two core variables are identified: (a) the value an individual places on a goal, and (b) the individual's belief that

a particular action will result in achieving that goal. In the health care setting, the variables are modified to reflect (a) the desire to avoid illness or get well and, (b) the belief that a certain behavior or action will result in avoidance of disease or a return to wellness.

The HBM consists of four dimensions and a stimulus; something to activate the decision-making process of the individual. The dimensions are described briefly below (Janz & Becker, 1984; Rosenstock, 1966; Rosenstock, Strecher & Becker, 1988).

*Perceived susceptibility* is an individual's belief in their own vulnerability to some threat to their health, or that they are at risk of actually acquiring a certain condition.

*Perceived severity* is the individual's personal assessment of the seriousness of acquiring a condition and includes physical and social consequences (i.e., disability, pain, death, loss of work, effect on relationships).

*Perceived benefits* refer to the individual's assessment of the positive results of adopting or implementing a certain health behavior.

*Perceived barriers* are the individual's assessment of the influences that interfere with or discourage adoption or implementation of a certain health behavior.

*Cues to action* are internal or external influences prompting the performance of a certain health behavior. Internal cues might be symptoms or personal experiences, whereas external cues include any communication received from a source other than within.

Mediating factors and components from the theory of self-efficacy were added to the model as it was developed (Rosenstock, Strecher & Becker, 1988). Mediating factors

include demographic information, social and psychological factors, perceived self-efficacy or self-control, personal health motivation, and perceived threat of not taking an action.

***Transtheoretical Model of Change.*** In the design of interventions, Reed et al. (2001), Reed (2004), Kidd et al. (2003) and Jenkins et al. (2007) included components of the transtheoretical model of change (TTM). Developed by Prochaska (1979), the theory was designed to facilitate moving an individual through a process of change to bring about a desired health behavior. The TTM identifies four main constructs: (a) stages of change, (b) processes of change, (c) decisional balance, and (d) self-efficacy. There are six stages within the change process an individual goes through to reach the end of the process, which is the new desired behavior as a way of life (Prochaska & DiClemente, 1982). A brief description of concepts follows (Prochaska, Norcross & DiClemente, 1994).

*Precontemplation* is the least change-ready stage. The individual might not even recognize there is a behavior that needs to be adopted or changed.

*Contemplation* is identified in an individual who is intending to begin some sort of change in behavior or adopt a health practice.

*Preparation* is when an individual may have already taken some small steps toward a behavior change in an attempt to get ready for the change.

*Action* is recognized when an individual has made the behavior change and is seeking ways to maintain commitment to the change.

*Maintenance* is the stage in which the behavior change has been implemented for at least 6 months.

*Termination* is the final stage of change. When a person has adopted or ceased a particular behavior and experiences no temptation to return to the former behavior, the termination stage has been reached. Termination stage is not required for an individual to achieve a behavior change.

The theory posits there are ten processes (concepts) involved in the stages of change (Prochaska, 1979). These processes progress along a continuum of change:

*Consciousness raising* is the process of acquiring more knowledge about a particular issue in order to make an informed decision in response to the issue

*Environmental reevaluation* is the mental process of changing an individual's response to a particular issue without changing the rewards or consequences involved.

*Dramatic relief* is the process of releasing pent up emotions resulting in a greater sense of well-being.

*Self-reevaluation* involves cognitive and affective assessments of a person's self-image as it relates to a particular health behavior.

*Helping relationships* consist of others with whom an individual has a caring, open, trusted and accepting relationship, and who support the desired health behavior.

*Social liberation* happens when changes in the environment make new options available to individuals in that environment.

*Self-liberation* occurs when a person realizes they have new alternatives for choosing a particular behavior or response.

*Counter conditioning* is defined as an individual changing their response to a particular stimulus.

*Contingency management* is the process of controlling rewards or consequences of a particular behavior.

*Stimulus control* happens when an individual makes changes in their environment to support new alternatives.

A core concept of the TTM, decisional balance, is an active process throughout the continuum; a mental activity of weighing the pros and cons of ceasing or adopting a behavior. As a person moves toward termination, the pros for the change increase and the cons decrease. Both internal and environmental conditions are involved in the TTM.

The final concept of the TTM is self-efficacy, an individual's perceived ability to perform or abstain from a certain behavior in specific situations. Self-efficacy scores are used to predict lasting change in an individual's health behavior.

***Pender's health promotion model.*** Pender first introduced the HPM in 1987. Three major components form the basis for the HPM: (a) cognitive/perceptual or psychological elements that determine health-promoting behaviors, (b) modifying circumstances that influence cognitive/perceptual factors and so indirectly influence health-promoting behaviors, and (c) the likelihood of action leading to enhancing or maintaining well-being. Pender, Murdaugh and Parsons (2002) identified the concepts described below as being most significant in their review of studies using the HPM.

*Cognitive/perceptual factors* include importance, definition, and perception of health, self-efficacy, health status, benefits, and barriers to health-promoting behavior.

*Modifying factors* include demographic and biological characteristics, interpersonal influences, and situational factors.

*Perceived benefits of action* are the anticipated positive outcomes resulting from the behavior.

*Perceived barriers to action* include real or imagined interferences with adopting a health promoting behavior.

*Interpersonal influences* are the behaviors, beliefs or attitudes of important others and include social support, norms, and modeling. The important others who influence are usually family, friends and peers.

*Situational influences* include an individual's perception of the environment or the context of a given situation that could facilitate or hinder a behavior.

Originally, the model was intended to explain the occurrence of behaviors aimed at increasing well-being. The model has been revised and applied to research focusing on HPD use among construction workers (Lusk et al., 1999), operating engineers (Lusk, Ronis & Hogan, 1997), and factory workers (Lusk, Ronis, Kerr & Atwood, 1994). A model based on the HPM has also been useful in predicting HPD use among farmers (McCullagh, Lusk & Ronis, 2002; McCullagh, 2010).

***PRECEDE-PROCEED.*** PRECEDE-PROCEED is a comprehensive framework for assessing health and quality of life needs, and designing, implementing, and evaluating health promotion programs (Greene & Kreuter, 1999). The theory behind the framework is that both individual and environmental factors influence health behavior. The acronym PRECEDE represents predisposing, reinforcing and enabling concepts in educational diagnosis and evaluation at the individual level. There is an emphasis on identifying educational deficits (diagnoses) and developing methods to change environmental and social influences on health behaviors in populations.

*Predisposing* factors include self-efficacy, knowledge, attitudes, personal preferences, beliefs, and skills with regard to a desired change in behavior.

*Reinforcing* factors reward or support the desired behavior change and include social support, financial rewards, and changes in social norms.

*Enabling* encompasses the skills or physical agents such as availability and accessibility of means to facilitate behavior change.

PROCEED was added to the original framework in recognition of ecological and environmental influences on health behavior. This acronym represents policy, regulatory, and organizational concepts in educational and environmental development.

The PRECEDE-PROCEED theory consists of eight phases: four planning phases, one implementation phase and three evaluation phases.

*Phase 1* is the identification of the social problem(s) in a given population that have a negative impact on quality of life.

*Phase 2* consists of development of epidemiological, behavioral and environmental diagnoses. Determination of specific health issues in a community, identification of health-related behaviors, and environmental factors that contribute to the issue are identified during this phase. This is the phase in which goals and objectives are established, and an intervention plan is developed.

*Phase 3* is when the predisposing, enabling, and reinforcing factors are selected based on the likelihood of the factors, if modified, to change and maintain health behaviors.

*Phase 4* involves organizational and/or administrative concerns of a community intervention. It is an evaluation of existing structures and resources that could either interfere with or promote the development of a health intervention.

*Phase 5* is the implementation of the intervention.

*Phase 6* is the process evaluation phase in which a determination of how well the process is adhering to planned protocol is assessed.

*Phase 7* is the impact evaluation phase in which measuring the preliminary effectiveness of the intervention with consideration of changes in predisposing, enabling, and reinforcing factors occurs.

*Phase 8*, the final phase of the process, is when the overall outcomes are evaluated and a determination is made whether the intervention had an effect on the community's quality of life.

***Social cognitive theory.*** Social cognitive theory is a learning theory based on the premise that people learn behaviors by observing others with whom they have a connection. Environmental, social, and cognitive factors are considered in this theory.

*Vicarious learning* is the essence of social cognitive theory. Simply stated, it is the process of learning a new behavior by watching another person perform that behavior. According to Bandura, it is also one of the four main ways self-efficacy is attained.

*Identification* with the individual demonstrating the desired behavior is an important aspect of the social cognitive theory. The greater the connection or identification between the observer and modeler, the more likely a change in behavior will occur.

*Self-efficacy* is the core component within social cognitive theory and has been a concept in all other theories described in this paper. However, the concept of self-efficacy has also been used independently. HPD use interventions have included self-efficacy as a theory in intervention implementation. For purposes of this paper, it will be explained as an independent theory.

***Theory of self-efficacy.*** Although self-efficacy is a major concept in Bandura's social cognitive theory (Bandura, 1977), Bandura himself refers to it as a theory (Bandura, 1982). Simply stated, self-efficacy is the belief in one's own competence to perform in a certain way to attain a certain goal or set of goals. In theory, if an individual has confidence or belief in their ability to perform in a certain way, they are more likely to carry out the behavior. The greater the self-efficacy of a behavior, the more likely will be performance of the behavior and goal attainment. According to Bandura, there are four ways to increase self-efficacy.

*Vicarious learning* described above, is also referred to as social modeling.

*Mastery experience* occurs when incremental successes toward achieving a desired behavior are accomplished.

*Improving physical and emotional states* requires the interventionist to ensure a rested and/or relaxed state before attempting to implement a behavior change.

*Verbal persuasion* provides encouragement to a person attempting a behavior change.

## **Shared Concepts**

Several concepts with similar meanings were shared by each of the theories (Table II.2). Self-efficacy was the only concept found in all six theories. Pender's health

promotion model, PRECEDE-PROCEED, social cognitive theory, and theory of self-efficacy all had some form of social support and modeling present. Susceptibility was described in the health belief model, transtheoretical model of change, Pender's health promotion model and PRECEED-PROCEDE. Social support was identified in the transtheoretical model of change, Pender's health promotion model and PRECEDE-PROCEED. The health belief model, transtheoretical model of change, and Pender's health promotion model all addressed benefits and barriers. Only two models shared cues to action: the health belief model and theory of self-efficacy. The transtheoretical model of change and Pender's health promotion model identified helping relationships in some form, and the transtheoretical model of change and theory of self-efficacy shared some kind of verbal reinforcement concept.

The transtheoretical model of change and Pender's health promotion model share seven similar concepts: susceptibility, benefits, barriers, self-efficacy, social support, increased awareness, and helping or supporting relationships. Pender's health promotion model and the health belief model share four concepts: susceptibility, benefits, barriers, and self-efficacy.

Cues or boosters were used in several studies (Gates & Jones, 2007, Kidd et al., 2003; Knobloch & Borste, 1998). Cues and boosters were important in the school-based interventions (Kidd et al., 2003 & Knobloch and Broste, 1998). They served as reminders of the importance of HPD use, reinforced the advantages of HPD use, and provided encouragement to take action. Knobloch & Broste (1998) reported 77% of the students thought the mailings were influential in their decision to use HPD. The effect of the booster used by Gates and Jones (2007), a mailed, colorful brochure, is not clear.

**Table II.2**

Grouping of Common Concepts in Farmer's HPD Use Intervention Theories

Construct	HBM	TTM	PP	HPM	SCT	TSE
Susceptibility*	X	X	X	X		
Threat						
Severity*	X					
Benefits	X	X		X		
Decisional balance						
Rewards						
Barriers*	X	X		X		
Decisional balance						
Situational influences*	X	X		X		
Cues*						
Physical agents to facilitate change						

**Table II.2 (continued)**

Concept	HBM	TTM	PP	HPM	SCT	TSE
Social support*	X	X		X	X	X
Helping relationships*						
Interpersonal influences*						
Identification*						
Stimulus control						
Verbal persuasion						
Vicarious learning						
Reinforcement*						
Sense of well-being						
Environmental reevaluation*						
Psychological factors	X			X		
Attitudes						
Self-efficacy*	X	X	X	X	X	X
Self control						
Counter conditioning*						
Belief in one's skill for behavior						
Mastery experience						
Self-liberation						

Note. Concepts with \* were operationalized in interventions that demonstrated statistically significant increase in HPD use.

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**Table II.2 (continued)**

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Concept	HBM	TTM	PP	HPM	SCT	TSE
Self-revaluation		X				
Preferences				X		

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Note. Concepts with \* were operationalized in interventions that demonstrated statistically significant increase in HPD use.

