a review of trends in hearing thresholds of european oil refinery workers

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ABSTRACT

The change of hearing thresholds was assessed in a study population of over 1000 noise-exposed oil refinery workers subject to noise at work regulations in Member States of the European Union. Audiometric data covering a period of approximately 12 years were retrieved from refinery occupational health departments. The data were screened using established procedures, standardised for age according to international guidelines and subjected to statistical analysis to identify time trends and differences between subgroups of younger and older workers. From the analyses of the data it was concluded that the workers' hearing did not deteriorate more than expected from natural ageing.

KEYWORDS

Audiometry, hearing loss, noise-induced hearing loss, noise, refinery workers, occupational noise exposure.

CONTENTS

SUMMARY

The change of hearing thresholds was assessed in a study population of over 1000 noise-exposed oil refinery workers subject to noise at work regulations in Member States of the European Union. New or revised noise at work regulations were introduced in the late 1980s after the issue of an European Council directive, which required the assessment of occupational exposure to harmful noise levels and the introduction of control measures. Health surveillance using audiometry (the measurement of minimum perceived sound levels at a series of selected frequencies to determine a worker's hearing thresholds) was part of the requirements, specifically to determine the effectiveness of control measures and hearing protection programmes implemented by operating companies.

A potential confounding factor in audiometry is that hearing thresholds are known to increase with age, particularly at the higher frequencies, even without illness or exposure to noise. Normal hearing threshold data have however been described in international guidelines as averages and standard deviations for age groups of people not exposed to noise. These formed an accepted basis for the evaluation of the hearing threshold increase observed in the population of noise-exposed oil refinery workers studied.

Audiometric data covering a period of approximately 12 years were retrieved from occupational health departments of 10 refineries in seven countries. These data were screened for non-noise related hearing deficiencies using established procedures and then corrected for age according to the international guidelines. The group averages of the corrected data were compared with the described reference.

Statistical analysis was undertaken to identify any time trends and differences between subgroups of younger and older workers.

The results obtained indicate that at the start of the study period the average hearing thresholds of the refinery workers population, corrected for age, were higher than for the general population. However, the subsequent increase of the average hearing thresholds over the studied period was less than expected on the basis of the international guidelines. This finding is in accordance with the hypothesis that, although there is potential for noise exposure to reach hazardous levels in some refinery workplaces, the level of protection is such that it prevents the development of more hearing loss than would be expected from ageing alone.

A comparison of the age-corrected data for the two subgroups showed that less hearing loss has occurred in younger workers than in older workers.

The findings of this study indicate that the average hearing of a subset of approximately 1000 European oil refinery workers exposed to noise at work from the mid 1980's to the late 1990's, did not deteriorate more than expected from ageing alone. This outcome supports the hypothesis that exposure to hazardous noise is well controlled.

1. INTRODUCTION

Prolonged exposure to excessive noise in the workplace may cause damage to an individual's hearing ability; this is called 'Noise-Induced Hearing Loss' (NIHL). European Council Directive 86/188/EEC of 12 May 1986, on the protection of workers from the risks related to exposure to noise at work, required European Member States to bring into force legislation and provisions for the evaluation of occupational noise exposures and the protection of workers' hearing capability. Workers with daily noise exposures above a first action level of 85 decibels A-weighted (dB(A)) should be able to have their hearing checked with the purpose of diagnosing hearing impairment and preserving hearing.

CONCAWE issued guidelines for hearing conservation programmes in the petroleum industry at the time that Directive 86/188/EEC was prepared (CONCAWE, 1985). These guidelines contained recommendations for technical control measures to reduce equipment noise levels as well as for the use of personal hearing protective devices and health surveillance. A review of daily noise exposures in Western-European oil refineries was also prepared (CONCAWE, 1990). The review indicated that for a number of typical refinery occupations the exposure to noise regularly exceeded the first action level of 85 dB(A), therefore requiring *inter alia* hearing checks.

As part of the amended proposal for a new directive on physical agents published in 1994, a threshold level for daily noise exposure of 75 dB(A) was specified. CONCAWE's Health Management Group subsequently initiated a programme of work to assess the need for this more stringent requirement. CONCAWE's Medical Subgroup was requested to undertake an evaluation of the hearing capability of noise-exposed refinery workers in Europe following the introduction of national regulations based on Directive 86/188/EEC and the implementation of the guidelines for hearing conservation programmes. The results of this evaluation are provided in the present report.

2. PROJECT ORGANISATION AND STUDY PROTOCOL

CONCAWE's Medical Subgroup carried out the evaluation with assistance in audiological science from the Institute for Sound and Vibration Research of the University of Southampton (UK) and in biostatistics from the Epidemiology Unit of the School of Public Health of the Université Catholique de Louvain (B).

2.1. STUDY DESIGN

The selected study design was a retrospective cohort study, utilising individual hearing test data obtained during routine health surveillance maintained in refinery occupational health department files. Noise-induced hearing loss is known generally to develop in the first 10-15 years of exposure (ISO, 1990) and a nominal length of 12 years was therefore chosen for the time period covered by the study. In view of the time when the European Council prepared and issued its Directive (1986), the starting point, i.e. the time of the "baseline" audiogram, had to be in the mid-1980s. This baseline audiogram was therefore not necessarily the first ever or pre-employment audiogram for the selected individuals.

