Using the Extended Parallel Process Model to Prevent Noise-Induced Hearing Loss Among Coal Miners in Appalachia

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Occupational noise-induced hearing loss is the second most self-reported occupational illness or injury in the United States. Among coal miners, more than 90% of the population reports a hearing deficit by age 55. In this formative evaluation, focus groups were conducted with coal miners in Appalachia to ascertain whether miners perceive hearing loss as a major health risk and if so, what would motivate the consistent wearing of hearing protection devices (HPDs). The theoretical framework of the Extended Parallel Process Model was used to identify the miners' knowledge, attitudes, beliefs, and current behaviors regarding hearing protection. Focus group participants had strong perceived severity and varying levels of perceived susceptibility to hearing loss. Various barriers significantly reduced the self-efficacy and the response efficacy of using hearing protection.

Keywords: *hearing protection; Extended Parallel Process Model; noise-induced hearing loss*

Noise is one our most pervasive and entrapping pollutants, invisibly damaging the hearing of more than 28 million Americans.[1] Research shows that more than 90% of coal miners experience moderate to significant hearing loss by retirement; moreover, by age 25, coal miners have about as much permanent damage to their hearing as a nonnoise-exposed worker by age 55.[2,3] Although technology and ecological advancements are helping to reduce noise pollution, the noise levels underground still necessitate individual

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hearing protection.[4] As a result, researchers from the National Institute for Occupational Safety and Health (NIOSH) have made hearing conservation a top priority.

It is well documented that culture shapes what is perceived as a health risk.[5] In the coal mining tradition, health concerns have been limited to black lung disease and the wearing of protective clothing (i.e., helmet, gloves, coveralls), not hearing loss.[6] Hence, the purpose of this article is to bring hearing loss into focus as a significant health threat with miners and to determine the most effective means of motivating them to protect their hearing. To focus on mining worker behavior change to adopt the use of hearing protective devices (HPDs) the Extended Parallel Process Model (EPPM),[7] was used as the theoretical framework with two goals for this endeavor: (a) to assess the coal miners' knowledge and perceptions toward hearing loss and the wearing of HPDs as they relate to constructs of the EPPM and (b) to determine how the model may help practitioners design messages for hearing loss prevention campaigns.

OCCUPATIONAL NOISE-INDUCED HEARING LOSS (NIHL) AMONG COAL MINERS

Noise is defined as "any unwanted auditory signal, a signal that interferes with the detection and discrimination of sound" (p. 1079).[8] NIHL refers to the sudden or gradual loss of hearing as a result of intense or extreme noise exposure. NIHL can occur through either traumatic and rapid noise exposure, such as a gunshot or explosion, or gradual, long-term exposure to hazardous sounds.[9] The destructive quality of noise is related to its intensity and duration, where intensity is established in decibels (dB). Small increases in decibel increment (e.g., from 20 to 25 dB) actually double the decibel level a hundredfold in intensity.[10] Despite individual differences (e.g., genetics) for susceptibility to noise, one established characteristic of NIHL is that more intense and/or longer duration noise exposure will lead to moderate to severe hearing loss.[6]

Given the seriousness of NIHL, the Mine Safety and Health Administration (MSHA) has implemented new engineering controls to reduce noise level. Yet current technology still necessitates additional hearing protection.[4] According to the Occupational Safety and Health Administration guidelines, effective hearing conservation program are more than technological advances. It also includes training workers in the use of hearing protection and audiometric testing.[11] As a result, this formative evaluation focuses on just one piece of the larger puzzle.

Coal miners should receive no more than 90 dB in an 8-hour working day.[9] Data[4] suggest that noise exposure measurements (made by MSHA personnel at a coal mine during a three-shift period) for longwall shearer operators exposure was 97 dB with maximum

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exposures of 116 dB. Similarly, roof bolters had an average exposure of 98 to 108 dB, with a maximum exposure of 115 dB. Continuous miner operators and continuous miner helpers recorded 95 to 100 dB, with maximum exposures of 118 dB. With these exposure levels in mind, every longwall shearer operator, roof bolter, continuous miner operator, and continuous miner helper is overexposed based on current MSHA noise standards. Thus, miners must actively protect their hearing.

