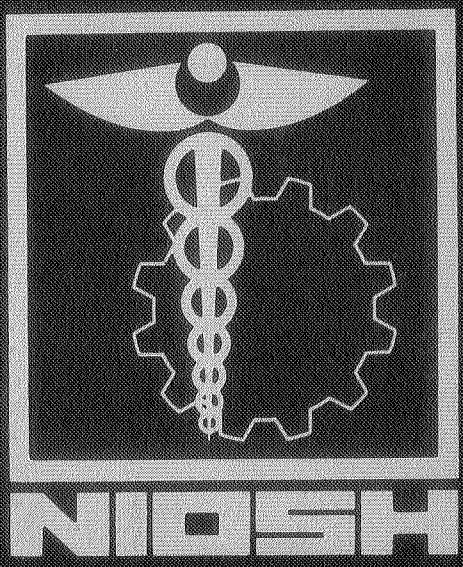

Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries

• Noise-Induced Hearing Loss •

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

Proposed National Strategy for the Prevention of Noise-Induced Hearing Loss

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1988

DHHS(NIOSH)Publication No. 89-135

Introduction

This document, *A Proposed National Strategy for the Prevention of Noise-Induced Hearing Loss*, summarizes what actions need to be taken to prevent occupational noise-induced hearing loss. It was developed in 1985 at a conference sponsored by the National Institute for Occupational Safety and Health (NIOSH) and The Association of Schools of Public Health (ASPH), which brought together over 50 expert panelists and 450 other occupational safety and health professionals.

In addition to the strategy for noise-induced hearing loss, NIOSH and ASPH have published strategies for the other nine leading occupational diseases and injuries: occupational lung diseases, musculoskeletal injuries, occupational cancers, severe occupational traumatic injuries, occupational cardiovascular diseases, disorders of reproduction, neurotoxic disorders, dermatological conditions and psychological disorders.

The proposed strategies were originally published in a two volume set, *Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries, Part 1 and Part 2*. These proposed strategies are not to be considered as final statements of policy of NIOSH, The Association of Schools of Public Health, or of any agency or individual who was involved. Hopefully, they will be used in the quest to prevent disease and injury in the workplace.

To learn of the availability of the complete texts of Part 1 and Part 2, or to obtain additional copies of this or other Strategies, contact NIOSH Publications, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Telephone (513) 533-8287.

A Proposed National Strategy For the Prevention of Noise-Induced Hearing Loss

I. Introduction

The causal relationship between noise and hearing loss has been observed anecdotally for centuries (*1*). Sir Francis Lord Bacon commented on sudden hearing loss resulting from loud sounds and also referred to Pliny the Elder's *Natural History*, which described the hearing problems experienced by persons who lived near waterfalls along the Nile in the first century A.D. (*2*). Reports that actually described occupational noise-induced hearing loss began to appear 100 years after Bacon's writings. In 1713, Ramazzini published "De Morbis Artificum Diatriba" in which he commented on copper workers who suffered hearing loss as a result of hammering on metal (*3*). In the 1800s, Thomas Barr documented noise-induced hearing loss (NIHL) in his studies of boilermakers in Britain, and Fosbroke described blacksmiths' deafness from continued exposure to noise (*4,5*). In this century, hearing loss sustained by many soldiers in World War II was the impetus for increased research activity into the health effects of noise, development of noise-control techniques, and the promulgation and enforcement of noise regulations.

Although exposure to nonoccupational or recreational noise may be severe enough to cause hearing loss, workers exposed to high levels of industrial noise show still greater NIHL than that found in workers who are not exposed to noise in the workplace (*6*). Workers exposed to excessive noise both on and off the job are in double jeopardy.

Increased regulatory activity in the United States between 1969 and 1972 to protect workers from hazardous noise exposure gave reason for optimism that noise-induced hearing loss in the workplace would no longer be a major health problem.

The first noise standard issued by the federal government was the Walsh-Healey Public Contracts Act in 1969 (*7*). This Act covered only workers on federally funded projects. Shortly afterwards, the Occupational Safety and Health Act of 1970 (OSH Act) required that workers be protected from various occupational hazards (*8*). In 1971, under authority of the OSH Act, the Occupational Safety and Health Administration (OSHA) promulgated an occupational noise standard for manufacturing establishments engaged in interstate commerce (*9*).