Hearing loss in individuals can be the result of a number of factors, including natural ageing, exposure to harmful noise levels, both occupational and non-occupational, disease, and use of some pharmaceutical products. In addition, audiometric testing, like any measurement technique, includes measurement error. These factors may not have an additive effect on the measured hearing thresholds, and their relative contributions cannot usually be distinguished reliably at the individual level. At the group level, however, where a group has a common factor such as occupational exposure to harmful noise levels, trends may be observed which can help assess the effect of this on hearing and e.g. the effectiveness of hearing conservation programmes (McBride and Calvert, 1994). In order to assess any trend resulting from one factor, it is necessary to eliminate or minimise as much as possible the effect of other factors. To achieve this a series of procedures (described below) was therefore developed to select an appropriate study population.

2.2. STUDY POPULATION SELECTION

A study protocol for the selection of refinery personnel to be included in the study and selection of audiograms was developed in co-operation with the University of Southampton, and member companies were required to submit data in a computerised workbook. A statistical protocol was developed for the data analysis. Representatives from member companies' refinery Occupational Health departments compiled the workbook entries. Member companies submitted their files to the CONCAWE Secretariat where these were coded in order to ensure confidentiality, and screened for obvious errors. The Secretariat also corrected, in accordance with the protocol, those entries where more or fewer than four audiograms had been provided as had been stipulated.

The aggregated workbook was then transmitted to the Epidemiology Unit of the School of Public Health of the Université Catholique de Louvain for data analysis.

For inclusion in the study a worker was considered noise-exposed when exposure had occurred at a level above 85 dB(A) for at least 1 hour per day for the duration of the study period. No distinction was made between workers on the basis of potential exposures to noise in view of the likely use of effective hearing protection.

A minimum study population of 1000 workers was set as a target. Workers were selected by their refinery Occupational Health departments on the basis of their noise exposure and availability of 4 audiograms covering an approximate 12 year period.

To be eligible for inclusion in the cohort, a worker should have had hearing tests at a baseline year in the 1980's, and thereafter at year 2, 7, and 12 nominally. Where no audiogram for the desired year was available, the audiogram nearest in time was taken, allowing the period of 1-3 years after baseline for the first follow-up test, the period 4-10 years for second follow-up, and the period 8-17 years for the last test. In addition, a minimum of 2 years was required between the follow-up tests. Audiograms showing right- and left ear hearing thresholds were measured at a maximum of six frequencies at each evaluation (500, 1000, 2000, 3000, 4000, and 6000 Hz).

Where only 3 audiograms were available for a worker, the individual was included if the overall time period was sufficiently long (i.e. 12 years). Similarly, if threshold data for one or two of the six audiometric frequencies were missing, audiograms could still be included under certain conditions.

2.3. DATA QUALITY ASSESSMENT

2.3.1. Exclusion of cases of hearing loss not related to refinery noise

Excessive noise exposure in an oil refinery environment is generally expected to affect both ears to the same degree. Asymmetrical hearing loss, detected in an individual, is therefore likely to be related to other causes, such as illness or non-refinery noise, e.g. use of firearms, and consequently eliminated from this study.

Exclusion criteria were established for persons with asymmetrical hearing loss for the two ears, based on Medical Guidance Note MS 26 of the UK Health and Safety Executive. The exclusion criterion related to the sum of the absolute differences between both ears at the frequencies 3, 4 and 6 kHz (i.e. those considered most vulnerable to noise-induced hearing loss). Workers presenting a sum greater than 60 dB at these frequencies in any of their audiograms were excluded. 40 dB was substituted when one of the three frequencies was missing, and 20 dB when the hearing thresholds were not available for the frequencies 3 and 6 kHz.

2.3.2. Comparison of left and right ear threshold distributions

Because left and right ears are expected to have similar hearing thresholds when a person has no hearing abnormality, the hearing threshold was compared between left and right ears using paired t-tests. Since multiple tests were conducted on the same population the significance criterion were set at a lower level in order to reject the hypothesis of similar hearing in left and right ears. These comparisons were performed within each refinery cohort and at each of the measured frequencies for the baseline audiogram.

2.3.3. Screening for measurement errors

Exclusion criteria were also adopted for apparent but biologically implausible improvements of hearing thresholds, as indicated by consecutive audiometric tests, on the basis of the typical measurement error. This error was assumed to be 10 dB.

The same value of 10 dB was initially adopted as the maximum allowed improvement between tests, but this was later changed to 20 dB (twice the measurement error).

2.4. DATA STANDARDISATION AND TRANSFORMATION

In order to eliminate the effect of the natural increase of hearing threshold due to age, individual data were corrected for age according to ISO 1999 (ISO, 1990). To allow comparison between individuals of different ages, all measured hearing thresholds for each refinery worker were transformed into Z scores, a value indicating at what deviation the individual is from the average in the normal population distribution. Z scores were calculated for the baseline and all follow-up audiograms.

Appendix A of the ISO 1999 guidelines describes the calculation of fractiles (upper area under a Gaussian curve) of the age-expected distribution of hearing threshold in men older than 18 years and not exposed at all to noise. Symbols hereafter are those used in ISO1999 guidelines. Coefficients *a* are taken from Table A.1 and coefficients b_L and b_U are taken from Table A.2 of these ISO1999 guidelines.

Table 1 Coefficients for calculation of age-expected distribution of hearing thresholds in men (ISO, 1990)

	Frequency (Hz)					
	500	1000	2000	3000	4000	6000
Coefficient *a*	0.0035	0.0040	0.0070	0.0115	0.0160	0.0180
Coefficient b_L	4.89	4.89	5.78	6.23	6.67	7.56
Coefficient b_U	6.12	6.12	7.23	7.78	8.34	9.45

$H_{0.50} = a(Y\text{-}18)^2$ is the expected mean value of the hearing threshold at the age of *Y* years;
$S_L = b_L + 0.356\ H_{0.50}$ is the expected standard deviation of the lower half of the distribution.
$S_U = b_U + 0.445\ H_{0.50}$ is the expected standard deviation of the upper half of the distribution.