## Operationalization of Concepts

The health belief model (HBM), with components from the theory of self-efficacy, was identified as the theoretical foundation of a school-based educational intervention with agricultural students (Knobloch & Broste, 1998). The educational intervention focused heavily on the HBM concepts of perceived susceptibility with video presentations by young people with farm work-related injuries and music demonstrations with sounds missing at certain levels. In keeping with the HBM, the researchers inundated students with cues to action every six weeks during the first two years of the program. Cues to action included yearly audiometric testing, newsletters, educational mail outs, classroom posters, parent and teacher influence, and noise level assessments.

Self-efficacy was implemented with guided instruction on use, practice, verbal encouragement, and a free supply of HPDs mailed to students' homes throughout the program. The authors did not directly state how the concept of perceived severity was implemented, nor is it clear how the researchers integrated perceived benefits and barriers in the intervention. Results reported post-intervention indicate an increase in HPD use for several different categories. Of those students who operated lawn tractors or mowers percent of participants wearing HPDs at least some of the time increased 47% ( $p = .04$ ), odds were 95% ( $p = .03$ ) higher for those who operated farm tractors and overall, increased 74% ( $p = .02$ ) for boys.

Kidd et al. (2003) reported on an educational intervention to increase safety behaviors, including use of HPDs, based on the TTM with agricultural students in 9<sup>th</sup> and 10<sup>th</sup> grades. The authors state the purpose of the quasi-experimental, cross-over design

intervention was not to test the TTM, but to see if an intervention could move an adolescent from the stage of contemplation to action with regard to safety behavior, including use of HPDs (Kidd, Reed, Weaver, Westneat & Rayens, 2003; Reed & Kidd, 2004; Reed, Kidd, Westneat & Rayens, 2001).

Concepts of susceptibility, consciousness raising, dramatic relief, helping relationships, counter conditioning, reinforcement management, and environmental reevaluation can be recognized by the researchers' use of narratives, peer involvement, physical simulations, and role-playing with the students. It could not be extracted from the articles how, or if, the researchers addressed the remaining concepts in the theory of social liberation, self-reevaluation, self-liberation, or stimulus control. Those who completed a minimum of two instructional units showed a positive, significant change in both attitude toward safety and taking action to prevent injuries. Changes in scores measuring students' attitude about susceptibility of acquiring a disability ( $p = .0005$ ) and ability to prevent an injury ( $p = .03$ ) were significant. Changes in scores of moving from the stage of contemplation to action were also significant in the intervention group compared to the control group ( $p = .0001$ ). Observations of a small number of the students ( $n = 29$ ) almost a year after the intervention confirmed students made at least one positive change in their safety behavior.

Gates and Jones (2007) used five concepts from three different theories to test the effectiveness of an intervention to increase farmers' use of HPDs when exposed to loud noise. Knowledge (HPM, PRECEDE-PROCEED), susceptibility and severity (HBM, TTM and HPM), barriers (HBM, HPM), and interpersonal support (TTM, PRECEDE-PROCEED, HPM) were the concepts used to guide intervention design. The concepts of

knowledge, susceptibility, and severity were employed by sharing results of noise exposure assessments with farmers in their homes and at organizational meetings. A video presentation demonstrating hearing loss and shared personal experiences by individuals with hearing loss served as an educational component.

The researchers attempted to overcome potential barriers such as cost and storage by placing HPDs in high noise areas. Bringing the farm families together for the educational sessions and asking family members to encourage HPD use provided interpersonal support. Reminder letters (cues) were also used in the intervention. The mean frequency of HPD use two months following the intervention increased significantly ( $p = .04$ ), but a statistically significant change in use was not demonstrated in the three-month follow-up measurements. One scale item from the transtheoretical model of change (“hearing loss would cause serious stress on my family”) was significantly correlated ( $r = .41$ ;  $p = < .05$ ) with frequency of HPD use. No other concepts were reported as statistically significant in HPD use.

Jenkins et al. (2007) designed an intervention using components from three different theories. The intervention involved audiometric screening, education, and hands-on learning. Perceived susceptibility (HBM) was incorporated into the intervention through audiometric screenings.

Identification with the modeler and self-efficacy (social cognitive theory) were operationalized by having an educator teach the participant how to use HPDs. Family members joined in the activities, operationalizing social support and reinforcing factors of the PRECEDE-PROCEED theory. Self-reported HPD use was reported as either “poor” (sometimes, rarely, never) or “good” (often or always). The authors reported

25.2% increased HPD use post-intervention (95% CI [17.2-33.2]). Only overall results were reported, without consideration to specific concepts.

In McCullagh and colleagues' (2010) one-group pre- and post-test design pilot intervention study among Midwest farmers exposed to loud noise ( $N = 27$ ), a supply of various types of HPDs (i.e. semi-aural caps, ear plugs) was mailed to each of the participants, who were asked to use the HPDs while completing farm tasks. The purpose of the study was two-fold, (a) to test study procedures and, (b) compare HPD use before and after the intervention. Pre- and post-test interviews conducted by telephone included demographic questions and the Farmer's Use of Hearing Protection Scale, (McCullagh, et al., 2002), which integrated the concepts in Pender's HPM to examine barriers to HPD use, benefits of HPD use, self efficacy, situational influences, interpersonal influences (modeling, norms and support), age, and gender. By mail, the researcher provided farmers with various types of HPDs and manufacturer's instructions for use. Post-tests two to three months following the intervention demonstrated a 44% ( $p = < 0.001$ ) increase in reported HPD use.

## **Summary**

Studies providing various types of HPDs to the participants were effective in influencing intention to use HPDs as well as increasing HPD use immediately following the interventions. HPD use among youth increased following each of the school-based studies (Kidd et al., 2003; Knobloch & Broste, 1998; Reed & Kidd, 2004; Reed et al., 2001). Subsequent to both school-based studies, a positive effect on use of HPDs was reported among the students' parents (Knobloch, 1999) and other farm workers (Reed & Kidd, 2004). Although interventions demonstrated positive results among adolescents,

prior research has demonstrated that education, awareness, and perception of risk are not enough to influence behavior changes in adult farmers (Murphy, Kiernan, & Chapman, 1996).

Each of the interventions resulted in increasing HPD use immediately following the intervention, regardless of its theoretical foundation. Eight similar concepts were applied in these interventions: (a) susceptibility, (b) threat, (c) benefits, (d) barriers, (e) situational influences, (f) social support, (g) self-efficacy, (h) knowledge.

## **Discussion**

Theory provides the structure for building practice-based interventions and forms the basis for testing for evidence of effectiveness. Theoretical frameworks implemented in HPD use intervention studies among farmers and farm operators include concepts from diverse models: the health belief model, transtheoretical model of change, Pender's health promotion model, PRECEDE-PROCEED, social cognitive theory, and theory of self-efficacy. Although terminology varied between the theories, many concept meanings conveyed similar ideas. The eight concepts identified in this study were operationalized in interventions resulting in increased HPD use among the farming community. Among the concepts, some form of social support was operationalized in five of the six theories and in each of the interventions. So, although ten different terms were used to convey social support, the concept appears to be a strong factor in HPD use interventions among the farming community. Likewise, the concept of self-efficacy was referred to six different ways (e.g., mastery experience, belief in one's skill for behavior, etc.) and in each of the theories and interventions. Environmental factors were also important (e.g., situational influences, barriers, cues, physical agents to facilitate change).

Initiatives to provide farm operators with practical ways to make HPDs accessible in their work environment would be expected to increase HPD use. Use of these concepts in interventions is supported by earlier predictor research to promote HPD use among factory workers (Lusk, Ronis, Kerr & Atwood, 1994), industrial workers (Melamed et al., 1996), and among farmers (Berg et al., 2009; McCullagh, Lusk & Ronis, 2002; McCullagh, Ronis & Lusk, 2010). Ensuring competency in HPD use and accessibility to HPDs are important components in hearing conservation programs in regulated settings and have demonstrated positive results in intervention research among the farming community as well.

Several concepts in this study concerned perception of threat or severity of NIHL and resulting hearing loss. Earlier research has shown that low scores on perceived threat or severity of HIHL are associated with low scores on HPD use (Carruth, Robert, Hurley, & Currie, 2007). Although some farmers do use hearing protection, many do not. Attitude (e.g., perceived susceptibility, threat, value) toward noise exposure and NIHL has been shown to be a factor in use of HPD (Carruth et al., 2007; McCullagh & Robertson, 2009) but not consistently (McCullagh et al., 2002, 2010). The effect of these theoretical concepts toward noise exposure and NIHL is not fully understood among farmers. Further study is indicated to understand how the theoretical concepts of susceptibility, threat, benefits, barriers, situational influences, social support, self-efficacy, and knowledge influence farmers' use of HPD.

### **Limitations**

Although every effort was made to identify all studies meeting inclusion criteria, some studies could have been inadvertently omitted from the review. Quality of study

design was not a determinant for inclusion in this paper. A meta-analysis was not feasible in this paper due to heterogeneity of study designs.

### **Implications for Future Research**

This study demonstrates several diverse theory-based interventions yielded positive results immediately following HPD use interventions, even with abridged use of theory. Social factors were operationalized in several of the interventions to varying degrees and are an important consideration in the design of future interventions. Although knowledge is not sufficient to increase HPD use, knowledge and empowerment, by increasing participants' self-efficacy and environmental control have implications for utility in future intervention design. Utilizing theory concepts of susceptibility, threat, benefits, barriers, situational influences, social support, self-efficacy and knowledge may strengthen future studies. These concepts were common to each of the interventions having a statistically significant effect on farmers' increased use of HPDs and are most closely aligned with the health belief model and Pender's health promotion model.

### **CHAPTER III**

#### **RELIABILITY OF SELF-REPORT IN HEALTH PROTECTIVE BEHAVIOR RESEARCH AMONG FARMERS**

Studies of health behavior focus on a variety of behaviors affecting health, such as a, b, and c. Generally, there are three categories of methods of measuring health behavior: biochemical, observation, and self-report. Self-report is the method of data collection in interventional research on farm operators' use of hearing protection devices. Memory, lack of motivation, and bias may affect reliability of use of hearing protection and other self-reported measures.

Yet, there are practical reasons to use self-report, and some will argue that self-reporting is a reliable method of data collection. Since self-report is prevalent in health behavior intervention research, it is important to understand the current state of the science with regard to reliability of self-reported versus other methods of data collection, as well as strengths and limitations of self-reporting methods.

Self-report is a common method of measurement in health protective behavior research (Gates & Jones, 2007; Jenkins, Stack, Earle-Richardson, Scofield & May, 2007; Kidd, Reed, Weaver, Westneat & Rayens, 2003; Knobloch, 1999; Knobloch & Broste, 1998; McCullagh et al., 2010; Reed & Kidd, 2004; Reed, Kidd, Westneat & Rayens, 2001). Health protective behavior is defined in this study as actions taken to minimize risk of a health hazard, such as use of hearing protection devices, use of protective eye wear, and use of skin protection such as clothing or sunscreen. Cognitive psychologists

warn that human memory is unreliable and subject to error due to such things as inaccuracy of recall, inattention to detail, memory blocking, misattribution of information, perceived expectations of self or others, and persistence (Schacter, 1999). If indicators are not reliable, they are not useful.

On the other hand, Chan (2009) argues that self-reporting may be a reliable method in the advancement of research, especially in field studies or naturalistic settings, and should not be rejected as a method of data collection. It is unclear whether self-reporting is a reliable method of measurement of health protective behavior.

Further investigation was warranted to understand the current state of the science of self-report as a measure of health protective behaviors. The specific aim of this paper was to examine collective knowledge of agreement between self-reported measures and non-self reported measures in health protective behavior research, particularly as it applies to studies of hearing protection device (HPD) use among farm operators.

### **Benefits and Limitations of Self-Report versus Observation**

There are pros and cons to the use of self-report in health protective behavior studies. Likewise, an argument can be made in favor, or against, the use of the alternative, skilled observation, as a method of data collection.

Self-reported data collection offers the advantages of generally greater speed and less cost than observation by trained observers. In addition, self-report methods eliminate logistic challenges associated with observation by trained observers in some settings.

Arguments against self-report include risk of errors due to reliance on memory, reporters' possible lack of motivation, and inattention to detail. Any of these conditions could present a threat to reliability of self-reported measures.

Skilled observation on the other hand, may be touted as a superior indicator of behavior in that it may be more objective and more accurate. Also, when observations are concurrent with performance of the targeted behavior, recall bias is eliminated.