To be in compliance with MSHA noise standards, miners who exceed 90 dB in an 8-hour shift must decrease exposure by half for every 5 dB added. Hence, a rise from 90 to 95 dB requires a reduction in noise exposure by 4 hours (MSHA standard, 30CFR section 70.510). Individual hearing protection significantly reduces exposure, thereby increasing the amount of time available to work underground. Earplugs have been reported to be the most effective method (up to 85% noise reduction), with earmuffs less effective (averaging 12% noise reduction) and semiaurals the least effective (around 3% noise reduction).[12] Regardless of the device used, it is important to correctly fit test the product to each worker and have the worker wear the device consistently to ensure proper hearing protection. Yet research indicates that less than 10% of the existing hearing conservation programs (HCPs) conduct fit testing or enforce continued wearing of HPDs.[13] Therefore, it becomes important to understand how to help these individuals to prevent NIHL.

THEORETICAL FRAMEWORK: THE EPPM

Fear appeal messages have been useful in behavior change as they highlight the risk(s) an individual faces for performing or not performing a recommended action. In coal mines, workers face significant risks if affected by NIHL, including self-injury or team member injury.[4] Hence, the EPPM is offered as a theoretical framework for how individuals might process fear appeals related to hearing conservation.

Although several theoretical frameworks could be used to examine this context, such as the Parallel Process Model (PMM)[14-16] or Protection Motivation Theory (PMT)[17,18] the EPPM[7] was selected. The EPPM is based on the explanatory mechanism of Leventhal's[14,15] PPM with Roger's[17,18] PVT research focusing on what makes fear appeals work. Specifically, the EPPM utilizes the protection motivation theory linkages among perceived levels of severity, susceptibility, response efficacy, and self-efficacy that lead to message acceptance and, ultimately, attitude, intention and behavior changes. Yet PMT does not specify directly in either the original or the revised model when and why people reject these recommendations. In a similar fashion, the PPM offers the distinction between generative cognitive and emotional reactions as viewed in the EPPM. The PPM, however, argues that protection behavior stems from attempts to control a real or potential threat (cognitions), not attempts to control fear resulting from the process (emotions).[15] In comparison, the EPPM offers 12 specific propositions and predictions as to the separate conditions under which fear/emotion and danger/cognition responses should occur, thereby elucidated why fear appeals messages should both succeed (i.e., danger control) and/or fail (i.e., fear control) (for a full review, see Witte[7, 32]). Although both the PVT and PPM are very useful frameworks for viewing responses to fear appeals messages, the EPPM appears to be a more inclusive framework for conducting this formative evaluation.

Since its inception, the EPPM has been used extensively across a variety of topics (e.g., tractor safety, skin cancer, and AIDS) and populations (e.g., farmers, Hispanics, and Taiwanese students).[19-24] The EPPM suggests that when presented with a risk mes-

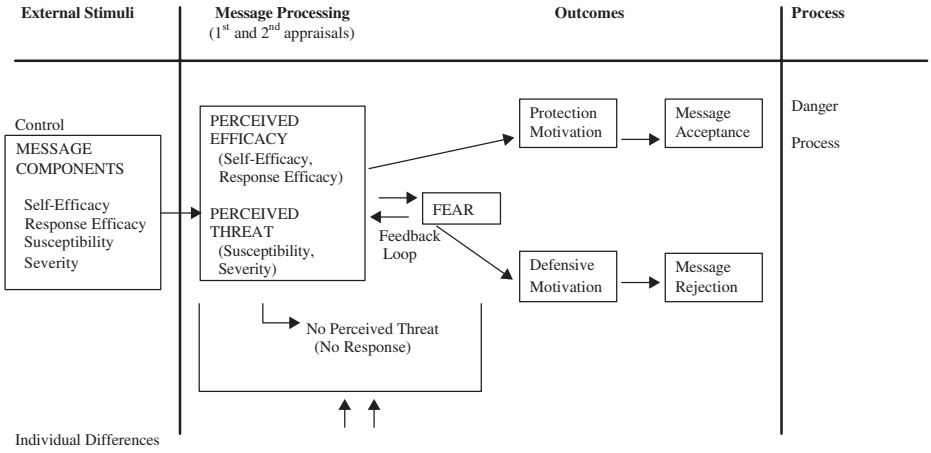

Figure 1. Witte's[7] Extended Parallel Process Model (EPPM).

sage, individuals engage in two appraisal processes which produces one of three outcomes (see Figure 1).

First, individuals appraise whether they are susceptible to the identified threat and whether the threat is severe. Perceived susceptibility is the extent to which an individual feels at risk for a particular health threat, whereas perceived severity is the extent to which an individual believes the threat to be serious or harmful. If the threat is perceived as either trivial or irrelevant, they will ignore the risk message and not even think about recommended behaviors (because the threat is not of concern to them).