Using these parameters of the age-related normal (Gaussian) distribution, a measured hearing threshold H_m was expressed as a standardised Gaussian score Z_m:

$$Z_m = (H_m - H_{0.50}) / S_U \quad \text{if } H_m > H_{0.50} \quad \text{and} \quad Z_m = (H_m - H_{0.50}) / S_L \quad \text{if } H_m < H_{0.50}$$

Example: A 45 years-old worker has a measured hearing threshold value, averaged for the two ears, of 20 dB at 4000 Hz. His age-expected mean value is $0.0160(45\text{-}18)^2 = 11.664$ dB with an expected standard deviation of 8.34+0.445(11.664)=13.53 dB; the corresponding Z score is (20-11.664)/13.53 = +0.616. Such a score value corresponds to a Gaussian fractile of 27% and means that 27% of normal hearing males, aged 45 yrs, have a hearing threshold higher than 20 dB at 4000 Hz.

The expression of the hearing threshold as a Gaussian score is intended to correct for the age effect under the assumption of a normal (Gaussian) distribution. Additionally, because those scores are also corrected for the audiometric frequency, the scores are expected to be similar across frequencies. If there is developing noise-induced hearing loss over the study period, those scores would increase with time, indicating that the study population is moving towards the increased hearing loss side of the general population distribution.

The ISO 1999 procedure described above is based upon a subject population screened to ensure otological normality. Such normal subjects would not be a fair comparison for a sample of audiologically unscreened workers; a sample of typical or ordinary males would be better. Passchier-Vermeer (1988) has reported the descriptive statistics for just such a population of unscreened male workers.

Interpolation between the values for fractiles 10, 50, and 90 led to adjustment of the median, and the upper and lower standard deviations. These adjusted or corrected statistics (with the typical population indicated by an asterisk) were based upon the normal population from ISO 1999 thus:

$$H^*_{0.50} = H_{0.50} + 2 \qquad S^*_L = S_L + 1.5606 \qquad S^*_U = S_U + 3.1211$$

The corrected Z score for any measured hearing threshold H_m was therefore defined as:

$$Z^*_m = (H_m - H^*_{0.50}) / S^*_U \quad \text{if } H_m > H^*_{0.50} \quad \text{and} \quad Z^*_m = (H_m - H^*_{0.50}) / S^*_L \quad \text{if } H_m < H^*_{0.50}$$

2.5. STATISTICAL ANALYSIS

Noise-induced hearing loss is known to develop primarily in the first 10-15 years of exposure, with an effect first showing first at 4000 Hz (ISO, 1990). Since it was thought possible that younger workers may have only experienced limited exposure to noise in the oil industry prior to the study period an attempt was made to distinguish between younger and older workers.

The data were analysed on an overall study population basis, and also by refinery to establish any possible refinery effect. An analysis of variance (AOV or ANOVA) was applied to compare the results from the multiple data subgroups. This method allows for and indeed reduces the variation of the main parameter studied (i.e. change in hearing threshold over the four observations), by controlling the variations induced by other factors, in this case age and refinery.

3. RESULTS

3.1. STUDY POPULATION

The study included workers from 10 oil refineries in 7 European countries (Belgium, Finland, France, Germany, Italy, the Netherlands, and the United Kingdom). This was the result of a call for data to all CONCAWE member companies. The data were assumed to be reasonably representative of the European situation, based on the geographical spread of the studied refinery populations, and the fact that the 10 refineries were a relatively large sample of the total of approximately 90 operated by CONCAWE member companies.

Audiograms were received for a total of 1323 oil refinery workers. Of these, 54 had less then 3 audiograms and were excluded. The remaining 1269 workers came from 10 refineries, with a minimum of 24 and a maximum of 345 workers per refinery. Because of the retrospective design of the study, data quality was carefully checked.

As described in section 2, a first check of the data quality was performed using the UK exclusion criterion for asymmetrical hearing loss in the high frequencies (HSE Medical Guidance Note MS 26). This check was performed for each test occasion. The distributions of right and left ears hearing thresholds (HT) were then compared using paired t-tests, with a significance level set at 0.05/60=0.0008 because of 60 statistical tests (6 frequencies in 10 refinery populations) (Bland & Altman, 1986; Bland & Altman, 1995). Individual average hearing threshold data were then calculated and checked for implausible improvement in time.

3.1.1. Exclusion of asymmetrical hearing loss

For each audiometric test the absolute difference between the left and the right ear hearing thresholds was summed over the frequencies 3, 4, and 6 kHz, and compared with the established exclusion criteria for the difference between the two ears. Thus, 183 workers were excluded because of excessive difference between both ears during one or more tests (see **Table 2**). 1041 data sets satisfied the criterion; an additional group of 45 workers with one missing audiogram ('M', see **Table 2**) was also included, making a total of 1086.

3.1.2. Comparison of left and right ear hearing thresholds at the baseline

At the baseline evaluation of the remaining workers (n=1086), the mean difference between right and left ear hearing thresholds (HT) with its 95 % confidence interval is reported in **Table 3**, at each frequency and within each refinery. A significant p-value was observed at the audiometric frequency of 1000 Hz in refinery number 10. This single significant p-value was due to workers no. 175 (right ear HT=50dB and left ear HT=20dB), no. 211 (right ear HT=35dB and left ear HT=10dB), no. 308 (right ear HT=50dB and left ear HT=20dB), and no. 345 (right ear HT=40dB and left ear HT=15dB). Of these, workers no. 175, no. 308, and no. 345 did not satisfy the next criterion for the maximum allowed improvement between consecutive audiograms (see below) and were excluded from further analysis. For all other frequency/refinery combinations, the p-value was not significant, confirming that the distributions of the right ear and left ear hearing thresholds could not be distinguished.