Yet, observation is not always practical or feasible. Some behaviors, environments, or populations are not easily observed. For example, it may not be feasible to observe certain health protective behaviors of construction workers operating heavy equipment, farm operators at expansive work locations, or electrical workers at high elevations. Also, the presence of an observer may affect participant behavior, presenting a threat of social desirability bias. While proxy observation by parents, guardians, or co-workers are alternatives to self-report, these methods could present error through lack of accuracy, or by misunderstanding the behavior under study.

Walz, Strickland, and Lenz (2005) point out several types of errors that could affect reliability of observation, especially if proxy or multiple raters are reporting. These include error of standards, halo/horn effect, logic error, similarity error, and the error of central tendency. A review of the literature examining concordance of self-report and non self-report data collection methods provides a better understanding of the reliability of self-reporting in health behavior research with a focus on utilization among farm workers.

## **Methods**

Although there is limited concordance research to explore the level of agreement between self-report and non self-report data for health protective behaviors, several populations and settings have been investigated. The extant literature was searched for methodology studies reporting reliability, agreement, or concordance of self-reported

with non self-reported measures. The Web of Knowledge database was queried because it is a robust database capable of searching multiple databases simultaneously. The grey literature was also searched for concordance information on health protective behaviors. Grey literature is information generated from industry, government, business or academic resources that is not controlled by commercial publishing sources.

Search terms included: concordance or agreement and self-report and observation, or validation, and personal protective equipment use, or respirator use, or hearing protection use, or eyewear/eye protection use, or helmet use. Some behaviors were excluded, such as nurses in a hospital setting, in an effort to examine behaviors closely related to the work and environment of the farming community. An attempt was made to obtain the most recent literature by limiting to publications since 2001. However, only three articles were produced with this limitation; therefore, date of publication was subsequently excluded as a search criterion. The revised query identified 3,220 articles. Titles and abstracts were examined for inclusion criteria. The publication had to include: (a) one of the following specific health protective behaviors: use of head protection, hearing protection, vision protection, respiratory protection, or skin protection, and (b) an analysis of reliability, validity, concordance, or some other agreement measure between methods of measurement. Articles were excluded if they were conducted with nurses in a hospital setting, or not written in the English language. Titles and abstracts that failed to meet inclusion criteria were eliminated, resulting in nine articles deemed eligible for inclusion in the analysis (Table III.1).

## Results

Health protective behaviors in the self-report and other report concordance studies included hearing protection (Griffin, Neitzel, Daniell and Seixas, 2009; Lusk, Ronis, and Baer 1995; Melamed, Rabinowitz, Feiner, Weisberg & Ribak, 1996; Trabeau, Neitzel, Meischke, Daniell & Seixas, 2008), sun protection (Girgis, Sanson-Fisher, Tripodi & Golding, 1993; Girgis, Sanson-Fisher & Watson, 1994; Lower, Girgis & Sanson-Fisher, 1998; Oh et al., 2004), and eye protection (Eime, Finch, Owen & McCarty, 2005). Participants in the studies included construction workers (Griffin et al., 2009; Trabeau, Neitzel, Meischke, Daniell & Seixas, 2008), sheet metal and warehouse workers (Griffin et al., 2009); blue collar workers (Lusk et al., 1995; Melamed et al., 1996), students (Girgis et al, 1993; Lower et al., 1998), outdoor electrical workers (Girgis et al., 1994), letter carriers (Oh et al., 2004), and squash players (Eime et al., 2005)

**Table III.1**

Study, Participant Characteristics, and Concordance of Self-report with Observed Report of Health Protective Behaviors.

<b>Author (date)</b>	<b>Behavior</b>	<b>Sample</b>	<b>N</b>	<b>Concordance results</b>	<b>Self-report method</b>	<b>Alternate method</b>
Eime (2005)	Protective eyewear	Squash players	192	Self-report 9.4% time HPD use Observed 5.9% time of HPD use.	Questionnaire	Trained observers
Girgis (1993)	Sun protection	Children	108	Kappa 0.31- 0.70 agreement	Diary	Trained observers
Girgis (1994)	Sun protection	Outdoor electrical workers	65	Kappa 0.42 – 0.89 agreement	Diary	Observers

**Table III.1**

**(continued)**

<b>Author (date)</b>	<b>Behavior</b>	<b>Sample</b>	<b>N</b>	<b>Concordance results</b>	<b>Self-report method</b>	<b>Alternate method</b>
Griffin (2008)	HPD use	Sheet metal, construction, warehouse	58	Logistic regression probability of concordance 99.5% – 92.6% agreement	Activity card Questionnaire	Researcher observers
Lower (1998)	Sun protection	Adolescents	53	>75% agreement of self-report, sensitivity/ specificity; PPV/NPV	Diary Questionnaire	Parents/ Guardians

**Table III.1****(continued)**

<b>Author (date)</b>	<b>Behavior</b>	<b>Sample</b>	<b>N</b>	<b>Concordance results</b>	<b>Self-report method</b>	<b>Alternate method</b>
Lusk (1995)	Hearing protection	Blue collar workers	48	Pearson=0.89; Spearman=0.84; Kendall=.69;Self-report 7.9% higher than observed	Questionnaire	Researcher observers Supervisor report
Melamed (1996)	Hearing protection	Blue collar workers	70	Kappa 0.70 agreement	Questionnaire	Observers
Oh (2004)	Sun protection	Letter carriers	1,036	Kappa 0.51 – 0.83	Questionnaire	Researcher observers
Trabeau (2008)	HPD use	Construction workers	58	Kappa 0.12 – 0.60	Questionnaire	Observers

## Hearing Protective Behavior Studies

Griffin et al. (2009) studied predictors of accuracy of self-reported HPD use associated with variations in noise exposure conditions (steady, variable, and unpredictable). Warehouse workers (steady), sheet metal workers (variable), and construction workers (unpredictable) ( $N=58$ ) self-reported HPD use with two different measurement methods: (a) daily activity cards to record HPD use when in high noise areas and, (b) a paper questionnaire. Researcher observation validated information on the self-reported activity cards. Each worker also completed questionnaires at the end of their first and last shift of the two-week study. HPD use reporting concordance between activity cards and observation was highest at the fixed steady site (99.5%) and lowest at the fixed variable site (92.6%). Validation of activity card reporting at the construction site was not reported. Researchers found HPD use was more accurately reported on daily activity cards than questionnaires completed on day 1 at the fixed steady ( $OR = 3.9, p = 0.08$ ) and fixed variable sites ( $OR = 1.4, p = 0.6$ ) and two weeks after the study began at the fixed steady ( $OR = 2.3, p = 0.2$ ) and the fixed variable sites ( $OR = 0.9, p = 0.9$ ). Workers in the fixed steady noise site were nearly 20 times more likely to report HPD use concordantly with observation than workers at the construction site ( $OR = 19.42, p = 0.02$ ). Self-reported use of HPDs on questionnaires was higher than activity card reports for all three groups of workers.

Lusk et al. (1995) studied the correlation between three measurements of HPD use among blue collar workers ( $N=48$ ): (a) trained observer report, (b) supervisor report, and (c) self-report. Trained observers measured noise levels in the vicinity of workers while discretely recording worker use or nonuse of HPDs. Supervisor reports were

obtained by researchers asking the supervisors' impressions of their workers' HPD use during the previous week, month, and three months. Workers self-reported the percentage of time they used HPDs in the previous week, month, and three months on a written questionnaire.

In addition to Pearson's  $r$ , Lusk et al. (1995) computed Spearman's  $\rho$  and Kendall's  $\tau$ - $b$  to evaluate agreement of self-report, supervisor report and trained observer report of HPD use. Self-report highly correlated with trained observer report (.89,  $p < .001$ ; .84,  $p < .001$ ; .69,  $p < .001$ ). Supervisor report was poorly correlated with trained observer (.47,  $p < .001$ ; .42,  $p < .01$ ; .33,  $p < .01$ ) and self-report (.50,  $p < .001$ ; .49,  $p < .001$ ; .38,  $p < .001$ ). There were very highly correlated reports of use in the three recall time periods (one week, one month, and three months) for both self-report (.96 to .99) and supervisor report (.91 to .96). These high correlations lead to a question of whether the responders assumed consistent behavior over the time periods, or if they accurately recalled and reported actual occurrences of HPD use. Other studies have reported a negative association between accuracy of self-report and length of recall time period (Griffin et al., 2009, Trabeau et al., 2008).

A self-report validation component was part of a study by Melamed et al. (1996) on HPD use. Workers ( $N=70$ ) in a manufacturing plant completed surveys regarding frequency of HPD use. Researchers validated self-report by direct observations of HPD use in two randomly selected plants. Authors reported a perfect match between workers who self-reported as non-users of HPDs and those who were observed to be non-users of HPDs ( $n = 13$ ). Of the workers who self-reported as HPD users ( $n = 57$ ), fewer were observed to actually use HPDs ( $n = 47$ ). Although there was over reporting with self-

report, agreement between self-report and observation of HPD use was reported as moderately concordant (kappa .70). It would be useful to know if workers were asked to recall HPD use, and over what period of time, or if reporting was concurrent with use. Unfortunately, the authors did not specify timing of data collection.

In a “Train-the-Trainer” program, Trabeau et al. (2008) compared agreement between self-report versus non self-report of HPD use among a group of construction workers ( $N=58$ ). Self-reports of HPD use were recorded on activity cards for one workday. Questionnaires were completed at three time intervals, (a) baseline, (b) immediately after the training session, and (c) two months after the training session. Staff observation was used as a comparison of activity cards and survey reports of HPD use. Moderate agreement (kappa .60) was reported between self-reported activity cards and observation. Poor agreement (kappa .12) was reported between activity cards and questionnaires completed at the two-month follow-up.

### **Eye Protective Behavior Studies**

Eime et al. (2005) conducted a validation assessment of self-reported use of protective eyewear among squash players ( $N=1,219$ ). Surveys were distributed to a randomly selected sample of squash players over two seven-week periods. Trained observers recorded players’ actual use of appropriate eyewear during practice and games. Self-report of protective eyewear use and observation of use data were collected concurrently. Researchers reported self-reported use of protective eyewear was significantly higher than observed use (9.4% and 5.9%; 95% CI).

## Sun Exposure Protective Behavior Studies

Four articles reported on sun protection behaviors among: (a) children ( $N=108$ ) ages 9 years old to 11 years old (Girgis et al., 1993), (b) adult outdoor electrical workers ( $N=65$ ) (Girgis et al., 1994), (c) adolescents ( $N=53$ ) in grades 7 thru 10 (Lower et al., 1998), and (d) letter carriers ( $N=1036$ ) (Oh et al., 2004). Children (Girgis et al., 1993) completed a sun protection diary and trained raters made five direct observations of each child during one outdoor period. The children completed diaries immediately following the outdoor period. Kappa scores of agreement varied with identification of body part covered such that face, neck, shoulders, torso, upper arms, lower arms, legs, and feet scores ranged from kappa .70 (head covered) to kappa .34 (feet covered). There was a low agreement score between self-report and observation when physical location of the participant changed frequently during the outdoor period, such as moving in and out of the shade ( $k = .31$ ).

In another study of sun protection behavior among electrical workers ( $N = 86$ ), Girgis et al. (1994) examined agreement of self-report versus direct observation during a pretest phase with a “proportion” of the workers. Electrical workers completed solar protection behavior diaries at the end of four two-hour blocks of time each day for five consecutive working days. Self-reported data using diaries demonstrated agreement with direct observations ranging from kappa .42 to .89 ( $p = < .05$ ), depending on body part protected. The lower score reflects participants having to recall what was worn on the face versus what was worn on the legs. Greater recall detail was required to report accurately wearing facial protection (i.e. sunglasses) during a particular two-hour time period.

Lower et al. (1998) studied sun protection behaviors with adolescents who completed a daily sun protection use diary, recording their use of clothing to protect various body parts (i.e. head, shoulders, face, etc.). Self-reporting data were compared to proxy observation reports by parents/guardians for eight-one hour observations over one weekend.

In sensitivity and specificity analysis, 54 of 59 (92%) accurately reported adequate facial coverage and 26 out of 44 (61%) said their faces were not adequately covered, when they were observed to be inadequately covered. Positive predictive validity for facial coverage was 76% (54/71) and negative predictive validity was reported as 84% (27/32). All other body part coverage sensitivity ranged from 59% to 98%, specificity ranged from 61% to 87%. Six out of seven indicators were classified accurately at least 75% of the time.