Second, if individuals believe they are susceptible to a severe threat (i.e., high perceived threat, which comprises both perceived susceptibility and perceived severity) and fear is aroused, they are motivated to act and appraise the extent to which the recommended response effectively deters the threat (i.e., response efficacy) and the extent to which they are able to perform the recommended response (i.e., self-efficacy). When perceived threat is high and individuals believe themselves able to perform a recommended response that effectively minimizes the threat, they will control the danger and follow the recommended guidelines. However, when the perceived threat is high but individuals doubt their ability to effectively minimize the threat (such as personal, social or physical barriers), they turn instead to controlling their fear and engage in denial, or defensive avoidance. In sum, perceived threat (i.e., perceived susceptibility and severity) motivates action. Perceived efficacy (i.e., recommended response efficacy and self-efficacy) determines whether individuals control the danger and make behavioral changes or control their fear through psychological defense mechanisms, such as defensive avoidance or reactance.

According to the EPPM, coal miners who perceive hearing loss to be a significant health threat and believe that hearing protection is effective are more likely to make a cognitive choice to engage in protective health behaviors (i.e., danger control). In contrast, miners who are afraid to confront potential hearing loss, or think HPDs do not work and do not want to invest time in finding the most appropriate form of hearing protection, are likely to focus on their emotional response. These individuals are likely to ignore or react to the advocated message leading to continued HPD disuse (i.e., fear control). Therefore, if the study reveals that miners' attitudes, beliefs, perceptions, and behavior are in the

opposite direction necessary to promote health behaviors, then the EPPM provides specific guidelines to induce threat and efficacy. It also assists practitioners as subjective norms and message channel preferences of the mining culture are measured (i.e., attitudes, beliefs, and behavior of the miners) to message recommendations for future NIHL campaigns.

METHOD

Research Design. A theoretically constructed focus group protocol administered to four different groups was considered to be the most appropriate methodological tool to assess the coal miners because of the ability to access complex psychological and social group processes associated with health and behavior.[25,26] Focus groups were conducted until answers and results produced significant overlap, thereby assuring that all potential variability has been displayed.[26]

Participants. A sample of 31 miners participated in four focus groups (ranging in size from 7 to 9 miners per group). Miners were volunteers from four mines: two moderate-sized mines (100 miners employed) in Indiana, Pennsylvania; and two smaller mines (65 miners employed) from Fairmont, West Virginia. The participants were male, with the exception of one female coal miner who was present for one session. Across the four groups, average coal miner age was 37, with years spent in coal mining ranging from 15 to 30 years. When analyzed separately, ages ranged from 29 to 51, with 10 to 30 years in the mining industry, for West Virginia; and 30 to 47, with 11 to 26 years in the mining industry, for Pennsylvania. No significant differences emerged between the ages and years in mining between the groups.

Procedure. Participants were told the United Mine Workers of America (UMWA) was interested in understanding whether miners perceived hearing loss as a major problem. The purpose was to improve safety campaign messages addressing this topic. After providing informed consent, participants were told they would be videotaped and audiotaped to ensure accurate transcription and paid $25 for their time. Each focus group lasted approximately 1½ to 2 hours. Participants were reminded their responses would remain anonymous and they should give complete, honest answers as their supervisors would not be privy to the information. At the conclusion of the focus groups, participants were thanked, paid $25 for their time, and told they would receive study results at the conclusion of the larger project.

Focus Group Protocol. Focus group questions were derived from the EPPM (i.e., perceived susceptibility, perceived severity, response efficacy, and self-efficacy) and discussions with researchers from NIOSH who serve this population on a continuous basis. The first author may be contacted for a version of the protocol used for this formative evaluation.

Pilot Tests. The focus group protocol was pretested in three ways. First, all research team personnel assessed the protocol for construct and face validity. Second, researchers met with NIOSH and MSHA personnel to review the protocol for completeness, accuracy, and flow. Third, the focus group protocol was pilot-tested with members of the UMWA to determine (a) flow/content of the protocol, (b) language usage (literacy com-

prehension and language appropriateness), and (c) introductory procedures (e.g., scripts and participant engagement). (See Krueger.[29])

Recruitment Phase. UMWA members and NIOSH personnel from the Office of Dust Control and Toxic Substances, Pittsburgh Research Laboratory, Pennsylvania, assisted in focus group recruitment. Personnel received a packet of information with project description and recruitment materials, including flyers and signup sheets. Miners were recruited for sessions before and after work shifts. Personnel set up for the site, day, and time of the focus groups for data collection.