Plots of the difference between the two ears versus the average of the two ears are presented for each frequency and refinery in **Appendix A**.

3.1.3. Exclusion of apparent measurement errors

The two ear-averaged hearing threshold (AHT) improved between two consecutive evaluations (2 years - baseline, 7 years - 2 years, or 12 years - 7 years) with more than 10 dB at one or more frequencies in 335 workers. The exclusion criterion was then changed to 20 dB which is the sum of the assumed measurement errors for two determinations. An AHT improvement of more than 20 dB in consecutive audiograms was observed in 73 workers (**Table 4**). These workers were excluded from further analyses.

3.1.4. The study population after the data quality checks

Following application of the quality criteria the definitive study population included 1013 workers (see **Table 4**). At the baseline evaluation, the overall mean age and standard deviation of the 1013 workers was 34 ± 7 years, and the median was 35 years. Age distribution was not the same across refineries. The youngest population was found in refinery no. 3, with mean 32 ± 4 years (range: 24 to 38); the oldest population was that of refinery no. 5, with mean 43 ± 8 years (range: 27 to 51). One third of the workers (337/1013) was younger than 30 years. In order to assess an age effect on AHT time trends, a cut-off age at the median of 35 years was established to form two subgroups according to age at baseline (i.e. up to 35 and over 35 years of age).

3.2. TIME TRENDS IN AVERAGE HEARING THRESHOLDS

Mean and standard deviation (SD) of AHT at each frequency are reported in **Table 5**, for the entire population of workers and for the two subgroups of workers according to age at baseline. As expected, mean AHT for most frequencies increased with time, and increased with audiometric frequency at any point in time. Mean AHT was higher in workers aged over 35 years than in workers under 35 years of age, at each audiometric frequency and at each time evaluation.

In order to standardise for age and audiometric frequencies, normalised scores or Z scores were computed according to ISO 1999 guidelines, as detailed in section 2.3. Summary statistics of Z scores (for normal subjects according to ISO 1999) and corrected Z* scores (for typical subjects according to Passchier-Vermeer) are reported in **Tables 6 and 7** for the total study population and the two age subgroups. Calculated scores and corrected scores for each refinery and for the two age groups are presented in **Appendix B**. The number for fractile in the last column of the tables in **Appendix B** corresponds to the expected proportion of the general population having worse hearing than the average of the study populations on the basis of ISO 1999 or the corrected distribution according to Passchier-Vermeer.

3.2.1. Analysis of average hearing thresholds at different frequencies

Analysis of variance (AOV) was performed in order to compare the scores across the six frequencies with average hearing threshold data. Changes of scores over time were not uniform across the frequencies, because highly significant changes in the scores were observed ($p<0.001$). When performing an AOV on the three main

frequencies for noise-induced hearing loss (3000, 4000, and 6000 Hz), the significant changes remained ($p<0.001$). Each frequency was therefore treated separately in the time trend analyses.

3.2.2. Overall time trend analyses

AOV for time trends in scores and in corrected scores, with a Refinery factor and an Age factor, could not be performed, because of database limitations, even at the frequency (4000 Hz) with the least missing data. Separate AOV were therefore conducted for the Age factor and for the Refinery factor. Scores were not significantly different between age subgroups ($p=0.84$ for scores, $p=0.41$ for corrected scores), but were significantly different between refineries ($p<0.0001$ for scores and for corrected scores). Time trends, frequency changes, and interaction between time and frequency had a highly significant effect on scores (all $p<0.0001$). AOV of time trends in scores and in corrected scores were therefore performed at each frequency level, with either Age or Refinery as a grouping factor.

3.2.3. Time trend analyses within each frequency level

The 24 analyses of variance of time trends in scores and in corrected scores showed that the decrease of scores with time was highly significant. This finding was surprising, because scores were expected to remain unchanged over time in case the workers' hearing evolved in the same way as predicted by ISO 1999 for the general population, or to increase in the event of an effect from noise exposure. The absolute measurements of the AHT were therefore also submitted to an AOV. Expected results were observed: the increases with age ($p<0.0001$), frequency ($p<0.0001$), and time ($p<0.0001$) were all highly significant.

The time decreases in scores (**Table 6**) and in corrected scores (**Table 7**) are illustrated in **Figures 1 and 2**, respectively. Similar results were observed in the two age subgroups, and in most refineries.

4. DISCUSSION

4.1. TIME TRENDS, CORRECTED FOR AGEING

This study was conducted to evaluate the change of hearing thresholds of noise-exposed oil refinery workers, taking into account the age-associated natural worsening of the hearing. This change was observed over a time period of 12 years beginning in the 1980's when noise control regulations were introduced on the basis of a European Council Directive.

The results indicate that at the start of the study period the average hearing thresholds, corrected for age, of the refinery workers population appeared to be higher than for the general population. This was not unexpected for a population of industrial workers and confirmed information provided by the participating occupational physicians about the employment history of a number of the members of the cohort.

The subsequent increase of the average hearing thresholds, however, was less than expected on the basis of natural hearing loss due to ageing as described in international guidelines. This finding is in accordance with the hypothesis that, although there is potential for noise exposure to reach hazardous levels in some refinery workplaces, the level of protection is such that it prevents the development of more hearing loss than would be expected from ageing alone.