That noise standard set a maximum exposure of 90 dBA time-weighted average (TWA) for an 8-hour period with a 5 dB trading ratio (i.e., for each 5 dBA increase, the permissible exposure time is reduced by 50%; conversely, a reduction of 5 dBA allows a doubling of the exposure duration). Peak levels of impulse/impact noise are not permitted above 140 dB. When worker exposures exceed the levels allowed, an effective hearing conservation program is required. The noise standard is still the legal basis for determining whether a worker is exposed to potentially hazardous noise.

In 1972, the Noise Control Act assigned responsibility to the Environmental Protection Agency for identifying safe levels of environmental noise, labeling noise-producing devices, and informing the public of the hazards of noise exposure (*10*). NIOSH published its Recommended Standard for Occupational Exposure to Noise in 1972 (*11*), recommending an 8-hour TWA of 85 dBA instead of 90 dBA. NIOSH still recommends an 85 dBA TWA for 8 hours with the 5 dB trading ratio, but there is no indication that this recommendation will be adopted.

In 1983, OSHA promulgated a hearing conservation amendment to the 1971 noise standard (*12*). Although the Amendment does not change the permissible exposure level of 90 dBA TWA, it defines an effective hearing conservation program and requires that such a program be started if workers have an exposure of 85 dBA TWA or greater. A hearing conservation program must include an assessment of noise exposure, audiometric tests of exposed workers, noise abatement and/or administrative controls, maintenance of records on noise and hearing data, availability of hearing protectors, and employee training and education.

A variety of regulations have been established to conserve the hearing of noise-exposed workers not covered by the noise standard. Consequently, most workers exposed to potentially hazardous noise, except those in agriculture, have some regulations protecting their hearing. However, the separate regulations are neither uniform across worker groups nor as rigorous as the 1971 noise standard with its 1983 amendment for manufacturing industries.

Some momentum generated by regulations of the early 1970s has been lost, as evidenced by a steady decline in the number of yearly plant inspections by Government enforcement agencies. This reduced number of factory inspections results in fewer citations for violations of the noise standard because many worksites not in compliance with the noise regulations are not checked. In addition, there is an apparent unwillingness to extend hearing conservation requirements to cover all noise-exposed workers e.g.,transportation, oil/gas well drilling and servicing, agriculture, construction, mining, etc. (*13*).

Both the public and the private sector have made many contributions to hearing conservation and noise control. Progress in the past 40 years includes 1) an increased establishment of hearing conservation programs, 2) development of improved personal hearing protectors, 3) more precise noise-measurement systems and effective noise-control technology, 4) greater knowledge through research into the effects of noise on the auditory system, and 5) increased education of the public regarding the need and requirements for hearing conservation. Despite this progress, much remains to be done to protect all workers from preventable noise-induced hearing loss.

The prevention strategy presented in this document draws on national expertise to eliminate occupational noise-induced hearing loss. Individual and coordinated efforts

are recommended to reduce hearing loss steadily in populations exposed to noise in the workplace until that component of hearing loss attributable to occupational exposure to noise is eliminated.

This document differs in several ways from the other strategy documents aimed at preventing leading work-related diseases and injuries (e.g., psychological disorders, disorders of reproduction, etc.).

- First, some critical issues and recommended actions incorporated in this document were addressed in previous national strategies for the control of noise effects (*14,15*). Hence, this is not the first effort to draft a national plan to alleviate problems of NIHL.

- Second, unlike the other work-related diseases and injuries, noise-induced hearing loss already has federal regulations for its prevention in the workplace. These regulations (mentioned above) specify permissible noise exposures and recommend preventive actions to preserve hearing.

- Third, an array of factors and pathological endpoints underlie many of the other leading work-related diseases and injuries and greatly complicate efforts to develop solid prevention strategies (*16*). Occupational noise-induced hearing loss is caused solely by overexposure to noise in the workplace. The agent and effect are both distinct and measureable. Consequently, the national strategy for preventing noise-induced hearing loss can be more focused than a strategy that must try to define the agents and effects that are noteworthy and in need of control.