Analysis. The audiotapes of the focus groups were professionally transcribed. Videotapes were not used for formal analysis but clarification if a portion of the audiotapes was poor. Three research team members analyzed the common themes from the transcripts according to a previously constructed coding scheme. The intercoder reliability (kappa = .88) was considered acceptable.[33] Disagreements were solved by roundtable discussions and reanalysis of the transcripts, which raised the intercoder reliability (kappa = .92). Table 1 summarizes the results of the unitized categories of this study. (For the barrier analysis, see Patel et al.[27])

RESULTS

Each of the dimensions of the EPPM were evaluated (i.e., susceptibility, severity, self-efficacy, and response efficacy) in addition to subjective norms and participants' channel preferences.

Perceived Susceptibility of Hearing Loss. All miners reported the concept of hearing loss as potentially scary and frightening. Comments ranged from "it got me 10 years ago" to "I got permanent damage to the right ear. I mean it's really bad and I always got the constant ringing." Although NIHL was perceived as a significant threat, there were significant differences in awareness of susceptibility. All West Virginia participants reported knowing someone with NIHL, whereas only a majority from Pennsylvania reported knowing those with NIHL. Across both states, however, all miners reported high personal risk and many reported current hearing loss. Participants who knew others with moderate NIHL reported greater susceptibility for future NIHL risk.

Whereas most reported a high noise environment and described their personal experiences with hearing loss (i.e., tinnitis, high-range frequency loss, turning head to hear others, and lip reading), several believed they experienced maximum hearing loss and "not much more damage could be done." For example, "I'm already deaf in the left ear and the right's pretty bad, there's nothin' going to help or hurt me for that matter" and " I didn't use hearing protection, but now it's a case of too little, too late" were common responses. Many said they did not know how much noise exposure they received daily and therefore had a difficult time assessing susceptibility. For example, "does anyone know where we're at for decibels" and "I wonder what the difference is between the scrubber and up at the face [where drilling occurs]." Most participants recognized the potential for NIHL by retirement, but were unable to determine their daily noise exposure.

Perceived Severity of Hearing Loss. Participants recognized NIHL as horrible, serious, harmful, permanent, and affecting their quality of life. No significant differences of

Table 1. Recommendations of Respondents for Effective Hearing Loss Awareness and Protection

Beliefs to change	Lack of multiple types of hearing protection devices (HPDs) available; lack of replacement parts for HPDs; environmental noise too great for HPDs to handle; miners lose hearing while wearing HPDs
Beliefs to introduce	Hearing protection does not drown out roof talk; hearing screenings should be conducted yearly; hearing protection must be worn regularly for benefit; hearing protection must be worn continuously, even when team is not immediately mining
Beliefs to reinforce	Hearing protection protects against noise hazard; wearing HPD regardless of other miner's nonuse or irregular use of protection; wearing protection is easy to do; wearing protection minimizes severity of damage; using hearing protection is low-cost
Improvements in self-efficacy	Cooler HPDs to wear in mines; how to keep hearing protection clean; learning to communicate while wearing HPDs; overcoming roof-talk while wearing HPDs; finding HPDs that fit well for continuous wear
Channel preferences	Direct mail; helmet stickers; UMWA newsletter; local mining office flyers, bulletins; postcards, pamphlets, and brochures in union offices
Source preferences	Doctor/health care provider; Mine Safety and Health Administration (MSHA) and/or UMWA representative; local safety administrator; miner with current hearing loss; NOT wife or family
Information to include	Personally relevant, humorous text; list of HPDs available; noise-induced hearing loss (NIHL) statistics; availability and locations for hearing screenings; address hearing loss with reduced quality of life; constant need to monitor hearing loss, wear HPDs

perceived severity were reported between the groups. Participants at all four mines reported that about half of their coworkers had some form of NIHL (e.g., tinnitis, loss of high-range frequencies, or deafness).