There are a number of possible explanations for this apparent relative improvement in hearing thresholds:

- use of screening audiometry in routine occupational health surveillance, where good hearing capability, with thresholds below a given value (e.g. 10 dB), is not analysed in full detail. However, a preliminary check of the reported data suggests that most data were actually measured thresholds. It can also be seen in the plots in **Appendix A** that the measurements are generally evenly distributed around the average, well below 10 dB, so the use of screening audiometry is an unlikely cause of the observed trend.

- changes in audiometric practices: increasing skill of occupational health personnel, and of workers when doing self-assessment, resulting in more accurate data and lower thresholds; similarly, technical developments such as the change from manual to computerised audiometer operation and the introduction of the insulated test booth may have played a role.

- a so-called 'healthy worker effect', where workers with excessive hearing deterioration are excluded from noise exposure. Since most workers were already exposed to noise before the start of the study period, noise-sensitive workers may have been excluded from the cohort. The fact that the same trend is observed in the younger and in the older workers suggests that, if it exists, any healthy worker effect is weak.

- the age-associated increase of the hearing threshold is overestimated by the ISO 1999 guidelines equations. In the absence of an effect from noise exposure, the expected value for the mean standardised AHT values or Z-scores would be 0 and have a standard deviation close to 1. The standard deviations (0.8-1.2) in **Table 6** show the spread in the study population to be similar to that of the

otologically normal population presented in Appendix A of ISO 1999. The data in **Table 7** with the corrected standardised AHT, according to Passchier-Vermeer, show mean values closer to 0 when compared with the uncorrected mean standardised AHT values in **Table 6**, but standard deviations are smaller (0.6-0.8). Although our data suggest that ISO 1999 may not be accurate, the results of this study are not suitable to verify the ISO 1999 guidelines, because the study population obviously can not be assumed to be free from noise-induced hearing loss.

4.2. COMPARISON OF THE TWO AGE GROUPS

The average age difference between the group of workers younger than 35 years and the group of workers over 35 years at the time of their baseline audiogram was 12 years (see **Table 5**). Coincidentally, this is the same as the nominal length of the study period. It is therefore possible to compare the hearing data of the older workers at the time of their baseline audiogram with the younger workers at the time of their final audiogram. As the mean age of both groups at those points of time was 41 years, the effect from ageing would be identical. As can be seen in **Table 5**, for all the test frequencies the average hearing of the younger workers at the final (12 years) audiogram was better than the average hearing of the older workers at baseline. This shows younger workers to have less hearing loss at age 41 than the older workers at age 41. Possible explanations may be better hearing protection for the younger workers and previous exposure of the older workers in high-noise industries or military services. A similar trend was also observed in most individual refinery groups (data not shown).

5. CONCLUSION

This study does not identify any noise-induced hearing loss from occupational noise exposure in a population of approximately 1000 workers drawn from 10 European oil refineries, exposed to noise at work in the period from the mid 1980's to the late 1990's. This conclusion is reached using measured hearing threshold data, corrected for the effect of natural ageing according to guidelines issued by the International Organization for Standardization. The same conclusion is also reached when using a modified age correction proposed in the scientific literature. This outcome supports the hypothesis that exposure to hazardous noise is well controlled through the refineries' hearing conservation programmes.

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Table 2 Number of workers satisfying (-) or not satisfying (+) the criterion (Sum over the frequencies 3, 4, and 6 kHz, of the absolute difference between left and right ear hearing thresholds, less or equal to 60 dB) at each time-point measurement.

Audiogram number				Refinery number										Total
1	2	3	4	1	2	3	4	5	6	7	8	9	10	number
-	-	-	-	32	55	41	101	16	5	250	197	48	296	1041
+	-	-	-	1	0	2	2	2	0	4	2	2	4	19
-	+	-	-	0	0	1	0	1	0	4	2	2	3	13
-	-	+	-	2	0	0	1	0	0	2	5	1	5	16
-	-	-	+	2	0	1	3	0	0	8	5	0	11	30
+	+	-	-	0	0	0	0	0	0	0	4	1	3	8
+	-	+	-	1	0	0	0	0	0	1	2	0	2	6
+	-	-	+	0	0	0	0	0	0	0	1	0	1	2
-	+	+	-	1	0	0	0	0	0	0	1	0	1	3
-	+	-	+	0	0	1	0	0	0	1	0	0	1	3
-	-	+	+	0	0	5	1	0	0	0	4	0	2	12
+	+	+	-	0	0	0	0	0	0	0	3	0	2	5
+	+	-	+	0	0	0	1	1	0	0	1	0	1	4
+	-	+	+	0	0	1	2	0	0	0	1	0	1	5
-	+	+	+	1	0	1	1	0	0	3	2	1	2	11
+	+	+	+	1	0	6	1	0	0	11	9	1	10	39
M	-	-	-	0	0	0	0	0	10	0	0	0	0	10
-	M	-	-	0	0	0	4	0	10	3	0	0	0	17
-	-	M	-	0	0	0	0	0	2	0	0	0	0	2
-	-	-	M	0	0	0	5	2	1	8	0	0	0	16
+	-	M	-	0	0	0	0	0	2	0	0	0	0	2
+	-	M	+	0	0	0	0	0	0	1	0	0	0	1
M	-	+	+	0	0	0	0	0	1	0	0	0	0	1
+	+	M	+	0	0	0	0	1	1	0	0	0	0	2
+	+	+	M	0	0	0	0	1	0	0	0	0	0	1
				41	55	59	122	24	32	296	239	56	345	1269
Excluded workers (N)				-9	0	-18	-12	-6	-4	-35	-42	-8	-49	-183
Remaining workers (N)				32	55	41	110	18	28	261	197	48	296	1086

Note: The criterion of 60 dB was set to 40 dB when one of the three frequencies was missing, and to 20 dB when frequencies 3 and 6 kHz were missing (mainly in refinery number 8). When the 4 kHz frequency was missing with at least one of the 3 and 6 kHz frequencies, the criterion was considered as missing (M).