Sun protection behaviors were the focus in a study of 1,036 letter carriers (Oh et al., 1994) in which self-reported use of protective clothing was collected with a paper and pencil survey. In this study, participants were asked to recall and record their use of sun protective clothing over the previous five workdays. Trained observers collected data prior to letter carriers completing their surveys. Kappa agreement between self-reported and observed protection ranged from 0.51 (95% CI [0.45, 0.56]) for using sunglasses to 0.83 (95% CI [0.78, 0.87]) for wearing long pants.

### **Statistical Tests for Agreement in Protective Health Behavior Studies**

A number of different analyses were used to determine concordance between self-report and non self-reported data in the above studies. These include kappa; Pearson's  $r$ ,

Spearman's *r*, and Kendall's *tau*; regression; and sensitivity and specificity, and positive and negative predictive validity. Analyses are briefly reviewed here.

***Kappa.*** Cohen's kappa coefficient was the most commonly used concordance measure among the studies examined in this report (Girgis et al., 1993; Girgis et al., 1994; Melamed et al., 1996; Oh et al., 2004; Trabeau et al., 2008). Kappa is a non-parametric statistical measure of agreement between raters and used when items are classified into mutually exclusive categories. With a dichotomous outcome, there is a 50 percent chance that two measurements agree. Kappa coefficient is a more robust measure than simple percent in that the analysis accounts for the possibility of agreement occurring by chance alone and requires a higher degree of matching than other agreement measures (Strijbos, Martens, Prins & Jochems, 2006). Therefore, it is a less sensitive measure than other agreement tests. Kappa magnitude values range from 0 to 1.0 and represent the proportion of agreement greater than what is expected to occur by chance.

Regarding interpretation of kappa, there is some variation in classification of magnitude of agreement. For example, Pallant (2007) reports magnitude level classification as .5 moderate, above .7 good, and .8 or above very good agreement. Landis and Koch (1977) classify kappa magnitude of agreement in ranges of .0 to .20 as slight, .21 to .40 as fair, .41 to .60 as moderate, .61 to .80 as substantial, and .81 to 1.0 as almost perfect agreement. When a significance statistic (p value) is given for kappa, it reflects the precision of measurement agreement. The significance of the magnitude value (0-1.0), on the other hand is a measure of how much agreement was obtained between the two raters. Therefore, the researcher and how important agreement is for the study objectives determine significance of the magnitude.

Kappa scores from the studies in this paper range from .012 to .89. Lower scores are related to lag time between performance of behavior and recording of behavior. Also, when greater recall detail was required for reporting (i.e., being in or out of the shade, or having sunglasses on or off during a certain time period) kappa agreement scores were lower. Moderate to high kappa scores of agreement between self-report and other report reflect higher reliability of self-report by daily activity cards, diaries or questionnaires completed soon after performance of behavior.

***Sensitivity, specificity, and positive and negative predictive validity.*** One study (Lower et al., 1998) used sensitivity, specificity, and positive and negative predictive validity to measure agreement between self-report and non self-reported data collection. Sensitivity is a classification of binary variables that measures the proportion of truly positive cases accurately classified as such (sensitivity) and the proportion of truly negative cases accurately classified as such (specificity). Positive and negative predictive validity can be calculated when sensitivity and specificity results are known, and provide the prediction of percent of cases that will be correctly identified.

Sensitivity scores of self-report compared to observation ranged from 59% to 98%. Specificity scores ranged from 61% to 87%. However, five out of eight scores were not calculated due to low rate of responses. Observer and participant agreement was lower when a behavior was self-reported but not observed, reflecting over-reporting by self-report. Overall, sensitivity and specificity results support agreement between observed and self-reported data.

***Logistic regression.*** Griffin (2009) used logistic regression and a five-by-five table to analyze concordance between activity cards validated by observation and

questionnaires completed by workers on day one of the study and two weeks after the study began. Logistic regression is used to predict the probability of an event. The researchers examined the predictive value of various noise characteristics to determine the probability of accurately self-reporting HPD use.

Logistic regression analyses demonstrated self-report of HPD use was more accurate at the worksite with fixed steady noise level exposure compared to fixed variable and unpredictable noise level exposure worksites. Self-reporting with daily activity cards was more accurate than questionnaires. Questionnaires reflected higher self-reports of HPD use compared to activity cards at all worksites. Not all probability of concordance results were statistically significant. Logistic regression more accurately predicted HPD use at fixed steady sites compared to variable or unpredictable noise level work sites.

*Pearson's r, Spearman's r, and Kendall's tau.* Pearson's  $r$ , Spearman's  $r$ , and Kendall's  $\tau$  were used to describe the reliability between self-report, observation, and supervisor report (Lusk et. al, 1995) of HPD use with ordinal level of measurement data. Pearson's  $r$  measured the degree of linear relationship between variables. Spearman's ranked correlation coefficient determined the amount of agreement between ranked pairs and Kendall's  $\tau$  was used to measure how many times a number of ranked pairs agreed or disagreed relative to the number of pairs that were measured (Girden, 2001).

The highest correlations of self-report with other report were found between self-report and trained observer reports of HPD use. Poor correlations were reported when supervisors were asked to recall whether workers were using HPDs over three previous time periods (one week, one month and three months). Results of studies using

correlation to measure agreement between self-report and other methods of behavior measurement showed high levels of agreement between trained observer report and self-report one week after performance of behavior.

Although there are several acceptable statistical tests to determine agreement between measures, comparison of results across studies is more of a challenge when investigators use different methods of analysis. Each of the statistical tests for agreement in the above studies provided valuable information regarding reliability of self-reported data when compared to non self-report measures. All results should be interpreted carefully with regard to clinical significance.

## **Discussion**

Job classification and worker characteristics are important factors to consider when designing methods for collection of data regarding health protective behaviors. While self-report and trained observation are both used, self-report of health protective behavior may be the only feasible method of data collection with some populations (farmers, construction workers, workers at high elevations or in confined spaces, etc.). However, there are some limitations to self-reported methods of data collection.

Based on review of the studies included in this analysis, the accuracy of self-report diminished with the amount of time between performing the behavior and reporting the behavior. Furthermore, questionnaires requiring recall of behavior for more than five days are less concordant with reports of skilled observation. Investigators asking participants to recall health behaviors beyond five days may experience reduced reliability of measurements of self-reported health protective behaviors. Self-report by questionnaire consistently resulted in higher reporting rates of health protective behavior

than skilled observer, or self-report by diary or activity card. Questionnaires requiring recall of behavior of more than five days may not produce reliable data.

Several studies focused on the reliability of self-report of HPD use. Noise level variability was a factor in self-report of HPD use. When noise levels are unpredictable or change frequently, compared to steady noise levels, self-reporting was less concordant with observed reporting. Similarly, when participants' physical location changed frequently during the observation period, there was more variability in agreement scores between self-report and observation (Girgis et al., 1993; Oh et al., 2004). Frequent work location changes and noise variability appear to play a role in reduced accuracy of self-reporting health protective behaviors.

Regarding sun protection studies, variability in agreement scores was evident in the studies involving identification of a particular piece of clothing worn for sun protection such as sunglasses (Girgis et al., 1994) or a particular body part being covered for sun protection such as upper arms or legs (Lower et al., 1998). Similarly, when participants' physical location changed frequently during the observation period, there was variability in agreement scores between self-report and observation (Girgis et al., 1993; Oh et al., 2004). Level of detail was important in self-report reliability, with greater detail resulting in lower agreement with observation.

Some jobs are dynamic in nature, requiring workers to change locations many times throughout the day and perform multiple tasks in one workday. Some jobs are performed in environments where workers are exposed to variable noise characteristics throughout their day, and some populations under study perform health behaviors that require greater detail in reporting health protective behaviors. For these populations, self-

report may be the only viable option for data collection. Self-report methods can be a reliable means to collect data with workers in variable noise level environments; those who change locations frequently; those who work in areas where observers may not be permitted, such as construction and farm work; and where detail in reporting is important, with certain qualifications.

Within self-reporting methods, concordance is dependent on the method of self-reporting (i.e. questionnaire, activity cards, diaries) and timing of data collection (i.e., same day as activity, five days and two weeks after the activity). Use of daily activity cards improves reliability of self-report in studies of workers who change locations frequently, work in environments with variable noise level exposures, and are requested to report greater behavior detail. Agreement between self-report and observation is also higher when reporting time intervals are shorter. Reporting accuracy may improve with brief time intervals of reporting on activity cards versus after an extended time (i.e., two hour recall compared to five day recall).

### **Limitations**

There are several limitations to this examination of concordance of self-report with non self-report data collection methods. Although a thorough search was made to identify all published and non-published studies meeting inclusion criteria, it is possible some studies could have been unintentionally missed in the review. Quality of study design was not a determinant for inclusion in this paper. Therefore, some reports have limited explanation of methods (i.e., Melamed et al., 1996; and Trabeau et al., 2008), as well as incomplete description of statistical analysis. Eime et al. (2005) and Lower et al. (1998) did not provide a discussion of statistical analyses in their studies.

The health protective behaviors in the selection criteria were intentionally narrow, limiting the protected regions to eyes, breathing zone, hearing, and skin. The focus of this study was to examine reliability of self-report for use among farmers. Broader inclusion criteria in future studies would produce more generalizable results. Despite limitations, these findings have important implications for researchers considering selection of methods for measuring health protective behavior.

### **Recommendations and Conclusions**

Review of the health-protective behavior studies in this analysis shows moderate-to-high concordance between self-report using diaries or activity cards completed on a daily basis or at brief time intervals, and skilled observation. These methods strengthen reliability of self-report for data collection methods, and may benefit research design. This method decreases lag time between the behavior and self-report, and may reduce measurement bias. To estimate the threat to reliability presented by social desirability responding, a social desirability instrument may be administered concurrent with self-report measures.

Farmers represent a unique worker group. In the same day they typically perform multiple job tasks, are exposed to variable and unpredictable noise levels, and change locations. These work characteristics make observation of self-protective behaviors difficult among this population. Collective knowledge of agreement between self-reported measures and non-self reported measures, particularly as it applies to HPD use among farm operators, supports the reliability of daily self-report activity cards for data collection of health protective behaviors.

Findings of the concordance studies reviewed in this paper suggest that self-report of HPD use through activity cards or diaries, in addition to questionnaires, are more accurate than questionnaires alone. Timing of recording behavior is important in self-reported health protective behavior data collection, and the inclusion of a measure of social desirability in the study will allow researchers to estimate the threat of social desirability or approval biases and may be considered for use in research among farmers with regard to health protective behavior.

**CHAPTER IV**

**GENDER DIFFERENCES IN PREDICTORS OF FARMERS' HEARING PROTECTION DEVICE USE**

According to the Centers for Disease Control and Prevention (Centers for Disease Control and Prevention [CDC], 2009) millions of men and women farmers in the United States are at risk for noise-induced hearing loss (NIHL). This condition is 100% preventable with the appropriate use of hearing protection devices (HPDs; CDC, 2009; Rabinowitz & Rees, 2005). Both men and women farm operators are exposed to harmful noise levels while performing farm work. Unfortunately, they also have low HPD use, and as a consequence, a high prevalence of hearing loss (Beckett et al., 2000; Carruth, Robert, Hurley & Currie, 2007; McBride, Firth & Herbison, 2003; McCoy, Carruth & Reed, 2001; McCullagh, 2002; Meeker, Carruth & Holland, 2002; Plakke & Dare, 1992; Reed, 2004; Schenker, Orenstein & Samuels, 2002; Tak, Davis & Calvert, 2009). Research to promote farmers' HPD use is sparse, and within the published literature, women farmers have been under sampled. For purposes of this paper, farm operators are defined as individuals responsible for the day-to-day operations and active in farming activities; farmers perform farm work tasks and may or may not be farm operators; farm families consist of adult and child or adolescent members of a family who live and work on a farm. When making references to all of the identities above, the term farming community will be used.

## **Women in Production Agriculture**

The number of women principal farm operators in the United States has increased in almost every category of farm type from 2002 to 2007, and women comprise 30% of total farm operators in the United States (United States Department of Agriculture [USDA], 2007). According to the USDA 2007 census, there are 306,209 U.S. farms with women principal operators, an increase of 68,390 over five years on farms of all sizes. During the same five year time span farm ownership by women increased by 60,719 farms. Farm operators are defined in the USDA (2007) census as the people who either do the work or make day-to-day decisions on the farm. In a National Opinion Research Center survey of 2,059 farmwomen, over one-half identified themselves as farm operators (Jones & Rosenfeld, 1981). Larger farm sizes, reduction of hired workers, and a trend for men to seek off-farm work to provide health care and other benefits for their families, have encouraged or necessitated women to take on larger roles on the family farm.