II. Examining the Problem

Although no comprehensive epidemiologic data on NIHL exist, an estimated eight million workers in the United States alone are exposed in manufacturing to potentially hazardous average daily levels of occupational noise at 80 dBA and above (*17*). This does not include the more than three million workers in agriculture, construction, forestry, government, mining, transportation, etc., exposed to average daily levels of occupational noise above 85 dBA. The number of workers in these industries exposed to 80-85 dBA is not available (*18,19*).

The number of workers at risk of developing occupational NIHL is necessarily a matter of concern. Twenty-five percent of the workers in manufacturing, transportation, mining, construction, agriculture, and the military are exposed to average daily occupational noise levels above 85 dBA (*13,18*). One U.S. worker in four exposed to 90 dBA noise over a working lifetime will develop a hearing impairment due to occupational noise exposure (*11,20*).

At least one million workers in manufacturing have sustained job-related hearing impairment (defined as greater than a 25-dB average threshold hearing level at 1,2, & 3 kHz), and about half a million of these have moderate to severe hearing impairment (defined as greater than or equal to a 40-dB average threshold hearing level at 1,2, & 3 kHz) (*17*). Workers file compensation claims for hearing losses thought to result from occupational noise exposure, and the cost of these claims for the period 1977-1987 has been estimated at $800 million (*21*). However, the costs of compensation for hearing loss may have been underestimated because the actual rise in claims exceeded the predicted number of claims on which the estimate was based (*22*).

Usually noise-induced hearing loss develops slowly and is not noticed in its early stages (*1,23,24*). This loss results from progressive and subtle destruction of sensory cells in the auditory organ — the cochlea, (*25,26*). Once damaged, these sensory cells cannot repair themselves nor can they be restored through medical intervention. The loss of hearing is, therefore, irreversible and increases in severity with continued exposure to noise.

Although an audiogram is the most accepted clinical measure of hearing sensitivity, the degree of hearing loss recorded in a quiet test setting using individual, pure-tone test signals may not reflect the full extent of auditory handicap experienced under less-than-optimal listening conditions. For example, an audiogram may not predict how a hearing-impaired person will fare when communicating in noisy environments, with someone in a distant room, or over the telephone.

Speech is the primary form of person-to-person communication, and a loss of hearing that impairs this communication produces a social handicap (*27,28*). This handicap is exacerbated by other consequences of hearing impairment, including anxiety and irritability from miscommunication, lowered self esteem, and self-imposed withdrawal from society (*29*). Hearing loss also reduces a person's enjoyment of music and environmental sounds.

The job-related consequences of occupational noise-induced hearing loss may threaten a worker's employment status. An employee with noise-induced hearing loss may face several problems in a noisy production area: communication difficulties (particularly for unexpected messages), which may be exacerbated by wearing hearing protectors; the reduced capacity to monitor changes in machinery sounds; and the inadequate audibility of potential safety hazards (*30-32*). Co-workers and supervisors may interpret these problems as actual reductions in job performance, and the worker may face transfer to another job and reduced employability.

Although the extra-auditory consequences of high-level noise exposure (more stress-induced illness, accidents, irritability, and performance problems) have been reported, noise-induced hearing loss has long been recognized as the primary and most direct health effect of overexposure to noise. If noise exposures can be reduced to prevent NIHL, extra-auditory effects of noise exposure may also be controlled (*33,34*).

III. Prevention Strategy

The proposed strategy for preventing job-related NIHL has three major components: regulation, information dissemination, and research. The first part of the strategy stresses the need to fully enforce and expand current hearing conservation regulations for all noisy workplaces. The second part calls for increased dissemination of information concerning noise control and hearing conservation. The third component elaborates the need for research in hearing science, exposure control, epidemiology, and techniques to increase group acceptance of safe practices.

Major short-term and long-term objectives of the three strategy components are enumerated to define the range and nature of those steps which, if taken, could be effective in preventing NIHL.

A. Regulation

Laws and regulations already exist for controlling occupational noise exposure in manufacturing (*9,12*). The 1971 noise standard and its 1983 amendment are

reasonable and feasible approaches to hearing conservation and should be the minimal hearing conservation regulation for all workers. Effective reduction of occupational NIHL requires, however, that federal laws and regulations already in place be fully implemented and enforced by the Department of Labor.

