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SOME ASPECTS OF NOISE INDUCED HEARING LOSS IN SINGAPORE

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SUMMARY

In Singapore there is now an emphasis on the industrial health and well being of workers. A recent Government requirement is that factory doctors have to undergo a course on industrial hazards faced by the workers. This move is timely with a constant emphasis on higher productivity and the tendency is towards increased mechanisation. In the past there has been either an insufficient education of the industralist or else little effort on his part so that workers are often exposed to dangerously high noise levels. Amongst the most serious offenders in the local industry are the textile and the metal working industries. In many cases the situation is worsened by the high number of overtime hours taken on by the worker. In this paper some aspects of noise induced hearing loss are reviewed and elaborated upon in the local context.

In association with proposed construction noise regulations [1], a study is made of the subjects on whom records were maintained in the various industries and audiology clinics of the air conduction thresholds of patients investigated for acoustic trauma. The study investigated patients who had had a diagnosis of noise induced hearing loss with a minimum of 5 years of noise exposure and looks into their background and working environment.

At the same time, a study is made of a systematic audiometric screening of young undergraduates in the first year of the National University of Singapore Engineering Course which has been in progress over the same period of time. Preliminary results show that a small number of these have minor hearing problems. Although the situation is far from serious at the present the trend cannot be ignored as these young adults are only just beginning their careers and their exposure to industrial noise have only just begun.

In all cases, the subjects were audiometrically evaluated in sound proof booths specially made for the purpose in the various plants or in the Ministry of Labour, the Singapore General Hospital and the National University of Singapore.

NOISE AND HEARING LOSS

It is common knowledge that a very loud sound of around 150 dBA would result in instant deafness to the hearer. However, if the human ear is exposed to a much lower continuous level of noise for a short period, a audiometric test of the sensitivity of that ear taken immediately afterwards would still reveal a small hearing loss known as a temporary threshold shift. The hearing threshold is the lowest sound pressure level which can be detected by the subject, and the loss may be by up to 20 dB after even a relatively short exposure. A sound would therefore have to be much louder than it was before the exposure, to be heard afterwards. Because the phenomenon is temporary in nature, the ear recovers its original sensitivity after a relatively short time and no permanent threshold shift persists.

At the exposure time increases, so too does the length of time the ear takes to

recover from it. As long as the exposure times are relatively short and the intervals between them are long, then no permanent effects remains. However for people who work in factories and workshops where the noise levels are consistently high, and when the exposure takes place regularly during their work every day, year after year, the effects cease to be temporary. A limit of 90 dBA for a eight hour day exposure is used in Singapore. It is known that when this level is exceeded permanent hearing loss develops which in time may become severe enough to make normal conversation difficult to follow, and ultimately lead to chronic disability. The damage is by this time permanent and irreversible, for no amount of "rest" will lead to any significant recovery. This condition is referred to as noise induced hearing loss and in Singapore is classified as a notifiable industrial disease and in extreme cases will be liable for industrial compensation under the workers Compensation Act. Recommended maximum noise levels in dBA is shown in Table 1 for duration of exposure in noise intensive working environments.

Cummulative Exposure	Number of noise interval exposure per 8-hr work day						
	1	3	7	15	35	75	150 or more
8 hr	90						
6 hr	91	92	93	94	94	94	94
4 hr	93	94	95	96	98	99	100
2 hr	96	98	100	103	106	109	112
1 hr	99	98	105	109	114	(115)	
30 min	102	106	110	114	(115)		
15 min	105	110	115				
8 min	108	115					
4 min	11						

TABLE 1 Permissible Average Noise Levels, in dBA, for Steady and Interrupted Noise Exposures

The form which a loss of hearing takes is usually independent of the mechanism which brings it about. There is however almost always an initial dip in the audiogram at approximately 4 kHz., whatever the frequency content of the noise exposure which caused the damage. In general the greatest shift is invariably at a frequency above that of the actual noise itself. This is typical of noise induced hearing loss both for temporary as well as for permanent threshold shifts.

Realising the need to reduce the risk of workers developing this condition, a Hearing Conservation Programme was launched by the Singapore Ministry of Labour in September 1975.

The main objective of the Programme is the preservation of the hearing capacity of workers exposed to high noise levels in their factory environment. The conservation programme aims at:-

(a) identifying high noise areas which present risk to hearing;

(b) advising personnel on the necessity for noise control measures whenever technically feasible;
(c) instructing on the necessity and the proper use of hearing protectors; and
(d) conducting audiometric tests to detect hearing impairment at an early stage.