All participants reported decreased hearing in time and increased difficulty engaging in conversation where background noise persisted (e.g., restaurants and stores). Many admitted they did not want to access hearing screenings or tests because that would require recognition of the severity of the hearing loss (e.g., "I haven't had a hearing test in more than 15 years and I'm not planning on one" and "Does anyone here remember when they last had their hearing tested? I don't even want to know."). One explanation for the reduction in perceived severity was their inaccurate knowledge about noise exposure from other teams operating in the workstation vicinity. Several reported that, "You don't need to wear 'em if the duster isn't on and you're in the back [of the operation]" or "I only wear them while at the face [where drilling occurs]." They believed their immediate environment led to NIHL, as noise emanating from other teams was of little consequence.

Response Efficacy. Most participants perceived hearing protection to be moderately effective. Some reported that "it really absorbs the sound" and "after wearing my [ear] muffs for two weeks, I could really see a difference." Participants from West Virginia, however, were much more likely to wear HPDs than those in Pennsylvania because they thought they worked.

Pennsylvania participants believed HPDs were only slightly effective in reducing overall environmental noise and they created more problems than solutions. For some, HPDs made perceived hearing loss worse. One participant reported, "When I have the machines on, the pig operator has [a] constant clanging, pounding, pounding. The muffs

are like a metal canopy over you and there's nothing to absorb the sound other than your ears and its drone, drone, drone." Another said, "You're already straining to listen because of that machine, and now put your plugs in, and tell me how in the world can you hear above the hummin' in your ears from the machine and do your job properly?" For some miners, HPDs were equated with the amplification of noise. In reality, HPDs primarily block high-frequency noise but not the low-frequency noise that is also a major source of stress on the ears.[34] Overall, a greater concern existed for job professionalism and others' safety underground than personal safety.

Some participants, however, felt that teammate safety also translated into personal safety (and used this as an excuse not to wear HPDs). When working underground, miners listen for shifts in bedrock and rock layers known as "roof talk" to determine if the bolted ceiling will cave in. They believed that "hearing is the only protection you have from it [a bad roof] and if you aren't sure of what you're hearing, you just had to know" and "we're so confined in there and even if you can't hear the echo, those sound waves are still bouncing around and I need to hear 'em." Although participants from Pennsylvania appeared more concerned than those from West Virginia, all four groups discussed the topic. Thus, it appears that these individuals are more concerned with immediate survival underground than the nuisance of hearing loss. Interestingly enough, none of the miners discussed the possibility of not using HPDs and going deaf, another condition in which hearing "roof talk" would be extremely difficult.

Self-Efficacy. Many participants identified that the self-efficacy barriers for HPDs were stronger than those associated with response efficacy. Their concerns ranged from comfort, hygiene of HPD products, and cost, to their inability to want to make a behavior change. For example, most Pennsylvania participants reported standard HPDs as too warm for daily use. At one mile underground, the temperature can be stifling, and as one said, "When you're down here on a shift you want to peel your clothes off, especially in the summertime, that's when it's really awful."

In terms of hygiene, their concern related to their ability to use the product correctly. Participants complained that some earplugs were too small and fell out of their ears. Although some put the plugs back in after they had been on the ground, others threw them away because of the potential for ear infections. As one participant related, "After taking them out and putting them back in each time we finished a section, I started getting ear infections. Now, I have to have my ear flushed every 2 to 3 months." Some also admitted being lax and not changing their earmuff inserts often enough (to keep the ear canal safe from noise and maintain cleanliness).

A third concern was cost. Although mine facilities are required to provide hearing protection, there appeared to be an ecological issue associated with participant self-efficacy. For example, West Virginia participants reported a constant shortage of replacement parts for the earmuffs. Yet in acknowledging a shortage, only one miner across both groups discussed purchasing his own hearing protection and replacement parts. More research is required to further assess if requested replacement parts were unavailable, if operation facilities did not carry specific parts for particular devices, or if individuals were only willing to use specific HPDs and a shortage existed for only those types of parts (and not others supplied).

Age and longevity in the mining industry also served as barriers for HPD use. Many reported ignoring their NIHL as it can be "hard to teach an old dog new tricks" and it was "probably too late to protect what I got." Several reported that "I have found myself the last couple of years turning my head a lot [to hear conversations], that's when I knew I got

it [hearing loss]" and "I wish I had started years ago. I mean I'm 40 years old and I'm one of the younger ones in there." Most believed that it is necessary to have hearing conservation and require hearing protection for new workers. Yet some older workers (those in the mine for 25 to 30 years) did not view themselves as still able to protect what hearing they still had or discus their duty as role models for younger workers.

