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A COMPUTERIZED PROGRAM FOR THE ESTIMATE OF OCCUPATIONAL HEARING LOSS IN INDUSTRY ACCORDING TO THE INTERNATIONAL STANDARD ISO/DIS 1999

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Summary

The International Standard ISO/DIS 1999.2 "Determination of occupational noise exposure and estimation of noise-induced hearing impairment" presents, in statistical terms, the relationship between noise exposure and hearing loss in people of various age occupationally exposed to industrial noise.
The procedures allow the estimation of noise-induced permanent shift (NIPTS) and hearing threshold level age related (HTLA).
Practical applications of ISO/DIS 1999 are many, but we wish to stress the estimation of the "expected" number of hearing handicaps among noise exposed workers when occupational exposure levels are known or may be estimated.
The procedures to calculate NIPTS and HTLA are laborious, especially for repeated estimations.
For these reasons we considered useful to prepare a program for ISO/DIS 1999 procedures calculation.
As an example, we applied the program to Emilia-Romagna metal workers noise exposure data. We estimate median audiometric curves with 0.05-0.95 percentiles limits in the examined groups and the "expected" number of subjects with hearing handicap. Results vary considerably according to various choosen criteria.
New International Standard ISO/DIS 1999 procedures for estimating noise induced hearing deterioration are certainly very useful for practical uses; among these applications we believe that estimation of the "expected" number of hearing loss may represent an interesting and useful example. Calculation provided by the Standard are easily and quickly carried out if an adequate computerized program, as the one we have prepared, is used.

Introduction

Hearing loss is a well known effect of industrial noise exposure, but relations among noise exposure levels and duration, degree of hearing impairment in exposed subjects and percentage of people that may be expected to develop an hearing impairment is still controversial.

The new International Standard ISO/DIS 199.2 "Determination of occupational noise exposure and estimation of noise-induced hearing impairment" [1] presents, in statistical terms, the relationship between noise exposure and hearing loss in people of various age occupationally exposed to industrial noise.

The procedures allow the estimation of hearing deterioration due to noise exposure (noise-induced permanent threshold shift - NIPTS) as a function of noise exposure level and time (expressed in years).

Moreover, the Standard provides procedures for estimating hearing threshold shift due to noise and age (hearing threshold level age and noise related - HTLAN).

HTLAN is a combination of the components associated with noise (NIPTS) and with age (hearing threshold level age related - HTLA). HTLA in a non noise exposed population vary considerably depending on the degree to which other factors as diseases, history of ototoxic drugs and unknown noise exposure both, occupationally and non occupationally, are included.

HTLA estimation is possible both from an otologically normal "highly screened" population ("persons in a normal state of health who are free from all signs and symptoms of ear diseases and from wax in the ears canals and who have no history of undue exposure to noise") - database A -, or from an unscreened non-noise exposed control population of the country under consideration - database B.

The International Standard provides a database A according to ISD 7029/1984 [2].

Database B has to be collected by the resarcher himself in an adequate non-noise exposed control population.

Unlike previous ISO 1999/1975 [3], ISO/DIS 1999.2 does not prescribe specific frequencies, frequency combinations or weighted combinations to be used for the evaluation of hearing handicap assessment nor does it specify the hearing threshold shift ("fence") which must be exceeded for

hearing handicap to exist. The Standard provides a method for the calculation of noise induced hearing impairment allowing the basis for handicap risk assessment according to the specific handicap definition selected by the researcher.

Practical applications of ISO/DIS 1999 are many; we wish to cite a few:
- the estimation of handicap risk in occupationally exposed groups according to different "fence" definitions;
- the evaluation of a definite threshold limit value effectiveness in the prevention of hearing handicap in exposed populations;
- costs/benefits ratio estimation of a definite noise exposure reduction;
- the estimation of the "expected" number of hearing handicaps among noise exposed workers in an industry and/or in a territory when occupational exposure levels are known or may be approximatively estimated.

ISO/DIS 1999/1982 procedures, although rather simple for a mathematical point of view, are neverthless laborious, especially for the application to many subgroups and/or for repeated estimations: in these cases procedures are time wasting and miscalculations are easy. For these reasons we considered useful to prepare a program for ISO/DIS 1999 procedures calculation. COBOL ANSI language was used. Present version is available for IBM personal computers and for all PC using MS-DOS operative system. The program is easily convertible for others operative systems.

Moreover the program is easily fitting in audiometric archives package.

Materials and methods

PC characteristics for the program use are the followings:
- 256 Kbyte RAM;
- single, double floppy or hard disk.