## **Roles of Women on the Farm**

The division of labor on farms varies by region, group, and family. Many women who characterize themselves as homemakers are regularly engaged in farm work such as working with animals, field irrigation, farm equipment operation, supervision, and management (Carruth, Skarke, Mottett & Prestholdt, 2001; Hardesty & Harmon, 1994; Reed, Westneat, Browning & Skarke, 1999). Women perform many regular and intermittent farm activities that expose them to mechanical and environmental hazards such as noise, machinery, equipment, chemicals, and livestock (McCoy, Carruth & Reed, 2001; Carruth, McCoy & Reed, 2001; Carruth et al., 2001; Reed, 2004).

Yet, because many farmwomen identify themselves as homemakers, they often do not see themselves as being at risk for injury from farm hazards (Reed et al., 1999). Rosenfeld (1986) found that women on farms are regularly involved in operating machinery, performing fieldwork, and supervising other workers, and the extent of their involvement is related to their decision-making authority on the farm. Such decisions included buying, selling, hiring, and supervising. Health and safety researchers and practitioners would be well served to consider the decision-making role of the woman on the farm and her influence on health and safety practices of herself, her family, and other workers in research design.

### **Susceptibility to Noise-induced Hearing Loss**

Although somewhat equivocal, there is evidence that women may be more vulnerable to hearing loss than men, even at noise level exposures below 83dB, a level lower than the 8-hour time weighted average exposure limit set by OSHA (Szanto & Ionescu, 1983). In a sample of factory workers (N=126), proportions of hearing loss between men and women were similar (67% and 62% respectively), even though women had shorter duration of noise exposure (Westbrook, Hogan, Penney & Legge, 1992). Pearson et al. (1995) reported that with aging, hearing sensitivity declines faster in men than women in the lower ranges. The degree of loss tends to level off or slow after age 50 in men. The same study indicated hearing acuity in women continued to decline at all frequencies and beyond age 50. While it is certainly necessary for men and women to protect themselves from NIHL, women might be more susceptible to greater loss of hearing.

## **Gender and Health Behaviors**

Marriage and other social relationships are associated with lower morbidity and mortality (Holt-Lundstat, Smith, & Layton, 2010; House, Robbins & Metzner, 1982; House, Umberson & Landis, 1988; Wallston, Alagna, Devilis & Devillis, 1983) and the benefits from these relationships to health in general seem to be greater for men than women (House et al., 1988; Schumaker & Hill, 1991; Umberson, 1992). Women also tend to be more knowledgeable about health issues, adhere to health care recommendations, monitor, and influence preventive health behavior of others (Briscoe, 1987; Norcross, Ramirez, & Palinkas, 1996). Harris and Guten (1979) and Mechanic and Cleary (1980) found that female gender was the strongest predictor of preventive health care behaviors.

Further research has shown women have a strong influence on health behaviors of men and indicated men are 2.7 times more likely to be influenced by women in health seeking behaviors. However, the reverse influence does not apply (Norcross et al., 1996).

Health behavior interventions to increase HPD use with children have demonstrated increased HPD use among the parents of the children (Kidd et al., 2003; Knobloch & Broste, 1998). Considering the increasing and expanding farm role of women, an examination of HPD use and predictors of HPD use among women farmers could yield important information in the development of interventions to increase HPD use among farmers of both genders and their families.

McCullagh et al (2002; 2010) examined factors related to HPD use among farm operators, both men and women. The data sets from these studies were used to explore HPD use among farmwomen.

## **Research Questions**

- 1) Previous research examined predictors of HPD use among farm operators (McCullagh, Lusk & Ronis, 2002; McCullagh, Ronis & Lusk, 2010). Gender-related differences in predictors were not examined in the earlier studies due to a small number of women in each study. Combining the data provides a sufficient sample size for secondary analysis (n=173). What are the predictors of HPD use among women farmers in the combined previous studies and how do they differ from men farmers?
- 2) Which gender of farm operators is more likely to use HPDs when in high noise areas?
- 3) Are there differences in HPD use predictors between men and women farm operators?
- 4) What are the implications of the results of this study for future HPD use interventions?

## **Methods**

### **Design**

A secondary analysis of previously collected data was conducted to examine gender differences in predictors of HPD use among farmers. The first (2002) of two studies was conducted with a convenience sample of farmers attending a regional farm show in the Midwest. The second (2010) study was a cross-sectional study using telephone surveys of a random sample of Midwest farmers. Pender's health promotion model guided both studies. The purpose of both studies was to identify factors related to HPD use. The

parent studies (McCullagh et al., 2002; McCullagh et al., 2010) tested the Predictors of Farmers' Use of Hearing Protection Model.

### **Sample**

The combined data set ( $N = 686$ ) included 513 men and 173 women. Power analysis ( $686 \geq 50 + 8m$  [ $m =$  number of predictor variables]) indicated sample sizes of each gender and total sample size were sufficient to test the model's multiple predictors with logistic regression analyses ( $n = 173 \geq 50 + 8m$ ,  $n = 513 \geq 50 + 8m$ ). Sample sizes of each gender group were also sufficient to test for individual predictors for both genders using logistic regression analysis ( $n = 173 \geq 104 + 7$ ,  $n = 513 \geq 104 + 7$ ).

### **Procedures**

Data files were obtained from the parent researcher and combined in a stacking method using SPSS (SPSS, Inc., Chicago, IL). Descriptive and categorical data analysis methods were used to examine the relationships between gender and predictors of HPD use in the combined parent studies (McCullagh et al., 2001, 2010). After stacking the parent study data sets all unmatched variables between sets were removed so only variables common to both data sets remained. Negatively worded items were reverse coded into new variables. The focus of the current study was to examine gender-related differences. Consequently, two cases with missing gender response were removed from the data set.

Demographic factors in the combined studies included age, gender, years of farming since age 18, race, and role on the farm. Hearing protection use was dichotomized into use or never use. Noise exposure was assessed by asking participants

if they were exposed to high noise while working on the farm. High noise is defined as having to shout to be heard by someone three feet or less away from the speaker.

Reliability analyses were performed after combining the two parent studies (McCullagh et al., 2002, 2010) and are shown in Table IV.1. Cronbach's alpha was used for calculating reliability of instruments. Cronbach's alpha score of .70 demonstrates acceptable reliability (Girden, 2001; Nunnally, 1978). Alpha scores below .70 on three of the instruments are likely due to a small number (fewer than ten) of items in the instrument. Theta coefficients were calculated for instruments with fewer than ten items. Individual characteristics and experiences of the participants were also examined in the combined data sets. These characteristics include age, gender, race, and farm role (e.g., owner, paid worker).

**Table IV.1**  
Instrument Reliability Coefficients for Combined Data Sets

Scale	Cronbach's alpha	Theta*	Number of items
Barriers	.85	*	18
Self-efficacy	.84	*	11
Situational Influences	.58	.50	7
Value	.77	.83	5
Total Interpersonal influences**	.70	*	11
Norms	.68	.69	5
Modeling	.50	.50	2
Support	.69	.72	4

\*Theta was calculated only for instruments with fewer than ten items.

\*\*Total scale includes Norms, Modeling, and Support instrument items.

Originally, participants were asked if they were exposed to noise in four different farm locations (e.g. shop, field, barn, grain dryer) and the percent of time (0-100) HPDs were used when in these locations. Data were used to calculate mean percent time use of HPDs when exposed to high noise. The outcome data had a non normal distribution, therefore responses were dichotomized into *no use* and *ever use* regardless of location and *exposed to high noise levels, yes* or *no* regardless of location.

The phenomenon of missing data is often a concern in research. This study had two cases with missing gender. Since the focus of this study was gender, it was necessary to eliminate those two cases from the data sets prior to analyses. With the large sample size in this study (N=686) it is unlikely two additional cases would have affected the results.

Chi square analyses of missing data were performed with each of the predictor variable items with gender and with exposed participants to determine if there were significant differences in variables with missing values. Most scale items did not have significant Chi square results, meaning there were no systematically identifiable significant differences associated with gender or exposure, between missing and non missing data. One item from self-efficacy for HPD use scale, "I am not sure if my HPDs are working correctly," and one item from Situational Influences instrument, "I have ear muffs of my own," indicated statistically significant differences in missing scores between genders, but no pattern was discernable.

Spearman's rank order correlation is a non-parametric alternative to Pearson correlation coefficients and was used to examine the strength and direction of the relationship between instruments appropriate for the data in the study. Examination of a

matrix of correlations between variables demonstrated Spearman's rho values of .5 or less, demonstrating a low risk of multicollinearity.

To determine the distribution of scale scores, normality plots and histograms were examined. Comparison of means with 5% trimmed mean shows very little influence of extreme scores. Kolmogorov-Smirnov tests of normality demonstrate all instruments, except for Barriers to HPD Use violate normality assumptions. While parametric tests are more powerful, they require normal distribution of data. Consequently, non-parametric tests were used for analyses of data. The use of non-parametric technique may have presented the threat of Type I error.

Total scale scores and mean scale scores were calculated for seven predictor variables (barriers, self-efficacy, situational influences, value, norms, modeling, and support). Mann-Whitney U tests were used to determine if there was a statistically significant difference between genders in median scores of independent variables. The Mann-Whitney U test is a non-parametric test similar to the t-test for mean scores on normally distributed data. Each parent study and the combined data sets were tested for significant differences in predictors of HPD use between genders. Multiple regression and path analysis are powerful techniques for statistical testing. However, both techniques require continuous outcome data. The outcome data in this study was categorical (use/no use) therefore logistic regression analysis was used to assess significant predictors of HPD use comparing results of farm operators by gender.

## **Instruments**

Variables from the parent studies are based on the Predictors of Farmers' Use of Hearing Protection Model (McCullagh et al., 2002) derived from the Predictors of

Workers' Use of Hearing Protection Model (Lusk, Ronis, Kerr & Atwood, 1994). Both models are guided by Pender's health promotion model. The Predictors of Farmers' Use of Hearing Protection Model hypothesizes that cognitive, affective, and other factors influence HPD use among farmers. Model variables are divided into two categories: 1) behavior-specific cognitions and affects, and 2) individual characteristics and experiences. The term behavior-specific cognitions and affects was derived from the social cognitive theory to describe an individual's thoughts or feeling about a specific action (Bandura, 1986).

Seven shared behavior-specific cognition and affect variables common to both studies include (a) perceived barriers to HPD use, (b) perceived value of HPD use, (c) self-efficacy for HPD use, (d) situational influences on HPD use, (e) perceived interpersonal norms for HPD use, (f) perceived modeling of HPD use, and (g) perceived interpersonal support for HPD use.

### **Independent Variables**

Perceived barriers to action are real or imagined notions about the inconvenience, cost, difficulty, or time-consuming nature of a specific behavior (Pender et al., 2010). The Farmers' Perceived Barriers to Use of HPDs instrument (McCullagh et al., 2002) is an adaptation of an instrument used previously to study barriers to use of HPDs among factory workers (Lusk, Ronis, & Hogan, 1997). McCullagh et al. (2002) modified the instrument for use with farmers. The instrument measures 18 items on a 6-point Likert scale. A sample statement from the barriers scale is, "Hearing protectors are difficult to use when the weather is extremely cold." Response options range from *strongly disagree* to *strongly agree*. Theta coefficient reported for the earlier (McCullagh et al., 2002)

study was .89; in the later farmers' study (McCullagh et al., 2010) Cronbach's alpha was .81.

Perceived benefits of use of HPDs are positive or reinforcing consequences of a behavior (Pender et al., 2010). Farmers' Perceived Value of Use of Hearing Protection was derived from a similar instrument used with construction and factory workers (Lusk et al., 1997). The participant was asked to rate the importance of five outcomes of HPD use such as, "Protection of inner ear" on a 10-point scale (McCullagh et al., 2010). Response options range from *slightly important* to *highly important*. The earlier parent study (McCullagh et al., 2002) consisted of a 10 mm visual analog scale with anchors being *slightly important* and *highly important* and values assigned according to placement of a hash mark along the scale. Theta coefficient for the earlier (McCullagh et al., 2002) study was .85; in the later farmers' study (McCullagh et al., 2010) Cronbach's alpha was .82.

Self-efficacy is an individual's belief in their ability to perform a certain behavior. Self-efficacy for use of HPDs was used in prior research with factory workers (Lusk et al., 1994) and modified by McCullagh et al. (2002) for use with farmers. The Farmer's Self-Efficacy for HPD Use instrument consists of 11 statements about using hearing protection such as, "I know how to use my hearing protection so that it works effectively." The six response options range from *strongly disagree* to *strongly agree*. Theta coefficient reported for the earlier (McCullagh et al., 2002) study was .76; in the later study (McCullagh et al., 2010) Cronbach's alpha was .75.