When participants were asked what they believed would increase HPD wear, there was general agreement that improved comfort was a priority. Miners reported a positive attitude with HPDs when they believed it could be performed easily and effectively. Yet West Virginia participants reported a preference for a particular type of HPD that fit better than those provided by their facility (although participants perceived the brand was not always replaced due to financial cost).

Subjective Norm. Across the groups, participants believed that both across the profession and within their mines, HPDs were becoming regular use equipment. When asked to estimate the number of individuals wearing hearing protection, most estimated it was between 50% and 70%. Yet participants cautioned that their estimation did not reflect continuous wear but rather that hearing protection is worn during different times of the day depending on the equipment operated. As one participant explained, "The guy who is at the face wears his most of the time, I only wear mine when the scrubber is on [due to differing noise levels]." Others agreed, stating, "When I bolt I'll put 'em on and then I'll drill the first row or two without 'em so I can hear what the roof sounds like" and "he flips his muffs up and down all day." Despite strong reporting for coworkers, focus groups participants estimated their own HPD use between 10% and 20% a day.

Despite participant perceptions of soaring HPD use industry-wide, hearing protection was viewed as an individual choice. Participants reported they did not believe they could influence coworkers to wear their hearing protection regularly. As one participant commented, "Jim here has been wearing his for more than 10 years, he's the smart one, but if I was to tell everyone it wouldn't work" and "we are responsible to each other underground, but we don't tell each other what to do." Again, there appeared to be a conundrum between personal safety and the safety of teammates underground.

Despite their many objections to HPDs, participants who wore hearing protection and challenged their teammates to try them for a week or two realized they all could hear verbal directions using protection when actively mining. Several noted that "after about a week, I can hear what he says to me, just takes time to get used to it" and "he's the smart one [referring to a coworker who has worn hearing protection for years underground], bet now he can hear better than me above ground." Still, those trying hearing protection for the first time found that they had to try several different options before finding one that fit. Again, concerns were raised that "the plugs are too loose" and "the earmuff doesn't cover my entire ear, so I don't feel protected." Although mining facilities are required to provide hearing protection, proper fit (thereby affecting comfort) remained one of the most significant barriers. Royster and Royster[12] reported similar concerns, as 76% of companies in the United States where hazardous noise levels exist do not conduct fit testing of hearing protection before it is dispensed to workers.

On a positive note, miners reported never teasing those who wore HPDs, either consistently or intermittently. Although they joked about the hazards of the mining industry, hearing loss was a serious concern. "Hearing loss is just as bad as getting black lung," one participant reported. Most agreed, saying, "I've never heard anybody tease anybody about hearing, maybe he can't see or can't sing, but there's nothin' funny about jaggin'

anybody about that." The consensus was that hearing loss was serious both personally and professionally.

Channel/Source/Message Preferences. When asked about what information they would like to receive about hearing conservation and how they would like this information transmitted, some participants believed that just discussing this topic was a step in the right direction. Several reported, "This is the first time I've had a chance to talk or even think about it" and "we're glad to know that you care and are concerned about us, we need more information."

Focus group participants said they wanted to learn more about hearing loss and protection in the UMWA newsletter "like we learned about the black lung." Another channel for preventing hearing loss revolves around the use of helmet stickers. According to participants, helmet stickers are collected and traded and serve as reminders of important mining events and industry information. They are akin to the safety posters (e.g., "Think Before You Act," "Safety—Insurance for You and Your Family," "Careless Is Dangerous," "Think, Your Actions Can Harm Others," and "If You Need Help, Ask!"), which remind workers of a particular message as they travel in and out of the mine. Several also inquired about access to information—"Can we get a pamphlet or flyer?" or "Would something be sent to us in the mail?" Therefore, it appears miners are receptive to a variety of channels for information distribution, in addition to continuous UMWA branch and safety meetings.

Although participants were interested in hearing loss prevention, they admitted spouse and family "nagging" was not effective. Several reported, "Hearing loss isn't so bad, at least now I don't hear my wife so often" and "I don't have to worry about those kids with those loud radios in their cars, I can't hear it anymore." Overall, information produced from the UMWA, MSHA, doctors, and hearing specialists would have the greatest effect in improving the wear of hearing protection on the job.

Message preferences were also solicited from the focus groups. Most miners perceived fear appeals as having a minimal effect in increasing the use of HPDs. For example, "I work this far underground every day where I could kill someone with a mistake, what could scare me?" and "Do we look like a bunch of scared men?" were common responses. From a long list of pregenerated message appeal strategies, humor was chosen as the most preferred persuasive method.