Table 3 Hearing thresholds (HT) at baseline evaluation: difference between right and left ear at each frequency and within each refinery

Frequency	Workers (n)	Right-Left ear HT Mean (dB)	95% confidence interval on mean difference (dB)	Paired t test	p-value	Difference d minimum (dB)	Difference d maximum (dB)	| d | * > 20 dB (n)
Refinery no. 1								
500 Hz	32	-1.719	[-3.81 ; 0.37]	-1.61	0.12	-15	10	0
1000 Hz	32	-0.469	[-3.05 ; 2.11]	-0.36	0.72	-25	10	1
2000 Hz	32	0.625	[-2.42 ; 3.67]	0.40	0.69	-20	20	0
3000 Hz	32	-2.656	[-6.44 ; 1.13]	-1.38	0.18	-25	15	1
4000 Hz	32	-0.313	[-2.60 ; 1.97]	-0.27	0.79	-15	10	0
6000 Hz	32	0.469	[-2.81 ; 3.74]	0.28	0.78	-10	20	0
								(1)
Refinery no. 2								
500 Hz	55	-0.091	[-2.10 ; 1.92]	-0.09	0.93	-15	15	0
1000 Hz	55	0.091	[-1.36 ; 1.54]	0.12	0.90	-20	10	0
2000 Hz	55	-0.818	[-2.42 ; 0.79]	-1.00	0.32	-20	10	0
3000 Hz	55	-1.727	[-3.84 ; 0.39]	-1.60	0.12	-30	15	1
4000 Hz	55	-1.546	[-3.45 ; 0.36]	-1.59	0.12	-20	15	0
6000 Hz	55	-0.636	[-2.47 ; 1.20]	-0.68	0.50	-20	15	0
								(1)
Refinery no. 3								
500 Hz	41	-4.512	[-7.04 ; -1.98]	-3.50	0.001	-17.5	10	0
1000 Hz	41	-2.988	[-4.60 ; -1.37]	-3.62	0.001	-12.5	10	0
2000 Hz	41	-1.281	[-3.66 ; 1.10]	-1.06	0.30	-15	22.5	1
3000 Hz	41	-3.232	[-5.89 ; -0.57]	-2.38	0.02	-20	15	0
4000 Hz	41	-1.585	[-5.42 ; 2.25]	-0.81	0.42	-57.5	22.5	2
6000 Hz	41	0.061	[-3.67 ; 3.80]	0.03	0.97	-20	35	2
								(5)
Refinery no. 4								
500 Hz	110	-0.636	[-1.30 ; 0.02]	-1.89	0.06	-10	10	0
1000 Hz	110	0.045	[-0.71 ; 0.80]	0.12	0.91	-10	20	0
2000 Hz	110	0.364	[-0.51 ; 1.24]	0.82	0.42	-10	20	0
3000 Hz	110	-0.909	[-2.23 ; 0.41]	-1.35	0.18	-30	25	2
4000 Hz	110	-1.136	[-2.86 ; 0.59]	-1.29	0.20	-30	40	3
6000 Hz	110	0.591	[-1.11 ; 2.29]	0.68	0.50	-40	20	1
								(6)
Refinery no. 5								
500 Hz	18	-2.222	[-4.20 ; -0.25]	-2.20	0.04	-10	5	0
1000 Hz	18	-1.111	[-4.70 ; 2.48]	-0.61	0.55	-25	10	1
2000 Hz	18	-0.833	[-4.81 ; 3.15]	-0.41	0.69	-20	10	0
3000 Hz	18	0.278	[-4.37 ; 4.93]	0.12	0.91	-20	20	0
4000 Hz	18	-1.389	[-6.39 ; 3.61]	-0.54	0.59	-25	15	1
6000 Hz	18	5.278	[-0.18 ; 10.74]	1.90	0.08	-15	30	2
								(4)

Table 3 (cont'd)

