The Role of Audiometric Data Management in Hearing Loss Prevention: Audiometric Data Management

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In support of the Mine Safety and Health Administration's development of noise control and hearing loss prevention regulations, NIOSH reviewed audiograms for coal miners and metal/nonmetal miners. NIOSH had also been reviewing the 22 databases that were collected under contract for NIOSH in support of the revision of the NIOSH Noise criteria document (these are often referred to as the ANSI databases). The initial databases included more than 22,000 audiograms for coal miners, 40,000 for metal/nonmetal miners, and 158,000 audiograms from the ANSI databases. These databases were longitudinal containing as few as two audiograms and as many as 22 audiograms per person.

Initial review of the audiograms revealed many problems. Audiograms for some persons were inconsistent from year to year. In other cases it was clear that the audiometric thresholds at 500 and 1000 Hz were elevated due to background noise levels in the test environment. There were occurrences of inter-ear differences at the limits of inter-aural attenuation. In other cases, differences in adjacent frequency thresholds were very large. All of these occurrences were very likely due to error in the administration of the audiogram or the recording of thresholds.

In order to remove the suspect data, it was necessary to review the record of each person in the database. Problem audiograms could be marked for deletion, and if a person had only one remaining audiogram, the person's entire record could be removed. A team of five audiologists took on this task for the ANSI databases and later for the audiograms from the coal miners.

Computer programs were written to identify audiograms with threshold shifts of 15 decibels (dB) or greater for the frequencies 500 through 6000 Hz. Additional programs identified audiograms with larger inter-aural differences of more than 25 dB at 500 Hz and more than 40 dB at 1000 through 6000 Hz–the lower limits of inter-aural attenuation. A further program screened for audiograms with low-frequency thresholds such that thresholds at 500 Hz were greater than those at 1000 Hz by at least 15 dB, and thresholds at 1000 Hz were greater than those at 2000 Hz by at least 10 dB, while the thresholds at 2000 Hz were lower than 15 dB HTL (re ANSI S3.6-1996).

The team of audiologists reviewed the results of each screening and identified those that were to be removed. The decision was also made as to whether to remove a person from the database. While each audiologist could review more than 200 audiograms per hour, the task was fatiguing. Those records remaining after the first screen were submitted to the second screen and those remaining after review of the second screen were submitted for the third. In this way, each successive screen evaluated smaller databases.

Notes were made for each decision to remove a record or all of the records for a person. When the audiograms were reviewed for the metal/nonmetal miners, the task was expedited by an expert system computer program based on the rules for deletion developed by the team of audiologists when they reviewed the other databases. In order to verify that the expert system performed according to the rules and the rules were sufficient, one audiologist's review of 1000 audiograms from the database was compared to the output of the expert system.

The expert system displays all of the audiograms in a database, person by person. Audiograms are flagged for deletion with the reason for the deletion. A reviewer can opt to override the deletion flag and retain the audiogram in the database. The system writes to files containing only the audiograms not

marked for deletion or to files containing all of the data with the deletions annotated.

The present system consists of three programs. Audfilt.exe opens a database file and processes all of the audiograms. Review.exe shows the results of the analysis, person by person. Revout.exe provides the output files for further analysis by other software that may be written in SAS or some other statistical programming language.

The NIOSH expert system evaluates the data for each person in the database, screening for unconfirmed threshold shifts, unsupported baseline audiograms, evidence of too much background noise in the test room, larger inter-aural differences in hearing thresholds, and large adjacent-frequency differences.

There are two applications for this expert system. First, it may be used to screen data that are imported into a database, whether the purpose of the database is to support statistical analysis or to serve as the foundation for a continuing program. Secondly, it identifies persons with problem audiograms so that they may be followed up. In this case, it may be possible to correct the audiograms if the source of the error is identified.

Draft ANSI standard S12.13, Method for Determining the Effectiveness of Hearing Conservation Programs, performs a statistical analysis of audiometric data, calculating the percent of audiograms with improvement of more than 15 dB and those with thresholds that are worse by 15 dB. It does this for sequential audiograms rather than making comparisons to the baseline audiograms. The standard has criteria for programs that are acceptable, marginal, or unacceptable. Without exception, those audiometric databases that have been filtered by the expert system meet the ANSI S12.13 acceptable definitions.

When HearSaf 2000 is released, it will include elements from the expert system so that each audiogram is screened as it is entered. The system will also evaluate any databases imported, such as from previous computer programs. It is also anticipated that a stand-alone version of the expert system will be available later in 2000.

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