Additional Advice From Focus Group Participants. When focus group members were asked for ideas to improve a hearing loss campaign, they suggested attention paid to message graphics (to increase interest and motivation) and audiometry devices to register decibel levels underground. Participants believed that awareness of personal susceptibility and hearing loss severity would be achieved by registering noise exposure with and without hearing protection according to the different machines operated. They also perceived that continuous hearing screenings to force recognition of the widespread problem would change current perceptions of hearing loss and increase HPD use.

DISCUSSION

Hearing loss among coal miners continues to be a significant health threat. Given the decibel rates below ground, it is apparent that HPDs are an absolute necessity to protect hearing. Although HPD wear constitutes only one-third of a hearing conservation pro-

gram, in addition to technological advances and annual hearing screenings, this self-protective behavior may help to reduce the progression of NIHL.

Using the theoretical model of the EPPM, when individuals perceive the health threat to be serious or severe, they attend to the message and follow the recommended responses. Although the miners recognized hearing loss as damaging (severity), there were some differences among the levels of perceived susceptibility. Specifically, those in the mines more than 25 years were not sure they could lose more of their hearing (as so much had already been lost). Those with fewer years in the mines, however, were more concerned about hearing protection. Although interested in protecting their hearing, participants across all four groups thought that hearing conservation needed to start on Day 1 and not 10 years or later into their profession. Thus, perceived susceptibility must be heightened in future campaigns.

According to the EPPM, the level of perceived threat is only the first half of the equation. Individuals must also have appropriate levels of perceived efficacy to avert a threat if health behavior change is to occur (i.e., danger control processes). Although none of the participants admitted to being in fear control (i.e., "not a bunch of scared men"), it was evident that some (i.e., older miners) were operating through fear processes. For example, several who self-reported NIHL did not want to have an annual hearing screening or were not sure they wanted to know how many decibels of noise they were exposed to underground. Some of these same individuals perceived a ceiling effect for their hearing loss (relating to perceived susceptibility) and therefore did not believe they were at risk anymore. The participants also perceived that "it can be hard to teach a dog new tricks." Therefore, it could be concluded that some older miners were indeed operating in fear control by ignoring and deflecting some of the methods available for determining hearing risk and subsequent conservation.

This is not to say, however, that all of the older participants reacted with fear. A majority of participants across the four groups were motivated toward danger control processes. Yet even these individuals lacked substantial perceived efficacy, as barriers existed for both response and self-efficacy to avert NIHL. In terms of response efficacy, miners were not always sure that HPDs worked (i.e., lack of protect fit) and that if they did work, they might be too effective, thereby blocking out important roof talk. These barriers were similarly evident in terms of self-efficacy as comfort, cost, convenience, age, improper fit, and perceptions of no further hearing damage (for those already affected) were excuses for not wearing HPDs. Thus, future work with this population must not only address the barriers faced in wearing hearing protection but demonstrate overtly how each one can be overcome.

As discussed, comfort and proper fit have been found to be the most difficult concerns in high noise industries.[28] Valoski[6] conducted a retrospective study of MSHA data regarding coal mining NIHL from 1980 through December 1994. In his report, 2,365 cases were reported (either the miner was diagnosed through a hearing test or was compensated for hearing loss), of which the greatest cluster of coal mining cases was found in West Virginia (1,403 cases), Virginia (116 cases), and Washington (20). In fact, West Virginia had more reported cases of NIHL than any of the other states combined (including Colorado, Illinois, Kentucky, Ohio, Oklahoma, Pennsylvania, Utah, Virginia, and Washington), which totaled 89.2% of all cases. In comparison, Pennsylvania only had 4 coal miners diagnosed or compensated with NIHL during the same time period. The data reported here appear consistent with Valoski's findings as they relate to perceptions of hearing loss. Given Valoski's and our work, it appears that several practical implications can be made to improve worker safety.

Implications for Practice

This study was completed just prior to hearing protection becoming mandated (as of the year 2000) and should serve as a baseline measurement to help to identify how to encourage consistent and continuous use of HPDs in the mining industry. Given these findings, there are several implications that merit discussion (see Table 1 for more details).

First, although hearing protection constitutes a second line of defense, technological advances need to continue for improving mining facility equipment, thereby reducing overall decibel levels. As miners appear to have only so much control of their environment (i.e., personal HPD wear and not selection of HPDs or mining machinery), mining facility management needs to make hearing conservation a top priority to maintain worker safety and productivity. Although this study was unable to determine the number of forms of hearing protection available to workers, it is clear that workers should have multiple options for wearing earplugs and/or muffs.