The experience of many professionals engaged in industrial hearing conservation suggests that governmental inspection efforts are inadequate to ensure compliance with the existing noise regulations. These professionals are also concerned that cutbacks in the number of worksite inspections plus the current focus on occurrences of more serious injury/disease is allowing continued exposure to noise conditions harmful to the hearing of workers (*13*). Implementing and enforcing existing legislation and regulations are essential steps in reducing noise-induced hearing loss.

Workers in transportation, oil/gas well drilling and servicing, agriculture (particularly seasonal workers), construction, mining, and the government are either not covered by a noise regulation or are covered by standards less complete than the noise standard and the hearing conservation amendment. Significant progress in reducing NIHL is possible by broadening the 1971 noise standard and its 1983 amendment to cover all occupationally noise-exposed workers and by enforcing those regulations rigorously.

1. Short-term objectives for regulations should include efforts to:

    a. Fully enforce the current federal noise regulations, which provide mechanisms for reducing the risks of hearing loss from exposures to workplace noise. The current regulations limit exposure to 90 dBA for an 8-hour TWA with a 5-dB trading ratio, and hearing conservation programs are required for workers exposed to 85 dBA. A hearing conservation program must include noise measurement, noise abatement and/or administrative controls, audiometric testing, hearing protection, recordkeeping, and employee training.

    b. Require implementation of regulations to include all feasible controls and procedures that can reduce noise levels significantly even if the noise reduction does not comply with the standard.

        OSHA should be encouraged to rescind its Directive Instruction CPL 2.45 CH-11, Guidelines for Noise Enforcement, which does not require engineering controls below 100 dBA and permits the use of hearing protectors if they reduce the noise reaching the ear to a permissible level. The most desirable (and sometimes the most difficult) approach to reducing the risk of occupational NIHL is reducing the level of noise. It is extremely foolhardy to regard hearing protection as a preferred way to limit noise exposures because most employees obtain only half the sound attenuation possible from hearing protectors (*35*). Even with training, some workers fail to obtain maximum benefit from these protectors because they have difficulty adjusting them properly (*36*), or they refuse to wear them because they fear such devices will impair their ability to perform their jobs properly or hear warning signals (*31, 32*). If, however, noise is reduced by engineering or noise control, the limitations of hearing protectors are of less concern.

    c. Require that noise specifications, in the procurement of new equipment on federally funded projects, are consistent with the goal recommended by NIOSH for an 85-dBA environment.

d. Provide recommendations for using clinical data to compute and assess the extent of hearing disability so that the calculation accurately reflects the extent of handicap a person experiences in daily activities. Adopting these recommendations would lead to compensation laws that are scientifically based, uniform nationwide, and equitable.

2. Long-term objectives in regulation should include efforts to:

   a. Extend the 1971 noise standard and its 1983 amendment to cover all industries (agriculture, mining, forestry, transportation, oil/gas well drilling and servicing, construction, etc.) where potentially hazardous noise is present. An estimated three million additional workers will be protected by such an extension.

   b. Recommend that all states compensate workers who suffer job-related, noise-induced hearing loss without regard to whether the loss was sudden or due to accumulated injury over the employment period.

   c. Develop national consensus standards for establishing hearing conservation practices, for evaluating the properties of hearing protectors, and for evaluating product noise levels. These consensus standards will facilitate the implementation of effective hearing conservation programs.

   d. Develop national consensus standards to provide noise labels on newly manufactured equipment through the initiative of appropriate trade associations. These labels will inform the purchaser of the effect this equipment will have on the overall noise environment and will permit a more accurate prediction of the noise exposure an operator will receive.

   e. Reestablish the EPA program to implement the provisions for product noise labeling required in part by the Noise Control Act of 1972. Although the Noise Control Act is still in effect, it currently lies dormant and is not being enforced.

B. Information Dissemination

Although a basic understanding exists of how NIHL occurs and how to prevent its progression, action is needed now to broadly disseminate existing techniques for hearing conservation and noise control. Education and motivation of management and labor alike will speed the implementation of effective preventive measures. This can be fostered by organizing the information into easily usable formats and widely distributing it through trade association newsletters and professional journals.