A mobile audiometric unit consisting of an audiometric van manned by a doctor and two industrial nurses was set up in 1976. The van travels to industrial premises to test the hearing ability of workers. The purpose is to provide a door-step screening service for early detection of noise-induced deafness. To defray part of the expenses, a nominal charge of Singapore $5 per person is made for each examination. Noise-induced deafness has been included in the new Workmen's Compensation Act which came into force in October 1975. Workers who have their hearing capacity impaired can claim compensation under the Act. Noise-induced deafness has been included in the Sixth Schedule of the Notifiable Industrial Diseases of the Factories Act [2]. Failure to report the occurence of the disease to the Chief Inspector of Factories will incur a fine not exceeding Singapore $500.

THE HEARING ASSESSMENT

It is recognised that the assessment of hearing is not a mere matter of the examiner speaking to the patient and noting his response. It ranges in complexity from simple audiometric screening procedures using pure tones at various selected frequencies to comprehensive diagnostic methods using elabrate and complex equipment. Any industrial hearing programme usually begins with the use of pure tone air conduction thresholds to screen the hearing of the worker and to anticipate hearing loss before it becomes too serious.

In order to ensure that the audiogram obtained represents a fair estimate of the hearing of the subject, some basic criteria must be satisfied. Firstly the acoustic environment in which the test is made must have a low background noise level complying with an established standard such as the ANSI S3.1 - 1977 [3]. Secondly the audiometric equipment should be regularly calibrated using some electroacoustic method or more exhaustively at longer periods according to the corresponding standard such as ANSI S3.6 - 1969 and the person carrying out the test must be trained or the patient adequately instructed where a self operating audiometer is used. In the latter case where special interest is present such as compensation cases or the like, results obtained may not be absolutely reliable.

AUDIOMETRIC EXAMINATION

Although there is a good deal of variation with respect to individual susceptibillity to noise, there are certain features of the audiometric profile that are common to most people exposed to high noise environments. The more noticeable of these features is the presence of a sensorineural hearing loss most pronounced in the high frequency region of the audiogram between 3000 and 6000 Hz. Generally the greatest amount of hearing loss is found about 4000 Hz with a slightly smaller amount of loss immediately above and below this frequency. As a result, this audiometric test result is often referred to as the 4000 Hz or 4 K notch and is considered by many to be a definite sign of noise induced hearing loss when coupled with a positive history of exposure to intense sound. In addition the typical audiometric profile variation with age of the subject starts falling off at and 1 kHz at a rate of about 6 to 8 dB at

10 kHz from the age of 40 onwards. This sign of aging in hearing is known as presbycusis.

The audiometric test result of a person with N.I.H.L is bilaterally symmetrical or almost so, which is a characteristic of this form of noise related hearing loss. In contrast, hearing loss due to gun firing practice for example, usually occurs at the right ear which is the ear nearest the firing point. In the former, continued exposure to the high noise level in his workplace results in a corresponding growth in the size of the 4 K notch. As hearing loss at 4000 Hz becomes greater, it begins to spread to adjacent higher and lower frequencies. Generally the frequencies of 6000 Hz and above are affected to a greater extent than the frequencies of 2000 Hz and below. At this point hearing impairment has progressed to a fairly severe degree of invovement with hearing thresholds significantly reduced at 1500 and 2000 Hz as well as at higher frequencies. The once distinctive 4000 Hz notch becomes no longer apparent in such cases as a result of the even greater loss of sensitivity at higher frequencies. In determining the overall hearing handicap percentage, however, greeater emphasis is often put on the hearing loss at 1000 Hz [4].

REFERAL CRITERIA

In Singapore, noise induced deafness is usually detected through routine surveillance such as the hearing conservation programme of the Industrial Health Division of the Ministry of Labour or that of the company in which the worker is employed. If a significant hearing loss is observed on a baseline hearing test, referal for otological evaluation is the appropriate course of action. However, in many countries there is little agreement as to what constitutes a significant hearing loss on an industrial hearing threshold screen. Certainly any credible hearing conservation porgram would make every effort to ensure that individuals with potential hearing loss receive follow-up evaluation. The Industrial Health Division of the Ministry of Labour recommend medical referal for anyone whose audiometric results show unusual irregularity. Unless there is evidence of a prior noise induced hearing loss, it is not sufficient to make the assumption based solely on results of an industrial audiometric test that the cause was in fact noise exposure. There are a number of variables that enter into the diagnosis of hearing loss that can only be made following more extensive audiological and otological examination.

