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AUDIOMETRY AS A SCREENING PROCEDURE FOR OCCUPATIONAL DEAFNESS

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Medical screening procedures have been defined as tests which can be rapidly applied for the presumptive identification of unrecognised disease or defect (10). They were successfully introduced for the early identification of contagious disease, where the objectives were twofold:

(a) that treatment provided at an early stage would increase the chance of recovery or reduce the extent of permanent disability;
(b) that isolation of the sources of infection at an early stage would reduce the number of persons subsequently infected.

More recently, a number of screening procedures have been developed for the detection of chronic degenerative diseases, with objectives limited to (a) above. They are less successful than had been hoped and as a result better evaluative methods were developed (7, 11 and 2).

A number of functions have been attributed to the use of audiometry in industry, which can be classified into two types: (a) screening (as defined above); (b) education. Only the screening function will be discussed further but this does not imply that the educational function of audiometry is without value (8). The objectives of screening audiometry in industry have been described as (1):

(a) CASE FINDING, which aims, by serial tests, to identify those individuals who have suffered a significant degree of noise-induced hearing loss but have not yet sought treatment;
(b) DIAGNOSIS, which aims to identify and fully diagnose those who are suffering from noise-induced hearing loss whether or not they have sought treatment;
(c) PRE-EMPLOYMENT SCREENING, which aims to identify those who have suffered noise-induced hearing loss as a result of previous exposure (the first test in a series for case finding purposes would not be included);
(d) GROUP MONITORING, which aims to detect changes in group hearing levels in order to evaluate the effectiveness of a hearing conservation programme.

Criteria have been developed whereby evaluation can give an indication of the effectiveness of a screening programme (1).

1 BIOLOGICAL CRITERIA

These are requirements which must be met by the disease in question before it can be accepted as suitable for screening.

(a) The natural history must be reasonably well understood. The progression of noise-induced hearing loss and its relation to exposure are now well understood (9) and are shown in Figure 1.

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The hearing loss described in the Figure is the result of two factors, noise and age, which are assumed to be additive. The noise-induced component is responsible for the rapid rise during the early years of exposure and is preventable.

There is one aspect of the natural history which is not understood, the apparently hypersensitive individual. We do not know whether these are a fundementally distinct group or simply the extreme end of the range of sensitivity exhibited by a population.

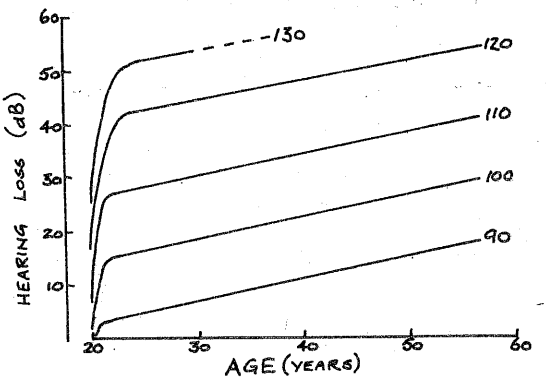

FIGURE 1
The progression of noise-induced hearing loss over a working lifetime (habitual exposure) for a variety of noise levels (dB(A)). Hearing loss is expressed as dB averaged over the frequencies 1, 2 and 3 kHz. (1)

(b) Tests are available which make it possible to recognise the disease in a latent or pre-symptomatic stage. As indicated in Fig. 1, there is no latent or pre-symptomatic stage in the progression of noise-induced hearing loss. Thus we cannot hope to prevent the disease by screening although we may be able to limit its progress and thus reduce the resulting disability.

(c) Effective treatment must be available. This is both an ethical and a practical requirement. Since the screening procedure involves the seeking of people who have not sought treatment it is considered unethical to then be unable to provide treatment. In the practical sense there is little point in seeking out those who suffer from a disease if nothing can be done for them. Noise-induced hearing loss is not treatable (5), hence early detection must aim to prevent further deterioration of hearing acuity either by personal protection or removal from the noisy environment.

Thus there are three ways in which noise-induced hearing loss fails to meet the requirements of the biological criteria. These are, in order of importance:

i) there is no latent or pre-symptomatic stage;
ii) there is no effective treatment for the disease and attempts to reduce further disability may be unacceptable or unsuccessful;
iii) there may be hypersensitive individuals for whom the natural history of the disease is not understood and particularly the rate of progression of the disease is not known.

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2 ECONOMIC CRITERIA

The degree to which audiometry is a net loss or benefit to a company is an important criterion. If the programme constitutes a net benefit then failure to meet some of the biological or social criteria may be acceptable. The area of cost-benefit studies is poorly researched but Kolozyn (6) has examined the audiometric programme of a large manufacturing company and failed to show any net benefit for case finding. Although it is not possible to generalise from such limited evidence we cannot assume that the economic criterion has been fulfilled.

3 SOCIAL CRITERIA

Merriman (8) has shown that the acceptability of the test to the target population (the workforce) is very important in the case of occupational audiometry. There are two aspects of acceptability:

(a) Acceptability of audiometry - freedom of choice in whether or not they are tested is an important element in workers attitudes to audiometry (8). Although there are now recommended test procedures (4) which make it difficult for individuals to consciously influence the test results without detection, a screening procedure which results in a substantial amount of non-compliance would not be likely to be successful. It would appear that such non-co-operation with the test is a possibility for some workers.

(b) Acceptability of the consequences of a positive result - even when a test procedure is acceptable, a screening programme may fail because the required treatment, in the event of a positive result, is unacceptable. In the case of audiometry the alternatives are hearing protection or a change of work. It seems likely that both of these may be unacceptable to some workers(3).

4 TEST CRITERIA

These are specific factors relating to the test procedure which must be taken into account in any evaluation (2).

(a) Accuracy - The test should measure the variable under investigation and accurately reflect the state of health or disease of the individual. There is little doubt that audiometry fulfils this requirement.

(b) Precision (test-retest variation or repeatability) - There are three sources of bias: subject error, observer (operator) error and method error. A number of studies have examined this aspect of audiometry and they tend to suggest that subject error and observer error are important (1). Variation at 4kHz generally gave a standard deviation of approximately 4dB.

(c) Sensitivity and specificity - Sensitivity is defined as the ability to give a positive result when the individual has the disease under investigation (ie high sensitivity results when the numbers of false-negative results is low). Specificity is the ability to give a negative result when the individual does not have the disease (ie the number of false-positive

results is low). Because these two aspects of the test are linked it is often not possible to reduce both at the same time. One estimate of specificity gives 0.7% false-positives in a high risk group (5). Since sensitivity was not estimated we do not know if this high specificity means there were a large number of false-negatives.

The objectives of an audiometric screening programme will affect the application of these criteria. For case finding there appear to be a number of factors which imply that such programmes may not be fully effective: (i) there is no latent stage; (ii) there is no effective treatment; (iii) the consequences of a positive result may be unacceptable or the action taken unsuccessful; (iv) poor precision means that large numbers of repeat audiograms are necessary; (v) possibly low sensitivity may result in unacceptable numbers of false-negative results; (vi) there is no evidence of a positive cost-benefit relation. For diagnostic audiometry the poor precision and doubtful sensitivity would appear to be insuperable problems. The factors itemised above for case finding also apply to pre-employment audiometry. These problems do not apply to such an extent to group monitoring but this is an aspect of audiometry which has received little attention.

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