Employers must be informed and encouraged to reduce the hazard to the workers by controlling noise at the workplace. The technology is not difficult to understand, but little has been done to catalog solutions for noise control from site to site. Systematically identifying and providing noise-control techniques to persons who are seeking solutions will encourage their use. The efforts wasted in solving problems already solved by others would be better directed to other prevention or control activities.

The OSHA Hearing Conservation Amendment prescribes required elements for a hearing conservation program but does not describe how to implement an effective program that includes five interrelated phases: sound surveys, engineering/administrative controls, education, audiometric evaluations, and hearing protection (*37*). If hearing conservation programs are to succeed in preventing NIHL, employers must understand how to organize and operate their programs to make them effective in protecting workers. Workers must also routinely accept and follow through on self-protective actions related to hearing conservation.

1. Short-term objectives for information dissemination should include efforts to:

   a. Develop and disseminate guidelines that show employers and providers of hearing conservation services how to ensure that their hearing conservation programs are effective in preventing NIHL.

   b. Identify existing training materials, curricula, and programs on the hazards of noise and its abatement and catalog them for easy access.

   c. Develop a curriculum model to provide guidelines for buying original equipment that meets federal regulations for sound power output. This model should be made available to schools that train future managers and overseers of safety programs.

   d. Disseminate guidelines showing employers how to use procurement specifications to induce manufacturers to reduce the sound power output of their machinery. If procurers emphasize the importance of quiet design, then manufacturers will give consideration to quiet design when developing new products.

   e. Encourage appropriate educational institutions — particularly the NIOSH-supported Educational Resource Centers — to place more emphasis on noise control and the health effects of noise.

   f. Develop and distribute awards (organizational or governmental) to groups or individuals who make significant contributions in protecting workers from hazardous noise. This will enhance the visibility of efforts to reduce noise and will provide an opportunity to showcase successful hearing conservation strategies.

2. Long-term objectives for information dissemination should include efforts to:

   a. Establish a central clearinghouse for collecting and distributing information about successes and failures in controlling noise exposure and in hearing conservation practices, the organizations to contact for assistance, and current data on the epidemiology of noise-induced hearing loss.

   b. Implement demonstration programs for noise control and/or hearing conservation in those industries and occupations shown by surveillance to be associated with a high incidence of noise and noise-related problems.

   c. Establish and supplement database systems (e.g., NTIS PB88-117916, Industrial Audiometric Data) to include appropriate information on noise control, noise levels, occupational and nonoccupational noise exposures, relevant medical history, etc.

d. Develop curriculum units for effective hearing conservation programs that can be disseminated to train professionals, such as physicians, audiologists, industrial hygienists, safety engineers, mechanical engineers, industrial engineers, and occupational health nurses.

e. Update existing manuals for noise-control products and compendia of engineering solutions as a basis for a catalog of usable, economical, and applied noise controls. Many manuals or compendia are currently geared toward scientists and engineers, and the information should be presented in an understandable way to health and safety practitioners who are not specialists but are responsibile for promoting safe and healthful workplaces.

f. Promote and support national and international standards for noise control, hearing conservation practices, and product noise control through such organizations as the American National Standards Institute, the Acoustical Society of America, the American Society of Mechanical Engineers, the American Society for Testing Materials, and the Society of Automotive Engineers.

g. Inform the public of the need to protect hearing to avoid the biologic and social consequences of exposure to noise. All forms of the media should be used. In addition, information shall be distributed to large public gatherings, such as state and local fairs, health conventions, etc.

h. Develop education programs and promote existing programs in primary and secondary schools and in universities for teaching the basic science of sound, including its hazards, and methods of self-protection.

i. Encourage developers of the credit-card-sized records for personal health information — sometimes called "smart cards" — to include space for information on hearing sensitivity.

C. Research

Information is currently lacking on the incidence of NIHL. Regular and accurate statistics must be collected to assess the magnitude of the problem and to monitor the effect of various prevention/intervention efforts. Although the burden of data collection and reporting should be kept at manageable levels, information must be acquired to effectively and efficiently direct resources that will reduce occupational NIHL. Some much-needed data can be obtained through national health surveys, such as the National Health And Nutrition Examination Survey (NHANES).