Second, fit testing must occur to ensure that workers are able to correctly use each product. By providing more choices and fit testing these devices, workers should have a better sense of how much noise is blocked by each HPD and be able to determine what might best fit their personal needs. With health educators working in conjunction with mine safety personnel, a concerted effort could be made to therefore improve perceived response efficacy of HPDs as well as reduce or eliminate many of the self-efficacy barriers related to hearing protection (as described by the EPPM).

Third, the level of threat used in education campaigns to heighten perceived need for HPDs should be varied according to the population under scrutiny. As a majority of workers recognized noise as a severe health risk to which they were susceptible, continued moderately high threat components should prove effective. Yet for workers who either misjudge the severity of their hearing loss or do not perceive themselves as still at risk, higher levels of threat should be evident in the message. Again, perceived threat must be maximized to encourage a response to garner efficacy levels.

Fourth, for those individuals who may not respond to fear tactics, message designers may want to first consider utilizing a range of health threats (i.e., from low to high) and, if this is not effective, should redirect their message to be combined with other tactics.[30] As noted, the participants in this study perceived humor to bolster attention to NIHL. Miners are an interesting target audience, as they appear to have low risk aversion given their working conditions. In this manner, some operate similarly to sensation seekers, a population that does not always respond to fear appeal messages. Thus, if fear strategies are used, they must be carefully monitored to ensure that it works to induce the advocated behavior change.

Fifth, hearing conservation messages should target the individual as well as subjective norms.[31] Most miners stated that they are concerned about protecting their hearing despite the perceived barriers regarding HPD use. And although they may not openly seek the support of other miners for their health behaviors, they are actively noticing others' use of hearing protection (i.e., "Jim here has been wearing his for more than 10 years, he's the smart one"). Thus, messages should be constructed to increase knowledge about NIHL and HPD use as well as to encourage normative standards for continuous hearing protection for teammate safety.

Limitations

There were several limitations to this study. As discussed, a ceiling effect existed for perceived susceptibility among some participants, as would be consistent with less risk-averse populations. Given that focus group participants represented 10 different mining operation positions, it would be useful to collect a second measure to determine if level of perceived susceptibility was a function of an individual's job position (i.e., discriminating between levels of hazardous noise exposure for different jobs), years of work in the mining industry, and/or related to personal experience of NIHL or knowing others affected by NIHL.

A second limitation was the age of participants under study. Focus group participants had worked in the mines for at least 10 years, with the vast majority between 15 and 25 years. It would be useful to sample several groups of younger miners (e.g., less than 1 year, 1 to 5 years, and 6 to 10 years) to determine their (a) perceptions and knowledge related to NIHL, (b) perceptions of HPD use and barriers affecting use, and (c) current HPD use (i.e., continuous or intermittent). Moreover, a comparison study of older and younger miners analyzing the change of hearing over type and correspondence of HPD perceptions would be very useful to help younger individuals understand the effect of not wearing HPDs. This information would greatly assist health educators in knowing if similar messages effective for older workers would be equally effective with younger workers.

Third, related to the population is greater understanding of the subjective norms of this culture relating to hearing conservation. Although focus group participants presented themselves as very individualistic, the interrelationship between members evidenced strong subjective norms (such as concerns relating to safety and roof talk). It would be helpful to take several of the message strategies, such as the posters or helmet stickers, and implement a HPD wear campaign to determine their effectiveness in impacting these work standards.

Fourth, as previously stated, this study was unable to provide a thorough evaluation of the types of hearing protection provided to workers. Given the numerous concerns about HPDs, future studies should actively pursue the interaction of type, daily use, and worker-perceived barriers of these devices (once proper fit testing has occurred). This information would greatly help individuals to choose the most appropriate fit protection (through a hierarchy of barriers) and help practitioners to design materials to work through this issue.

Conclusion

Future studies should not only continue to assess the dimensions of the EPPM (i.e., perceived susceptibility, perceived severity, response efficacy, and self-efficacy) and limitation of this work but should also determine worker HPD use and management conditions for choosing HPDs. There is much work to be conducted to better understand the overall process of hearing conservation in this environment given the ecological challenges presented in this industry. Overall, the lesson learned from this theoretically guided formative evaluation is that attention to noise-induced hearing loss greatly improves the chances of developing effective health messages and improving worker safety.

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