Data required for the calculation are sex, age (years), noise exposure levels (exposure as equivalent continuous A-weighted sound pressure level for the daily occupational exposure period - 8 h), exposure time duration (years), exposure time duration pae each year (12 months) (Table 1).

In the present version, the user has to select 1-6 audiometric frequencies (from 500 to 6000 Hz), and 1-3 percentiles (from 0.05 to 0.95): NIPTS and HTLA at selected frequencies are then calculated according to indicated statistical distribution.

Table 1 - Data required from the program.

Sex
Age (years)
Exposure duration (years)
Exposure per year (months)
Exposure level (dBA Leq)
Audiometric frequencies (Hz)
Percentiles (0.05 - 0.95)

Furthermore, the program calculates mean HTLAN of the choosen frequencies.

Median audiometric curve and the requested percentiles distribution are therefore easily calculated.

In this way it is possible to estimate the percentage of subjects exposed to a definite noise level that will develop an handicap according to user's own "fence" definition.

As an example, we applied the program to Emilia-Romagna metal workers noise exposure data.

According to Emilia-Romagna Occupational Medicine Services data [4] in 1984 male workers in metal industry were 107,215. Estimated mean age was 35.1 years.

24% of the whole group was exposed to 81-85 dBA Leq noise, 21.1% to 86-90 dBA Leq, and 15.2% to noise level exceeding 90 dBA Leq (Table 2). A normal noise exposure distribution wihtin the classes was assumed, so we considered respectively 82.5 and 87.5 dBA Leq mean exposure in the first and second class, in the third class 92.5 dBA noise exposure was presumed.

Table 2 - Main characteristics of the examined group.

No. of male workers	107,215
Mean age	35,1
Estimated noise exposure (dBA Leq)	
81 - 95	41,491
86 - 90	37,831
> 90	27,893

Lacking more detailed informations, a mean age of 35.1 years was considered in all groups; furthermore all subjects were considered exposed to the same noise level from 18 years age: estimated noise exposure time, therefore, was 17 years.

The examined group is obviously unscreened for otological diseases, use of ototoxic drugs, etc. and therefore an appropriate database B should be choosen for HTLA estimation; having not such an adequate control group, database A was nevertheless adopted.

Results and discussions

In Figures 1, 2, 3 are reported the estimated median audiometric curves with 0.05-0.95 percentiles limits in the examined groups.

As we presumed, in 82.5 dBA Leq exposed workers, all audiometric frequencies are virtually within 25 dB limits (Figure 1).

In exposed to 92.5 dBA Leq median audiogram is markedly worse and a significative percentage of estimated audiograms goes beyond the 25 dB limit at 3000-4000 and 6000 Hz frequencies (Figure 3).

87.5 exposed workers are intermediate and only for 4000 and 6000 Hz frequencies in a significative percentage of subjects HTLAN goes beyond 25 dB (Figure 2).

Another interesting practical Standard ISO/DIS 1999 application is the estimation of the "expected" number of subjects with hearing handicap among exposed groups of workers.

The subsequent criteria were choosen as reference limits for hearing handicap definition:
1) mean hearing loss of 25 dB or more for 0.5-1-2 kHz [3];
2) mean hearing loss of 25 dB for 1-2-3 kHz [5];
3) mean hearing loss of 25 dB for 1-2-4 kHz [6].

Results are reported in Table 3.

Applying criteria 1 and 2 no cases of hearing loss are expected in the examined population. Applying criterion 3 no cases of hearing loss are expected in 81-85 dBA exposed group, while in 86-90 and >90 dBA exposed workers the "expected" number of subjects with handicap are respectively 558 and 2231.