The Situational Influences on HPD Use instrument (McCullagh et al., 2002) is an adaptation of an instrument previously used by Lusk et al. (1994) to study HPD use

among factory workers. McCullagh (2000) modified and tested the wording and content of the instrument to be more appropriate for use with farm operators. It is a seven-item instrument that measures situational factors influencing HPD use. A sample statement from the Farmers' Situational Influences on Use of HPDs instrument is, "Ear plugs are available close to high noise areas." Six response options are given ranging from *strongly disagree* to *strongly agree*. Theta coefficient reported for the earlier (McCullagh et al., 2002) study was .66; in the later study (McCullagh et al., 2010) Cronbach's alpha was .81.

Farmers' perceived interpersonal influences on HPD use were measured using three subscales: (a) Farmers' Perceived Interpersonal Norms of HPD Use, (b) Farmers' Perceived Interpersonal Modeling of HPD Use, and (c) Farmers' Perceived Interpersonal Support for HPD Use. These instruments were modified from the original format to be more appropriate for farmers by having questions relate to the farmer's family, other farmers, and farm equipment dealers.

Farmers' Perceived Interpersonal Norms of HPD Use is an instrument that measures how much participants believe other people (family members, healthcare workers, other farmers, equipment dealers, and extension workers) think they should wear hearing protection. The participant is asked to rate, on a four-point scale, how strongly they believe other people think they should use HPDs. Response options include, *not at all*, *sort of*, *a lot*, and *does not apply*. Theta coefficient reported for the earlier (McCullagh et al., 2002) study was .75; in the later farmers' study (McCullagh et al., 2010) Cronbach's alpha was .63.

The Farmers' Perceived Interpersonal Modeling of HPD Use instrument contains two items on a four-point scale. The participant was asked to rate how much they think others, such as family members and other farmers, wear HPDs when in high noise. Response options include *never*, *usually not*, *about half the time*, and *usually*. Theta coefficient reported for the earlier (McCullagh et al., 2002) study was .68; in the later farmers' study (McCullagh et al., 2010) Cronbach's alpha was .49.

The Farmers' Perceived Interpersonal Support for HPD Use instrument measures how much certain people encourage or praise the participant's use of HPDs. This scale contains four statements and two categories of people: family and other farmers. A sample statement from this instrument reads, "My family praises me for wearing hearing protection," with response options *never*, *sometimes*, and *often*. Theta coefficient reported for the earlier (McCullagh et al., 2002) study was .73; in the later farmers' study (McCullagh et al., 2010) Cronbach's alpha was .69.

### **Outcome variable**

The dependent variable in the current study was use of hearing protection devices when in high noise areas. Participants self-reported the percent of time (0 to 100) they used HPDs while in high noise in selected farm work locations: (a) barn, (b) field, (c) grain handling system, and (d) shop. High noise areas were defined as environments in which a person has to shout to be heard by another at least three feet away.

### **Subject characteristics**

Participants (N = 686) were primarily men (74.8%). The mean age of participants was 52.14 years (SD = 12.15). By gender, mean age for men was 53.16 years (SD =

12.24) and women 52.09 years (SD = 11.91). Years in farm work since age 18 ranged from 1 to 72 (M= 28.29, SD = 13.27). Women, on average, reported fewer years in farming since age 18 ( $m = 27.97$ , SD = 13.65) than men ( $m = 28.40$ , SD = 13.15).

Participants in the combined parent studies were overwhelmingly (90%) Caucasian. Study participants owned an average of 1,719 acres ranging from 0 to 80,000 (SD = 5,174.93). The majority of participants identified their role on the farm as manager (83.3%), followed by non-paid worker (8.7%), full-time paid (4.4%), and part-time paid (3.5%) worker. Of the women ( $n = 173$ ), 27% ( $n=47$ ) identified themselves as non-paid workers. A Mann-Whitney U test revealed no significant difference in age between men ( $Med = 51.00$ ,  $n = 507$ ) and women ( $Med = 52.00$ ,  $n = 172$ ),  $U = 171904$ ,  $z = -.214$ ,  $p = .83$ ,  $r = .008$ ) in the present study (Tables IV.2 and IV.3).

**Table IV.2**

Sample Demographics of Men Farmers (n=513)

Characteristic	Mean	SD	N	%
Age (years)	53.16	12.1		
Years in farming	28.4	13.15		N/A
Farm role				
Manager				81.8
Full-time paid				4.9
Part-time paid				3.9
Non-paid				9.4
Race/Ethnicity				
Caucasian			458	89.6
African American			1	<. 01
Hispanic			6	.01
Native American			41	8.0
Asian			1	<. 01

**Table IV.3**

Sample Demographics of Women Farmers (n=173)

Characteristic	Mean	SD	N	%
Age (years)	52.09	11.91		
Years in farming	27.97	13.65		
Farm role				
Manager			139	80.8
Full-time paid			8	4.7
Part-time paid			7	4.1
Non-paid			18	10.5
Race/Ethnicity				
Caucasian			146	84.4
African American			4	<. 01
Hispanic			2	<. 01
Native American			17	10.2
Asian			1	<. 01

Chi-square test for independence (with Yates Continuity Correction) indicated no significant association between gender and self-reported exposure to loud noise,  $X^2(1, n = 680) = .000, p = 1.00$ ). Regarding HPD use, a greater percentage of women (50.3%,  $n = 87$ ) reported ever using HPDs compared to men (48.9%,  $n = 251$ ), but differences were not significant,  $X^2(n = 686) = .049, p = .825$ ).

The Mann-Whitney U test was performed to compare median scores of predictor variables (i.e., Perceived Barriers to HPD use, Value of HPD Use, Situational Influences on HPD Use, Self-efficacy for HPD Use, Perceived Interpersonal Support for HPD Use, and Interpersonal Norms and Modeling of HPD Use) between men and women. There were no significant differences in scores of men and women.

The relationships between HPD use and barriers, value of HPD use, self-efficacy, situational influences, interpersonal norms, interpersonal modeling, and interpersonal support were investigated using the Spearman rho correlation coefficient by gender. Barriers to HPD Use had the strongest correlation with HPD Use for the men ( $\rho = -.39, n = 513, p < 0.01$ ) with high levels of barriers associated with lower HPD use. For women the strongest correlation with HPD use was situational influences ( $\rho = .35, n = 173, p < 0.01$ ). All correlations between HPD use and gender can be seen in Table IV.4.

### **Predictor Variables for Men and Women**

In the first parent study (McCullagh et al., 2002) the distribution of scores on the dependent variable (HPD use) was highly skewed with more than one-half (56%) of the respondents reporting no HPD use in the past year. Consequently, the assumptions for use of multiple linear regression were not met, and the authors dichotomized the

dependent variable into non-use (0 % mean use coded 0) and ever-use (> 0 % mean use coded 1) for analysis with logistic regression. Similarly, dependent variable data were highly skewed in the combined data sets. Logistic regression was performed to assess the impact of several factors on the likelihood of reporting HPD use for men and women participants. The full model contained seven of the Predictors of Farmers' Use of Hearing Protection Device model variables.

**Table IV.4**

Bivariate Correlations of Predictor Variables with HPD Use of Men (n = 513) and Women (n = 172)

Farmers.

	Barriers	Self- efficacy	Situational Influences	Value	Interpersonal Norms	Interpersonal Modeling	Interpersonal Support
Men	-.39**	.30**	.32**	.29**	.09	.21**	.24**
Women	-.29**	.31**	.35**	.15	.22**	.27**	>.23**

Note. \*\*Correlation is significant at the 0.01 level (2-tailed).

(barriers, self-efficacy, situational influences, norms, modeling, support, value of HPD use, age, and gender). The full model was statistically significant,  $\chi^2 (9, N = 686) = 147,930, p = < .001$ , indicating that the model was able to distinguish between participants who reported use and those who reported no use of HPDs. The model explained between 20% (Cox and Snell R square) and 27% (Nagelkerke R square) of the variance, and correctly classified 70.5% of cases.

Five of the predictors (barriers, self-efficacy, situational influences, interpersonal support, and age) made a unique statistically significant contribution to the model. The strongest predictor in this model was interpersonal support, showing an odds ratio of 1.77. This indicated that those respondents who reported having social support for HPD use were 1.77 times more likely to report HPD use. Similar to parent studies, barriers, situational influences, and interpersonal support were significant in the earlier (McCullagh et al, 2002) study; and barriers, situational influences, and gender were significant predictors in the later (2010) study.

The odds ratio of .61 ( $p = .000$ , 95% CI [.48, .79]) for barriers to HPD use indicated that for every one unit decrease in barriers score, participants were 1.64 times more likely to report HPD use. Situational influences was an important indicator of HPD use in the full model ( $OR = 1.27, p = .007$ , 95% CI [1.07, 1.52]) for both genders. Decreasing scores in age predicted an increase in likelihood of HPD use ( $OR = .98, p = .024$ , 95% CI [.97, .998]). Gender was not a significant predictor of HPD use in this model ( $p = .72$ ).

Removing the main effects of gender from the full model produced a statistically significant model,  $\chi^2 (8, N = 686) = 147.797, p = < .001$ , as did removing the main

effects of age,  $\chi^2 (7, N = 686) = 143.417, p = < .001$ . Neither action resulted in a change of significant predictors. Adding the interaction term of gender to each of the predictors in the full model identified statistically significant interaction effects of gender with self-efficacy for HPD use ( $p = .006$ ; Table IV.5).

### **Analyses by Gender**

Logistic regression was performed separately for men and women participants. A statistically significant model with men participants was produced,  $\chi^2 (8, N = 513) = 102.405, p = < .001$  with four significant predictors (Table IV.5). The model explained between 19% (Cox and Snell R square) and 25% (Nagelkerke R squared) of the variance in HPD use, and correctly identified 71.3% of the cases. The strongest predictor of HPD use for men participants was interpersonal support, with an odds ratio of 2.00. This indicated that respondents most likely to report having interpersonal support for HPD use were two times more likely to report HPD use. Situational influence was also predictor of HPD use for men with an odds ratio of 1.29, followed by age ( $OR = .98$ ) and barriers ( $OR = .57$ ).

The model for the women participants containing all predictor variables was also statistically significant,  $\chi^2 (8, N = 173) = 56.448, p = < .001$  (Table IV.7). The model explained between 28% and 38% of variance for the women and predicted 72.2% of cases correctly. Two predictor variables demonstrated statistically significant results with the women participants; self-efficacy for HPD use ( $OR = 2.26, p = < .003$ ), and value of HPD use ( $OR = 1.50, p = .043$ ). See Figure IV.1.