Another criterion for medical referal from baseline test results is the presence of a unilateral hearing loss or an assymmetry in the audiometric configuration between the two ears. Hearing loss from industrial noise exposure is generally found to be equal in both ears. Thus, a difference of approximately 15 to 20 dB or more between ears of an individual usually suggests that an agent other than the usual industrial noise exposure may be responsible for the existing hearing impairment and necessitates further investigation.

The purpose of monitoring audiometry results is to identify changes in hearing threshold in the direction of decreased hearing that may be noise related. Since hearing loss resulting from noise exposure generally affects the higher frequencies first, careful evaluation should be made of potential threshold shift at these frequencies. The OSHA (1970) [5] regulations define a "significant threshold shift" as an average change in hearing threshold at the

frequencies of 2000, 3000, and 4000 Hz of 15 dB or greater relective to the baselines audiogram. In Singapore compensation is not generally considered unless a severe loss of at least 50 dB in each frequency is detected. This is then confirmed by a panel of specialists and depending on how severe the hearing loss, the worker may be eligible for compensation under the Workman's Compensation Act of Singapore[6]. Such compensation cases usually involve fairly substantial losses of between 50 dB to 100 dB.

METHOD

The phenomenon of sensorineural hearing loss associated with noise - induced deafness was evaluated by examining selected patient charts. Patients selected for the study were chosen by criteria that occluded possible sensorineural hearing impairments due to previous ear surgery, familial history, fistular, use of ototonic drugs, presbycusis or infection of the middle ear.

Analysis was made of the air-conduction thresholds of patients examined for acoustic trauma during the five-year period between 1977 and 1981. This sample of patients, by no means included all patients seen for acoustic trauma during this 5 year period. All the patients were audiometrically evaluated at least twice in the sound - proof booths by qualified staff knowledgeable in the establishment of hearing thresholds [7].

All the subjects were previously submitted to a careful ear examination by the E.N.T. medical doctors or specialists and the relevant medical history was recorded. Air and bone conduction thresholds were obtained in an audiometric two-room suite using a clinical diagnostic audiometer (Amplivox Model 103) calibrated to the required standards. Air conduction thresholds were obtained for the frequencies from 250 to 8000 Hz and bone conduction thresholds for 250 to 4000 Hz. The audiometric measurements were made by the necessary persons trained in audiometric examinations.

A comparison was made with a parallel study of the hearing of first - year University engineering students made over the same period. In the University acoustic laboratory, the subject was tested in a Amplivox noise excluding booth in an airconditioned room to meet the low background noise requirements [3]. The audiometer used was the Interacoustics Model TA155 using pure tone air conduction and bone conduction measurements. For additional background noise exclusion Amplivox Audiocups were used in the airconduction test. Masking is used when using the bone conduction test to allow discrimination between the two ears when testing the bad ear.

RESULTS

Typical results obtained for the audiological evaluation of subjects with noise induced hearing loss in shown in figure 1 and those obtained at the University from figure 2. Overall analysis of the findings is shown in Table 2 and confirmed cases of noise induced deafness obtained by the Ministry of Labour in Table 3 [8].

OBSERVATIONS

According to the annual reports of the Industrial Health Division of the Ministry of Labour of Singapore, noise induced deafness was the leading notifiable industrial disease in Singapore in 1977. The number of confirmed noise induced deafness cases however fell from 529 in 1977 to 257 in 1978 and

there were 158 cases of hearing loss due to noise in 1979. It then rose again in 1980 to 229 confirmed cases and last year fell to only 99 cases. Most of the cases were detected under the Ministry of Labour's Hearing Conservation Programme in which a total of 5,529 workers from 108 factories were examined in 1979. The factories were mainly in the industries categorised under shipbuilding and repairing, textile, woodworking and metal working where the noise levels were noticeably higher than in the other industries and hence total worker exposure with overtime often being taken.