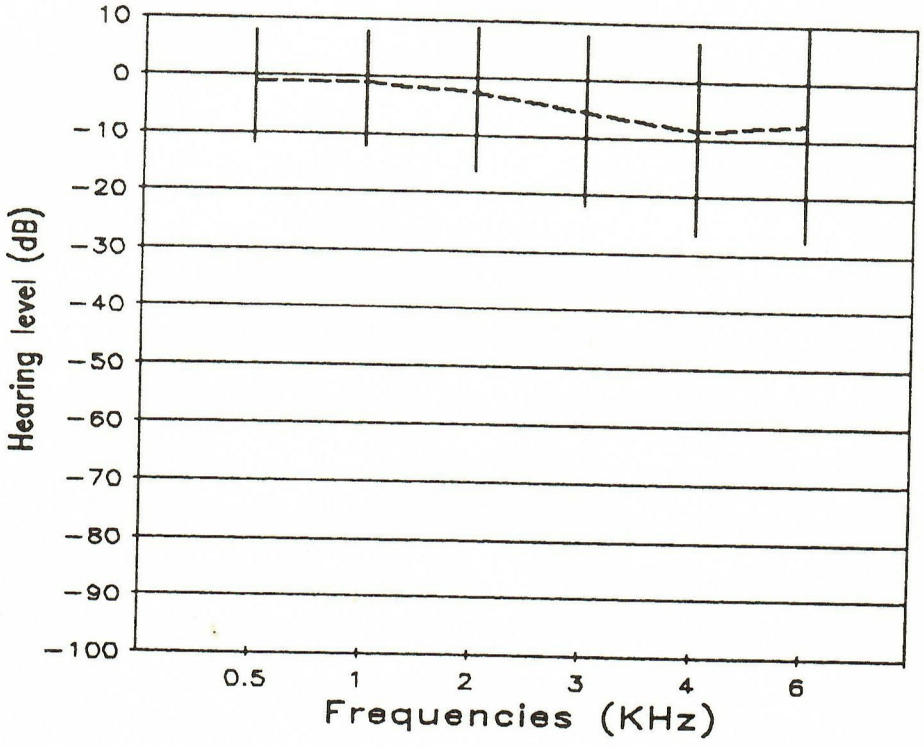

Figure 1 - Estimated median audiometric curve, with 0.05 and 0.95 fractiles, in subjects occupationally exposed to 82.5 dBA Leq noise level for 17 years.

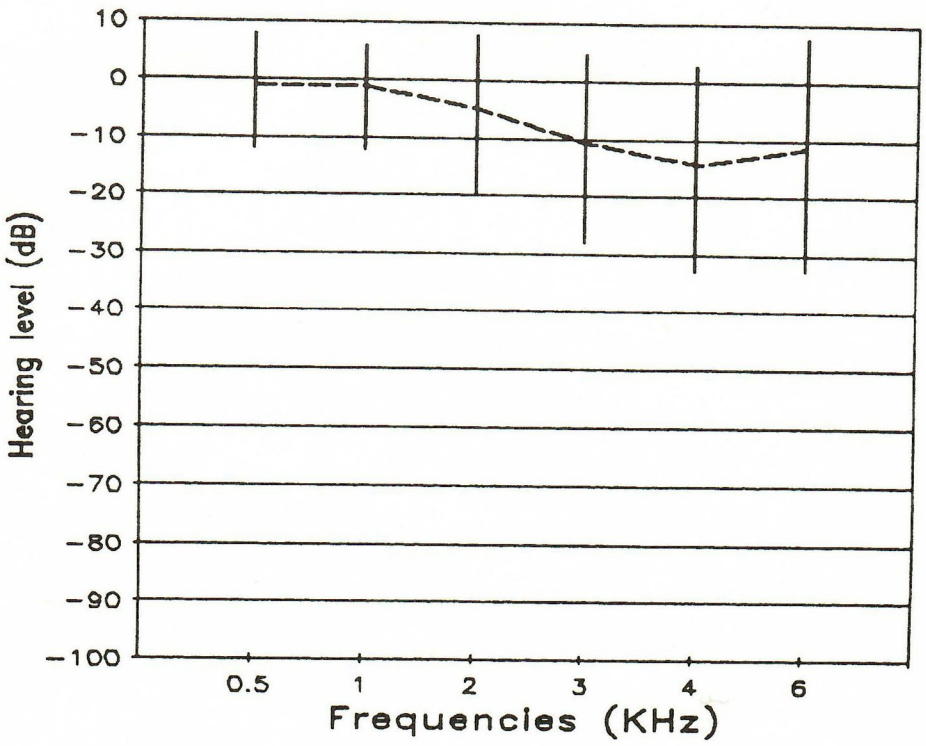

Figure 2 - Estimated median audiometric curve, with 0.05 and 0.95 fractiles, in subjects occupationally exposed to 87.5 dBA Leq noise level for 17 years.