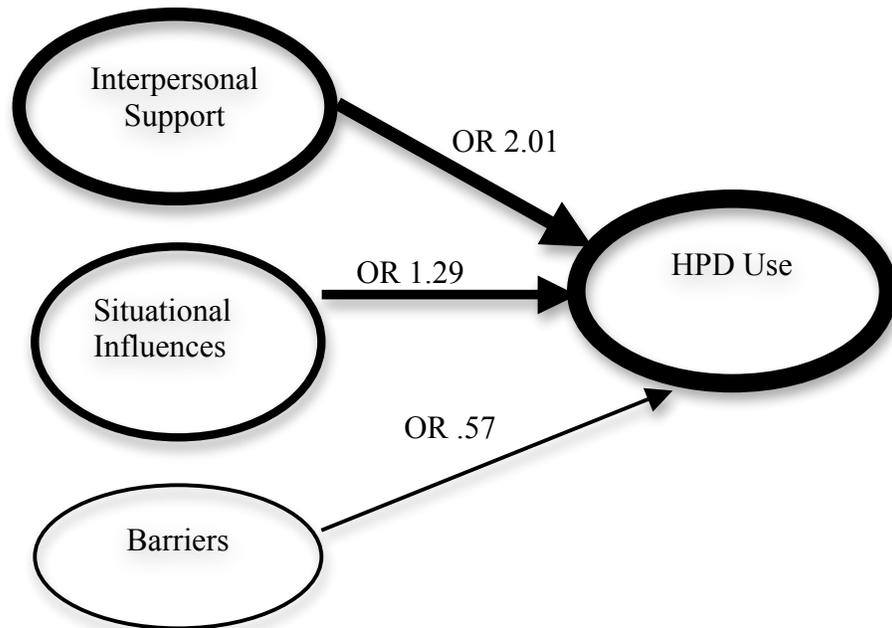
**Table IV.5**

Predictors of Hearing Protector Use Among Men and Women Farm Operators (Logistic Regression; n = 668)

Variable	B	S.E.	Wald	df	p	Odds Ratio	95.0% C.I for Odds Ratio	
							Lower	Upper
Barriers*	-.50	.13	15.77	1	.00	.61	.47	.78
Self-efficacy*	.31	.12	7.32	1	.01	1.37	1.10	1.71
Situational influences*	.21	.09	5.78	1	.02	1.24	1.04	1.47
Value	.10	.08	1.77	1	.18	1.11	.95	1.28
Norms	.03	.18	.03	1	.87	1.03	.72	1.47
Modeling	.11	.11	1.16	1	.28	1.12	.91	1.37
Support*	.56	.23	6.03	1	.01	1.76	1.12	2.76

*Note.* Logistic Regression of PFUHPM predictor variables only. B = unstandardized beta coefficient, S.E. = standard error, *df* = degrees of freedom, *p* = significance, C.I. = confidence interval, \* Significant predictors

A. Men Farm Operators



B. Women Farm Operators

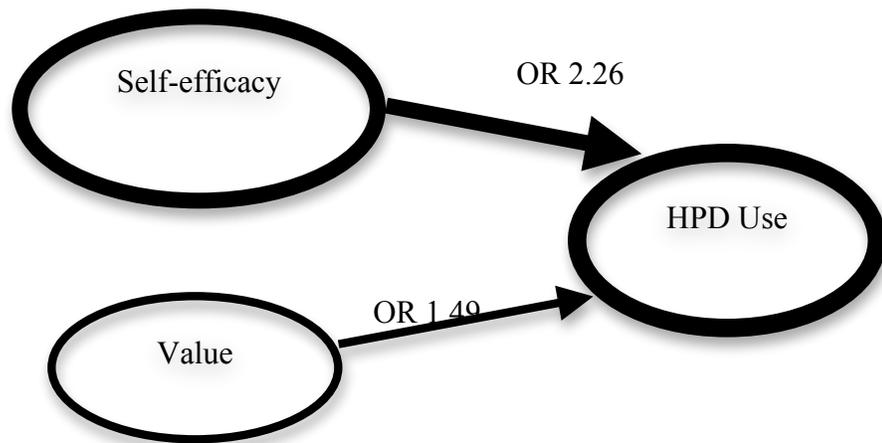


Figure IV.1. Odds Ratio (OR\*) for predictors of hearing protection device use in this study.

\*  $p \leq .05$

**Table IV.6**

Predictors of Hearing Protector Use Among Men Farm Operators (Logistic Regression;  
n = 499)

Variable	B	S.E.	Wald	df	p	Odds Ratio	95.0% C.I for Odds Ratio	
							Lower	Upper
Barriers*	-.56	.15	14.70	1	.00	.57	.43	.76
Self- efficacy	.16	.14	1.32	1	.25	1.17	.90	1.52
Situational Influences*	.25	.11	5.68	1	.02	1.29	1.05	1.58
Value	.09	.09	1.03	1	.31	1.09	.92	1.30
Norms	.00	.22	.00	1	1.00	1.00	.65	1.55
Modeling	.16	.12	1.79	1	.18	1.18	.93	1.50
Support*	.70	.26	7.09	1	.01	2.01	1.20	3.35
Age*	-.023	.009	6.91	1	.01	.98	.96	.99

*Note.* B = unstandardized beta coefficient S.E. = standard error, *df* = degrees of freedom, *p* = significance, C.I. = confidence interval, B = unstandardized beta coefficient, S.E. = standard error, *df* = degrees of freedom, *p* = significance, \* significant predictors

**Table IV.7**

Predictors of Hearing Protector Use Among Women Farm Operators (Logistic Regression; n = 169)

Variable	B	S.E.	Wald	df	p	Odds Ratio	95.0% C.I for Odds Ratio	
							Lower	Upper
Barriers	-1.2	.29	1.54	1	.69	.89	.50	1.58
Value*	.40	.20	4.10	1	.04	1.49	1.13	2.20
Self-efficacy*	.82	.28	8.62	1	.00	2.26	1.31	3.90
Situational influences	.25	.18	1.92	1	.17	1.28	.90	1.81
Norms	.06	.37	.03	1	.87	1.06	.51	2.20
Modeling	.16	.23	.48	1	.49	1.72	.75	1.84
Support	-.14	.53	.07	1	.80	.87	.31	2.47
Age	-.00	.02	.70	1	.79	.99	.96	1.02

*Note.* B = unstandardized beta coefficient, S.E. = standard error, *df* = degrees of freedom, *p* = significance, C.I. = confidence interval, B = unstandardized beta coefficient, S.E. = standard error, *df* = degrees of freedom, *p* = significance, \*significant predictors

## Discussion

A comparison of predictors of HPD use by gender revealed that predictors of HPD use were different for men and women. Predictors of HPD use for men farmers were interpersonal support, situational influences, age, and barriers. For women farmers, predictors were self-efficacy and value of use of HPDs.

Similar to both parent studies, results from the current analysis suggest that the concepts of barriers and situational influences are important factors affecting HPD use. In addition, interpersonal support was identified as significant in one parent study (McCullagh et al., 2002) as well as in the study reported here, but not in the later parent study (McCullagh et al., 2010). One possible explanation of the differences between the three studies (McCullagh et al., 2002 & 2010; and the current study) may be related to measurement. Reliability of an instrument is a function of its length (Waltz, Strickland, & Lenz, 2005); instruments with a low number of items may not perform well. Interpersonal influences consists of three sub-scales; interpersonal support, interpersonal modeling, and interpersonal norms. Each of these scales contains a low number of items and there were differences in results between the studies measuring these attributes. These findings suggest further instrument testing or revision may be warranted.

Another explanation of dissimilarities between results could be gender ratio. The earlier study (McCullagh et al., 2002) and the current study were comprised of 97% and 75% men, respectively. The later study (McCullagh et al., 2010) consisted of 69% men, a greater reflection of the distribution of gender in the population of farmers.

Analysis using the full model that included gender and age in addition to the cognitive and affective variables identified barriers, self-efficacy, situational influences,

interpersonal support, and age as predictors of HPD use. Gender specific analysis in the current study identified interpersonal support, barriers, situational influences, and age as predictors for men. The researchers in gender-related differences of HPD use predictors among blue collar workers (Lusk et al., 1997) found the strongest predictors of HPD use, barriers, perceived self-efficacy, and situational influences were important variables for men and women. This finding is different from the gender specific analysis of farmers, in which barriers, situational influences and interpersonal support were predictors for men but not for the women, while self-efficacy and value were predictors for women. Interestingly, low rate of HPD use in this study is consistent with earlier studies (Carruth et al., 2007; McBride et al., 2003; McCoy et al., 2001). Half of the women (50.3%) and less than half of the men (48.9%) in the current study reported ever wearing HPDs. Yet, self-efficacy and value of HPD use were significant predictors for the women. Neither of these predictors was found to be significant in either of the parent studies alone. The increased sample size may have had an influence on the power of the secondary analysis to identify significance.

One possible explanation for this difference in predictors of HPD use is that although not statistically significant, more women reported ever using HPD than men. This leads to the inference that either the women did not encounter the barriers the men encountered, or the value of HPD use for women was high enough to overcome barriers to HPD use.

Differences in results between the blue collar worker studies and the farmer studies may be related to work environment. Regulated industries have mandated hearing conservation programs designed to promote HPD use by increasing knowledge,

HPD use instruction and training, hearing health screenings, cues, and availability of various types of HPDs at no cost to the workers, and allow negative consequences for non-use of HPDs. Gender is not a factor in health and safety regulation enforcement; therefore one would expect differences in predictors of HPD use related to gender to be minimized in this environment. Regulated enforcement in independently owned and operated farming operations is not likely to be feasible, enforceable, or desirable.

Some differences in results between studies may be explained by statistical tests. Lusk et al., (1997) used path analysis to examine HPD use. Path analysis is a form of multiple regression, more powerful than logistic regression, and useful with continuous data. Because the dependent variable (ever use HPD/never use HPD) was dichotomized, logistic regression was the only statistical test choice to examine predictors of HPD use in the current farmers HPD use study.

Gender specific analyses suggest men and women are different when it comes to predictors of HPD use. This paper has cited interesting evidence regarding health behaviors of women. As stated earlier, women tend to have a greater interest in health issues than men (Briscoe, 1987; Norcross et al., 1996), an interest in the prevention of illness in themselves and others (Norcross et al., 1996), and a strong influence on health and safety behaviors of others (House et al., 1988; Schumaker & Hill, 1991; Umberson, 1992). In addition, women have an increasing role in farm operations and represent one-third of farm operators, which means they have a direct influence on the day-to-day operation of the farm (USDA, 2007). Taking these findings a step further, having evidence of the strong interest and influence of women on health and safety behavior practices of others, there may be the potential for women to be instrumental in

influencing other farm workers' HPD use. More research is needed to understand the influence of gender on HPD use among farm operators.

Overall, the Farmers' Predictors of HPD Use Model performed well in this study, predicting over 70% of variance in HPD use. This finding, along with previous findings, supports the use of the model in further HPD use predictor studies and intervention design.

### **Limitations**

Some limitations of this study may have affected the results. As this was a secondary data analysis derived from two different but similar studies, measurements were not originally designed for the study reported here. Generalizability of the results is somewhat limited due to the use of a convenience sample in the first parent study. A random sample was used in the second. Parent studies included primarily farm operators and few hired farm workers, who represent a large portion of the agricultural workforce. The researchers did not validate actual noise exposure levels, and although there is some evidence that self-reported use of HPDs can be a reliable measure, there still remains the issue of information recall when self-report is used as the only method of data collection. The responders' desire to provide a socially favorable response may have presented bias. Regrettably, educational level was not included in one of the parent studies, therefore the effect of education level on HPD use among this sample of farm operators was not able to be evaluated.

## Strengths

That being said, the results discussed below provide an indication of areas warranting further study and perhaps provide guidance for future interventions among men and women farm operators to promote HPD use. The Predictors of Farmers' Use of Hearing Protection Model as a whole explained between 20% and 27% of variance in HPD use and correctly classified 70.5 % of the cases. This study supports the use of the Predictors of Farmers' Use of Hearing Protection Model among farmers, both men and women. Although the model produced significant predictors for both genders, the significant predictors were not the same. Men participants demonstrated predictors of use to include interpersonal support, situational influences, and barriers. Age was also included in the analysis and identified as a significant predictor, with younger age being associated with greater HPD use.

Women participants demonstrated self-efficacy for HPD use and value of HPD use as significant predictors from the Farmer's Use of Hearing Protection Model. Self-efficacy is a strong predictor in many health behavior studies, but was not significant in earlier studies of farmers, nor was it significant for the men farmers in this study. Age was not a predictor of HPD use for women in this study. The significance of value of HPD use is important in light of earlier research cited in this paper.

Women have an influential role in preventive health behaviors and adherence to recommendations for preventive health behaviors for themselves and others (Briscoe, 1987, Harris & Guten, 1979; Mechanic & Cleary, 1980; Norcross et al., 1996). Considering the expanding role of women on farms, conveying the preventive benefits of

HPD use for the prevention of NIHL to farmwomen could impact the use of HPDs in all farm workers.

### **Implications for Future Research**

Although women have been underrepresented in farmers' HPD use research, they represent one-third of farm operators in the United States. Farm operators have a direct influence on the day-to-day operation of the farm, including safety and health issues.

Research cited in this paper provides evidence for important findings about women. In the area of health, women tend to have a greater interest in health issues than men (Briscoe, 1987; Norcross et al., 1996), have a strong influence on the health behaviors of others (House et al., 1988; Schumaker & Hill, 1991; Umberson, 1992), and are interested and active in the prevention of illness in themselves and others (Norcross et al., 1996). Another important factor in United States farming is that women have an increasing role in farm operations (United States Census Bureau, 2007). With consideration of women's influential role in health care behavior and the increasing and expanding role of farm women, further exploration of HPD use and predictors of HPD use among women farmers could yield important information in the development of interventions to increase HPD use among all farmers and their families.

This study supports the use of Predictors of Farmers' Use of Hearing Protector Device Model among farmers, both men and women. However, further development of the model with gender considerations is warranted

## **CHAPTER V**

### **DISCUSSION**

Noise induced hearing loss among the farming community is a serious issue that affects men, women and children. Yet, this impairment may be prevented with appropriate use of hearing protection. Studies cited in this paper demonstrate a low use of HPDs and significant hearing loss among these workers. To answer the question, “What is the current state of the science in intervention research to promote HPD use among farm operators?” three areas of concern were identified and explored.