OSHA required (1983 Amendment to the Noise Standard) that simultaneous, continuous, intermittent, and impulsive sounds between 80 dBA and 130 dBA be measured together and evaluated to determine if the noise exposure exceeds an 8-hour TWA level of 85 dBA (*12*). If this approach is used to assess noise exposure, then errors may lead to the overexposure of workers (*38-40*). The method was adopted partly because of a lack of scientific data on which to base a more accurate technique.

Research is needed to better define the hazardous parameters of impulse/impact noise and the relative hazard posed by "quiet" periods that interrupt the noise

exposure. An understanding of how hearing loss is produced by the various parameters of impulse/impact noise and non-steady-state noise will permit development of accurate, damage-risk criteria for protecting workers' hearing.

Although implementating the regulation and information-dissemination components of this strategy will have an immediate impact on reducing NIHL, the following research issues should be pursued to keep the outlined strategies up-to-date and effective.

1. Short-term objectives in the area of research should include efforts to:

   a. Keep a central file on some gauge of hearing capacity (either a standard threshold shift or some other measure of hearing) to permit a yearly monitoring of hearing in the workplace.

   b. Review annual reports from OSHA on the number of plants that have hearing conservation programs in effect and the number of employees covered by these programs. These data should be arranged using the Standard Industrial Classification.

   c. Analyze data collected under the OSHA Hearing Conservation Amendment to evaluate the effectiveness of regulations.

   d. Recommend a standard format for entering audiometric data on a computer to facilitate the exchange of information and to begin developing a national audiometric data base. The NHANES III Hearing Assessment Format is a model that should be evaluated.

2. Long-term objectives in the area of research should include efforts to:

   a. Collect hearing data for populations not exposed to occupational noise as a baseline for comparing the hearing of groups exposed to noise. Norms should be established as a function of geographic region, sex, race, age, etc.

   b. Perform additional field evaluations of personal hearing-protection devices to document their real-world performance. Better laboratory and/or field procedures can then be devised to improve the accuracy of standardized attenuation tests in estimating field performance.

   c. Conduct research to better define the relative hazard of different kinds of noise (impulse, impact, intermittent, etc.).

   d. Determine through investigations the degree to which noise interacts with other agents in the work environment (solvents, metals, prescription drugs, etc.) to affect hearing. Although some drugs and industrial solvents have been established as ototoxic (*41-43*), recent data indicate that noise exposure combined with exposure to drugs or industrial solvents may result in more hearing loss than would be predicted from a summation of individual effects (*44-46*). In light of these findings, further investigation of possible potentiation of occupational hearing loss by chemical agents seems warranted.

   e. Assess the impact of noise-induced hearing loss and hearing protection through research on speech communication and the identification of warning signals.

f. Develop audiometric indicators for data from both individuals and groups to identify noise-sensitive workers who need additional protection and hearing conservation programs or practices that may not be fully effective.

g. Develop improved hearing-protection devices that would provide clearer and more natural audition. Special consideration may be necessary for individuals with hearing losses or for users of hearing aids.

h. Develop a time-weighted-average noise descriptor for employees exposed to noise on an irregular basis, such as an 8-hour or longer workday once a week, or one week per month.

i. Describe the physiologic mechanisms associated with noise-induced hearing loss (e.g., energy integration, degenerative and recuperative processes, etc.). These studies may clarify which noise parameters contribute the most to damage in the ear.

j. Investigate the changes in non-auditory effects (accident rate, absenteeism, productivity, fatigue, etc.) that have been noted after hearing conservation programs have been instituted (*47*). These findings need confirmation.

IV. Summary

Noise-induced hearing loss is a progressive injury that develops as a result of cumulative exposure. Both its beginning and its progression can be prevented by limiting noise exposure. Because no remedial action can completely restore or compensate for hearing capacity that has been lost, prevention is the preferred strategy. The two major approaches for preventing occupational NIHL are limiting noise in the workplace and encouraging affected individuals and involved organizations to accept and practice effective hearing conservation techniques.

The diverse talents and expertise of many individuals and groups are needed to address the objectives proposed in this document. A consensus on all the proposed objectives for reducing noise-induced hearing loss is not necessary, but all persons concerned with the issues raised must address those objectives to which they can effectively contribute. These efforts, taken together, could make attainment of the desired goal possible: a significant reduction and ultimate elimination of occupationally related, noise-induced hearing loss.

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