Frequency	Workers (n)	Right-Left ear HT Mean (dB)	95% confidence interval on mean difference (dB)	Paired t test	p-value	Difference d minimum (dB)	Difference d maximum (dB)	| d | * > 20 dB (n)
Refinery no. 6								
500 Hz	28	1.250	[-0.74 ; 3.24]	1.23	0.23	-10	20	0
1000 Hz	28	-1.250	[-2.81 ; 0.31]	-1.57	0.13	-10	5	0
2000 Hz	28	-1.429	[-2.93 ; 0.07]	-1.87	0.07	-10	5	0
3000 Hz	28	-1.964	[-5.75 ; 1.82]	-1.02	0.32	-15	40	1
4000 Hz	28	-1.964	[-5.00 ; 1.07]	-1.27	0.22	-20	20	0
6000 Hz	28	-3.750	[-7.26 ; -0.24]	-2.09	0.05	-25	15	2
								(3)
Refinery no. 7								
500 Hz	261	0.709	[0.16 ; 1.26]	2.53	0.01	-10	20	0
1000 Hz	260	0.462	[-0.23 ; 1.15]	1.32	0.19	-35	40	2
2000 Hz	260	-0.885	[-1.63 ; -0.14]	-2.33	0.02	-50	15	2
3000 Hz	188	-1.888	[-3.03 ; -0.75]	-3.25	0.001	-30	30	4
4000 Hz	260	-1.577	[-2.63 ; -0.53]	-2.95	0.004	-30	25	5
6000 Hz	248	-2.319	[-3.66 ; -0.97]	-3.38	0.001	-45	30	13
								(24)
Refinery no. 8								
500 Hz	197	0.127	[-0.50 ; 0.76]	0.40	0.69	-15	15	0
1000 Hz	197	-0.025	[-0.71 ; 0.66]	-0.07	0.94	-25	30	2
2000 Hz	197	-0.563	[-1.56 ; 0.43]	-1.11	0.27	-20	30	2
3000 Hz	0							
4000 Hz	197	-1.624	[-2.64 ; -0.61]	-3.14	0.002	-20	20	0
6000 Hz	0							
								(4)
Refinery no. 9								
500 Hz	48	-0.938	[-2.09 ; 0.22]	-1.59	0.12	-15	10	0
1000 Hz	48	-1.563	[-3.73 ; 0.60]	-1.41	0.16	-35	10	1
2000 Hz	48	0.729	[-1.96 ; 3.42]	0.53	0.60	-15	35	2
3000 Hz	48	1.042	[-1.40 ; 3.48]	0.84	0.41	-15	20	0
4000 Hz	48	1.146	[-1.79 ; 4.08]	0.76	0.45	-20	20	0
6000 Hz	48	2.292	[-1.16 ; 5.74]	1.30	0.20	-25	35	2
								(4)
Refinery no. 10								
500 Hz	0							
1000 Hz	296	1.588	[0.78 ; 2.40]	3.85	0.0001	-15	30	4
2000 Hz	296	0.135	[-0.64 ; 0.91]	0.34	0.73	-40	30	3
3000 Hz	296	-0.608	[-1.39 ; 0.17]	-1.53	0.13	-30	20	3
4000 Hz	296	-0.152	[-1.07 ; 0.77]	-0.32	0.75	-35	30	6
6000 Hz	296	-1.960	[-3.17 ; -0.75]	-3.17	0.002	-35	35	17
								(30)

* number of cases with absolute difference > 20 dB. Total number of workers is indicated in brackets

Table 4 Number of workers without (-) or with (+) a decrease of at least 20 dB in average hearing thresholds (AHT) between two consecutive time-point measurements, at the same frequency. f = number of audiometric frequencies presenting such a decrease.

	Refinery number										Total
f	1	2	3	4	5	6	7	8	9	10	number
-	31	55	39	105	18	28	255	194	45	243	1013
+ 1	1	0	2	5	0	0	6	3	3	31	51
+ 2	0	0	2	2	0	0	1	1	0	5	11
+ 3	0	0	1	0	0	0	3	0	0	5	9
+ 4	0	0	0	0	0	0	0	0	0	2	2
	32	55	44	112	18	28	265	198	48	286	1086
N excluded	-1	0	-5	-7	0	0	-10	-4	-3	-43	-73
N remaining	31	55	39	105	18	28	255	194	45	243	1013
Mean age (yr)	38	40	32	33	43	38	32	32	41	36	34
Stand. dev. (yr)	±4	±3	±4	±10	±8	±5	±7	±6	±7	±7	±7

Note: The initial criterion of a decrease higher than 10 dB was set to 20 dB because too many workers (n=335) satisfied the initial criterion. In retrospective studies, the reproducibility of a HT measurement can be higher than 10 dB.

Table 5 Time course of average hearing threshold (dB) at each frequency, and within Age subgroups of workers.

	Time	Total (N=1013)	Age £ 35 yrs (N=555)	Age > 35 yrs (N=458)
Age (yrs)	Baseline	34 ± 7	29 ± 5	41 ± 4
Frequency: 500 Hz				
	Baseline	6.84 ± 5.66	6.32 ± 5.48	7.55 ± 5.84
	2 yrs	6.47 ± 5.90	5.51 ± 5.46	7.81 ± 6.23
	7 yrs	7.18 ± 6.29	5.95 ± 5.69	8.87 ± 6.68
	12 yrs	8.33 ± 7.03	6.87 ± 6.35	10.35 ± 7.43
Frequency: 1000 Hz				
	Baseline	8.97 ± 7.84	7.56 ± 7.25	10.70 ± 8.19
	2 yrs	8.62 ± 7.95	7.02 ± 7.33	10.57 ± 8.24
	7 yrs	7.98 ± 6.87	6.13 ± 5.87	10.24 ± 7.31
	12 yrs	8.90 ± 7.48	6.88 ± 6.40	11.35 ± 7.96
Frequency: 2000 Hz				
	Baseline	8.79 ± 8.21	7.17 ± 7.08	10.79 ± 9.02
	2 yrs	8.83 ± 8.50	6.71 ± 7.28	11.41 ± 9.14
	7 yrs	8.17 ± 8.08	6.16 ± 6.53	10.62 ± 9.05
	12 yrs	9.33 ± 9.31	6.45 ± 7.59	12.85 ± 9.98
Frequency: 3000 Hz				
	Baseline	13.64 ± 10.14	10.40 ± 7.86	16.80 ± 11.08
	2 yrs	13.39 ± 10.51	9.53 ± 7.92	17.42 ± 11.34
	7 yrs	13.94 ± 11.13	10.24 ± 8.13	17.80 ± 12.45
	12 yrs	14.93 ± 12.40	11.02 ± 10.14	19.58 ± 13.23
Frequency: 4000 Hz				
	Baseline	14.88 ± 12.00	11.06 ± 9.79	19.55 ± 12.78
	2 yrs	15.16 ± 11.96	11.07 ± 9.97	20.16 ± 12.30
	7 yrs	17.31 ± 13.16	12.84 ± 10.94	22.74 ± 13.59
	12 yrs	19.27 ± 14.38	14.20 ± 12.32	25.45 ± 14.30
Frequency: 6000 Hz				
	Baseline	20.50 ± 12.48	16.01 ± 10.11	25.06 ± 13.01
	2 yrs	20.74 ± 12.52	15.83 ± 9.86	25.84 ± 12.95
	7 yrs	22.96 ± 13.55	17.91 ± 11.24	28.23 ± 13.75
	12 yrs	25.64 ± 21.31	21.61 ± 24.66	30.42 ± 15.18

Data are mean ± SD

Table 6 Time course of Z score representing normal average hearing thresholds at each frequency, and within Age subgroups of workers. The scores were computed according to ISO1999 guidelines (see text for details).