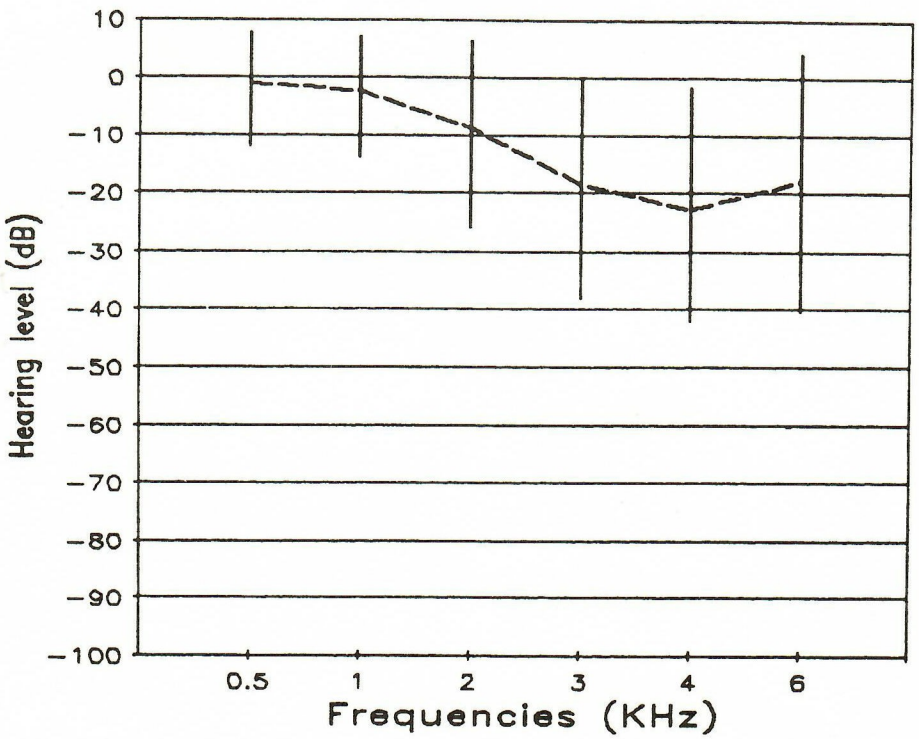

Figure 3 - Estimated median audiometric curve, with 0.05 and 0.95 fractiles, in subjects occupationally exposed to 92.5 dBA Leq noise level for 17 years.

Table 3 - "Expected" number of subjects with hearing handicap among workers exposed to different noise levels when a "fence" of 25 dB is adopted.

	Exposure (dBA Leq)		
Hearing loss > 25 dB	81 - 85	86 - 90	> 90
$\frac{0.5 - 1 - 2 \text{ kHz}}{3}$	0	0	0
$\frac{1 - 2 - 4 \text{ kHz}}{3}$	0	0	0
$\frac{1 - 2 - 4 \text{ kHz}}{3}$	0	558	2231

Using a more restrictive mean hearing loss (20 dB) for the same frequencies (Table 4) once again no handicap cases are expected with criterion 1, 189 and 2270 cases are respectively expected in 86-90 and >90 dBA exposed subjects applying criterion 2, 5021 and 6694 in the same exposure classes using criterion 3.

Table 4 - "Expected" number of subjects with hearing handicap among workers exposed to different noise levels when a "fence" of 20 dB is adopted.

	Exposure (dBA Leq)		
Hearing loss > 20 dB	81 - 85	86 - 90	> 90
$\frac{0.5 - 1 - 2 \text{ kHz}}{3}$	0	0	0
$\frac{1 - 2 - 3 \text{ kHz}}{3}$	0	189	2270
$\frac{1 - 2 - 4 \text{ kHz}}{3}$	0	5021	6694

Conclusions

New International Standard ISO/DIS 1999 procedures for estimating noise induced hearing deterioration are certainly very useful for practical uses, as an example in the analysis of costs/benefits ratio of a definite decrease of noise exposure.

Calculations provided by the Standard are easily and quickly carried out by an adequate computerized program.

Normal hearing values supplied from ISO/DIS database A were recently criticized by some authors [6-8]. Objections concerned substantially database A accuracy, nevertheless the Standard allows the application of a database B collected by the researcher himself in HTLA estimation. Moreover the ISO/DIS does not specify criteria for hearing handicap diagnosis that can be defined by users.

For these reasons we believe that best applications of the Standard is within audiometric archives package or in an audiometric data bank. In effect data from archives can supply an adequate database B to be applied in HTLA calculation, while repeated observations in occupationally exposed groups can be compared with Standard estimations allowing a control of ISO/DIS 1999 precision in nowaday populations of industrialized countries.

On the other hand, ISO/DIS 1999 provides quickly procedures for the estimation of hearing impairment on the "real" files data of the archive.

Among these applications of the Standard we believe that estimation of the "expected" number of hearing loss may represent an interesting and useful example.

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