Behavior change theory concepts were examined for similarities and application of concepts in the interventions. To assess reliability of self-report as a measurement method for future research among farm operators, a literature review and analysis of results of self-report and non self-report concordance studies was performed. Finally, a secondary analysis of two similar studies examined a previously unexplored topic: gender-related differences in farmers’ HPD use.

#### **Examination of Selected Theoretical Concepts**

An examination of published interventions identified six theories used in five interventions. None of the published interventions used a specific theory in its entirety, but substructured selected concepts from a theory or theories. Even though theories were not used in their entirety, implementation of selected theory *concepts* in the interventions resulted in increased use of HPDs.

Comparison of the theory concepts guiding farmers’ HPD use intervention research shows that concept definitions from several theories overlap in meaning, but use

different *words* to identify the concept. It is not the words that are of primary concern, but rather the *ideas* the words express. Examination of the 37 concept labels used in the selected studies and combining them into 11 unique concepts (ideas) helped to clarify the concepts being studied in farmers' HPD use interventions. Unfortunately, contextual definitions of the concept words were frequently not provided. So the assumption was, the researchers used the concept exactly as intended by the theorist. This may or may not be true. Clarification of concepts is an important aspect of knowledge synthesis and would have been useful in the examination of these studies.

Theory concepts that were implemented in the interventions resulting in a significant positive change in HPD use included self-efficacy, social support, susceptibility, benefits, situational influences, and health motivation. Concept development is a continuing process and further refinement, particularly in the context of research with farmers may be beneficial to build on current knowledge.

### **Examination of Self-report Concordance Studies**

Self-reporting of health behaviors is a practical method of data collection for several reasons; it can be cost effective, expedient, and used with those who work in places not amenable to observation (i.e. elevated heights, confined spaces, etc.). Sometimes self-report is the only feasible method of data collection. To examine reliability of self-report of health protective behaviors several different populations were studied in the concordance literature. This paper examined concordance studies of children, adolescents, postal workers, electrical workers, factory workers, and squash players. Several different statistical analyses were used to examine concordance, which

makes comparison of results a challenge. Nonetheless, measures of agreement were obtained from each of the studies and an assessment of concordance was made.

There is a basis for questioning self-report by questionnaire alone. Unlike reliability comparison studies with factory workers (Lusk et al., 1997), the results of the studies in this paper found over-reporting of HPD use consistently when questionnaires were the sole method of reporting HPD use. While self-report of HPD use among workers in an environment such as a factory, with consistent work tasks and steady noise levels has shown reliability, the farming environment is quite different.

The research reviewed in this paper suggests that as time passes, people forget. However, some researchers did demonstrate improved self-report reliability with recording of behavior with occurrence, or shortly after, reducing potential recall error.

Self-report measurement methods may introduce two types of systemic error: social desirability bias and social approval bias. Each of these can result in measurement error. Social desirability has been defined as “the defensive tendency of individuals to portray themselves in keeping with perceived cultural norms” (Adams et al., 2005). Social approval is, “the tendency for an individual to seek a positive response in testing situations” (Hebert et al., 2002). The potential for error may be minimized by including measures of social desirability and/or social approval bias in the design of the interventions. Surprising to me, none of the studies measuring HPD use by self-report included a measures of social desirability or social approval biases.

## **Gender Differences in Predictors of HPD Use**

This was the first study to examine gender-related differences in predictors of HPD use among farm operators. The results of this study indicate there are differences. Interventions tailored for women farmers with a focus on value of HPD use and self-efficacy for HPD use would be expected to result in an increase in HPD use. Likewise, applying intervention methods related to interpersonal support, situational influences and decreased barriers for men should also result in increased HPD use among farmers.

### **Strengths**

Combining parent study datasets provided a larger sample size for analysis. The increased sample size produced a study with higher power compared to the parent studies, reducing the potential for a Type II error, failing to detect a true effect. The higher power may have contributed to identification of two predictors (self-efficacy and value of use) that were not identified in either of the individual parent studies.

The findings in this study build upon the existing intervention research to promote the use of HPDs among farmers by supporting previous research findings and adding new information specific to gender. They also support the use of established theory concepts, self-reporting of HPD use (with qualification), and use of the Farmers' Predictors of Hearing Protection Device Use Model. This was the first study to compare gender differences in predictors of farmers' use of HPDs. Important differences were demonstrated by combining two data sets for analysis. The larger sample size of men in the combined studies (n=513) compared to the women (n=173) might appear that men were oversampled. However, considering the fact that women comprise 30% of United

States farm operators, this ratio is reflective of the farming population, an indication that sampling methods in the parent studies were effective.

### **Weaknesses**

Paucity of published intervention research to promote the use of HPDs among farmers presented a challenge in both collection of information and analysis. Very few intervention studies appear in the literature and of those that do, heterogeneity of design and statistical analysis prohibited meta-analysis.

Also, a limitation of the secondary data analysis includes a potential difference between the original study designs and the objectives of this secondary analysis. In the case of the current analysis, both parent studies contained similar populations, instruments, theoretical models and dependent variable. The main objective of the secondary analysis was to determine gender differences in the same population. Therefore, this limitation was minimal.

### **Implications for Future Research**

Because homogeneity of terms is useful for comparative studies, future research on concept analysis and refinement may be appropriate and useful in the development of research among farmers to promote HPD use with farmers, especially since this is a relatively young area of research (Sartori, 1984). Utilization of theory concepts that have been shown to be predictors of HPD use may strengthen future interventions. Further testing of the Farmers' Predictors of Hearing Protection Use Model are indicated. Revision of instruments with low reliability scores, and small number items may

strengthen future research as well as the development and testing of self-reporting methods.

Longitudinal studies with long term follow up to assess maintenance of HPD use are needed to understand the phenomenon of low HPD use among farm operators. Secondary analyses of studies with similar design, such as the parent studies in this paper will be useful in the advancement of research focused on the hearing health of the farming community. Homogeneity in design will support those studies.

Cultural studies among the farming community may increase researchers understanding of gender influence, social desirability, and social approval attributes within this worker group.

Reliability analyses in this paper indicate self-reporting can be an appropriate method of data collection, especially among this population of workers. Future method designs that include daily activity cards to provide farm operators the opportunity to report HPD use concurrent with work activity may strengthen reliability of self-reporting of HPD use.

Interventions to increase self-efficacy for HPD use and increase knowledge of NIHL risk and prevention (value of HPD use) may strengthen future interventions among women farm operators. Focusing on the social support aspect of HPD use, ensuring availability of HPDs, and removing barriers to HPD use may have a positive effect on HPD use among men farm operators.

Interventions have been implemented on the population level that included increasing awareness of NIHL and providing information on prevention to farming communities at strategic locations (Lower, Fragar, Depczynski, Challinor, Mills &

Williams, 2010; Smith et al., 2008). It is unknown if these population-based interventions had an effect on HPD use. In a cost-analysis study, Donham, et al., (2007) found evidence of decreased injury-related costs in counties where individual interventions promoting farm safety were implemented compared to control counties. There is a need for studies comparing the effectiveness and cost-effectiveness of primary prevention strategies at the individual and population levels.

McCullagh et al. (2010) suggested considering revision of the Predictors of Farmers' Hearing Protection Device Use Model to remove the predictors of self-efficacy, age, and value in future studies. However, in the combined data sets, these were found to be significant predictors of HPD use; removal might be reconsidered with additional studies. Consideration might be given to increasing the number of items on some instruments. Specifically, the instrument to measure Interpersonal Influences was subdivided into three distinct scales, resulting in a low number of items in each scale. If each of the concepts in the sub-scales is truly unique, increasing the number of items may increase reliability and utility of those scales.

Studies promoting HPD use were limited to a maximum of three months of follow-up with the exception of one study. Reed & Kidd (2004) reported observation of behavior change as far as one year following the intervention. Consequently, the long-term effectiveness of interventions is unknown. Future studies to promote farm operators' HPD use would be strengthened by including a measurement of HPD use over time (e.g., greater than three months).

## **Policy Implications**

Prevention of disease has been described as having three levels: primary, secondary, and tertiary. However, only primary prevention addresses avoidance of the disease before it occurs. The United States government, specifically the Department of Health and Human Services, has an interest in the health status of the American people and the prevention of disease. This interest is demonstrated in national objectives such as Healthy People 2020, the latest of four 10-year plans to improve the health of the nation, both of individuals and aggregates. Attention is given to the elimination of preventable diseases, injuries, and premature death. Objectives include creating social and physical environments that support good health behaviors. Government funding supports projects designed to meet the goals and objectives of these health promotion efforts. Noise induced hearing loss is a preventable disease and has been shown to contribute to injuries (Sprince, et al., 2002; Wallhagen, et al., 1997).

Prior research has indicated that good health behaviors (e. g. use of HPDs) can prevent this disease. Nurses and other health care professionals can work toward improving the hearing health of the United States farming community with research and interventions designed to promote farmers' use of HPDs.

Research consists of building knowledge and learning something new about a particular phenomenon, but does not have the immediate goal of changing behavior. Research on predictors of behavior forms the foundation on which behavior change interventions are built. Without predictor research, behavior change interventions may be poorly conceived. This research may consist of qualitative information gathering or quantitative data collection. Research may also be retrospective, longitudinal, or cross-

sectional; it could take place in a laboratory or in field studies. Whatever design of the predictor research, it must be undertaken prior to designing behavior change interventions.

Behavior change interventions use knowledge derived from predictor research to effect behavior change. Assessing maintenance of the behavior change will allow researchers to better determine achievement of intervention objectives, and inform future behavior change interventions, thereby building on the body of knowledge. Continued funding to support such research will move us, as a nation, closer to meeting the goal of improving hearing health in the farming community.

NIOSH is responsible for conducting research and developing recommendations for the prevention of work-related illnesses and injuries. Farmers represent a community of workers at risk for NIHL. Government funding for the necessary research to work toward preventing this disease is an important part of decreasing the incidence of NIHL among farm workers.

It is difficult to measure what never occurs; so it is with preventative health initiatives. Hearing loss can be measured, use of HPDs can be measured, but measuring the amount of hearing loss prevented by use of HPDs is an impossible task. What researchers do know is that farmers are exposed to hazardous noise levels throughout their workday, properly used HPDs can prevent NIHL, HPD use among farm workers is low, women are more likely to use HPDs than men, women influence health practices of others, and more interventions are needed to promote the use of HPDs among this high risk group. Allocation of resources to efforts aimed at the prevention of NIHL among our

farming community to improve the health status of this underserved population is justified by evidence.

Unfortunately, there appears to be a disconnect between our stated health objectives as a nation and practice guidelines in the area of hearing health. A thorough search of the Affordable Care Act, signed into law in 2009, does not contain recommendations or provision for hearing health screening for adults. Ironically, it does allow for a tax exemption for the purchase of hearing aids. Likewise, neither the American College of Physicians, nor the Agency for Healthcare Research and Quality address the hearing health of adults.

### **Significance**

The analyses in this paper indicate that current intervention research to promote HPD use has produced limited positive results, but is constrained by a small number of heterogeneous studies, small sample sizes, lack of random controlled trials, and self-reported measurements without validation.

In this paper, theories and theory concepts were identified as relevant for intervention design and suggestions for further concept development or refinement were offered. Comparative studies are useful in developing research interventions, but can be complicated by semantic heterogeneity between studies. Refinement and synthesis of concept terms may be useful for future studies, fostering homogeneity and clarity of concepts.

Self-report, a practical and sometime the only feasible method of data collection in HPD use research among farmers, was examined for reliability. The analyses in this

paper suggest that researchers may enhance the reliability of self-report of HPD use as a measurement method when certain precautions are taken in method design. The greater the reliability of a measure, the more assured researchers can be of the validity of the findings. Researchers and practitioners can interpret study findings with more confidence when intervention designs control for systemic biases such as social desirability, social approval, and recall biases.

Testing of the Farmers' Predictors of Hearing Protection Device Use Model supported its usefulness among this population. Predictors of HPD use among women farm operators that had not previously been identified were identified in the secondary analysis; some predictors were consistent with other studies. These findings support the utility of the model and relevance for further use in farmers' HPD use studies.

This study was developed to examine the current state of the science of interventions to promote HPD use among farmers. Results from this study affirm that overall, the limited positive results from the current intervention studies indicate the need for further research development, implementation, and evaluation. Information from this study can be used in the design of interventions to promote HPD use among farmers with the goal of reducing the incidence of NIHL among these workers.

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