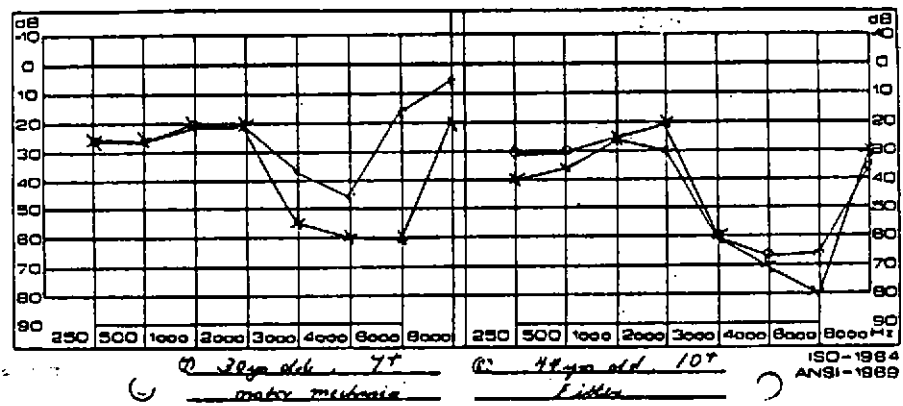

Fig. 1 Typical audiogram of N.I.H.L

In 1980 some 5014 workers were examined under this program and 4657 from 86 establishments were examined in 1981. The fall off in numbers examined was largely due to the encouragement given to the larger factories to have their own examination facilities for worker hearing and other health conservation programmes. Advisory services on industrial health problems were also rendered by this department of the Ministry of Labour. It is of interest to note that in 1980 33% of the consulting offered were on noise, giving some indication of increasing noise problems in the local industrial scene. Details of some methods used in reducing the noise exposure of employed persons were given in a previous paper [9].

Table. 2 Analysis of results for University subjects screened

Year	Percentage of hearing loss			
	< 10%	< 30%	30-50%	> 50%
1978	94	11	0	0
1979	88	9	0	0
1980	92	9	1	0
1981	54	2	1	0
1982	32	0	0	0

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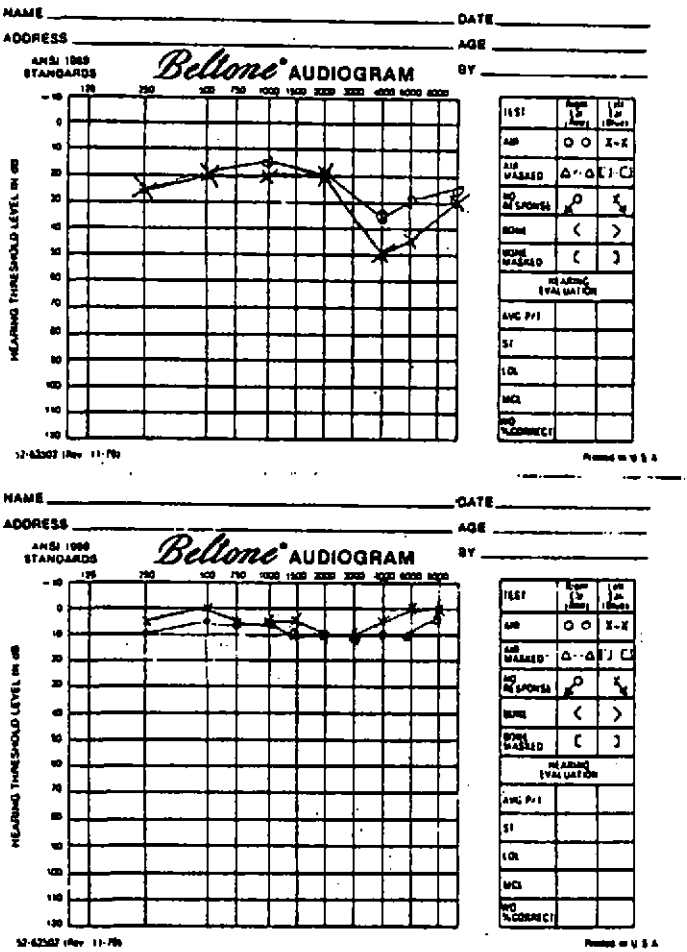

Figure 2. Typical audiogram of undergraduate students

Table 3. Noise induced deafness

Year	New Confirmed Cases
1977	529
1978	257
1979	158
1980	229
1981	99

CONCLUSION

The study has shown that noise induced deafness is not yet a serious problem in Singapore. The number of confirmed cases is found to be rising but the majority are in the early stages of the disease and the number of new confirmed cases last year fell quite dramatically. More employers now arrange hearing tests for their workers and many are now having their own facilities where these can be carried out. Doctors are now being specially trained in industrial related diseases. Also better worker awareness and additional noise precautions are expected to bring about an improvement in the situation.

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