Time	Total (N=1013)	Age £ 35 yrs (N=555)	Age > 35 yrs (N=458)
Age (yrs) Baseline	34 ± 7	29 ± 5	41 ± 4
Frequency: 500 Hz			
Baseline	0.872 ± 0.868	0.920 ± 0.874	0.805 ± 0.856
2 yrs	0.752 ± 0.876	0.743 ± 0.865	0.764 ± 0.893
7 yrs	0.730 ± 0.888	0.705 ± 0.871	0.765 ± 0.910
12 yrs	0.741 ± 0.964	0.703 ± 0.956	0.794 ± 0.973
Frequency: 1000 Hz			
Baseline	1.139 ± 1.150	1.097 ± 1.146	1.190 ± 1.155
2 yrs	1.023 ± 1.157	0.967 ± 1.160	1.091 ± 1.150
7 yrs	0.786 ± 0.937	0.711 ± 0.894	0.877 ± 0.979
12 yrs	0.747 ± 0.982	0.675 ± 0.955	0.835 ± 1.008
Frequency: 2000 Hz			
Baseline	0.786 ± 0.977	0.806 ± 0.937	0.761 ± 1.025
2 yrs	0.705 ± 0.986	0.679 ± 0.956	0.736 ± 1.020
7 yrs	0.448 ± 0.875	0.454 ± 0.811	0.439 ± 0.947
12 yrs	0.358 ± 0.947	0.290 ± 0.915	0.441 ± 0.979
Frequency: 3000 Hz			
Baseline	1.001 ± 0.974	1.047 ± 0.911	0.956 ± 1.031
2 yrs	0.862 ± 0.968	0.847 ± 0.911	0.878 ± 1.025
7 yrs	0.644 ± 0.933	0.674 ± 0.836	0.613 ± 1.025
12 yrs	0.469 ± 0.989	0.464 ± 0.970	0.474 ± 1.013
Frequency: 4000 Hz			
Baseline	0.917 ± 1.028	0.948 ± 1.018	0.879 ± 1.040
2 yrs	0.795 ± 0.972	0.823 ± 0.989	0.760 ± 0.951
7 yrs	0.662 ± 0.971	0.706 ± 0.990	0.609 ± 0.946
12 yrs	0.462 ± 0.959	0.476 ± 1.002	0.444 ± 0.905
Frequency: 6000 Hz			
Baseline	1.190 ± 0.953	1.292 ± 0.937	1.085 ± 0.959
2 yrs	1.058 ± 0.899	1.155 ± 0.898	0.958 ± 0.891
7 yrs	0.885 ± 0.891	1.003 ± 0.916	0.762 ± 0.849
12 yrs	0.714 ± 0.889	0.846 ± 0.918	0.557 ± 0.828

Data are mean ± SD

Table 7 Time course of the Z* scores representing typical average hearing thresholds (AHT) at each frequency, and within age subgroups of workers. See text for details of the normal-to-typical correction.

	Time	Total (N=1013)	Age £ 35 yrs (N=555)	Age > 35 yrs (N=458)
Age (yrs)	Baseline	34 ± 7	29 ± 5	41 ± 4
Frequency: 500 Hz				
	Baseline	0.363 ± 0.617	0.383 ± 0.612	0.335 ± 0.623
	2 yrs	0.284 ± 0.629	0.264 ± 0.612	0.313 ± 0.651
	7 yrs	0.281 ± 0.645	0.247 ± 0.623	0.329 ± 0.673
	12 yrs	0.301 ± 0.710	0.256 ± 0.693	0.364 ± 0.730
Frequency: 1000 Hz				
	Baseline	0.550 ± 0.814	0.498 ± 0.800	0.613 ± 0.828
	2 yrs	0.475 ± 0.822	0.412 ± 0.810	0.551 ± 0.831
	7 yrs	0.325 ± 0.686	0.251 ± 0.643	0.415 ± 0.726
	12 yrs	0.313 ± 0.729	0.239 ± 0.696	0.403 ± 0.759
Frequency: 2000 Hz				
	Baseline	0.368 ± 0.738	0.363 ± 0.692	0.373 ± 0.791
	2 yrs	0.313 ± 0.751	0.272 ± 0.714	0.363 ± 0.792
	7 yrs	0.133 ± 0.684	0.120 ± 0.621	0.149 ± 0.755
	12 yrs	0.075 ± 0.758	0.001 ± 0.719	0.166 ± 0.794
Frequency: 3000 Hz				
	Baseline	0.581 ± 0.752	0.581 ± 0.683	0.581 ± 0.814
	2 yrs	0.482 ± 0.757	0.438 ± 0.689	0.528 ± 0.819
	7 yrs	0.332 ± 0.749	0.329 ± 0.650	0.335 ± 0.841
	12 yrs	0.205 ± 0.810	0.178 ± 0.774	0.237 ± 0.850
Frequency: 4000 Hz				
	Baseline	0.545 ± 0.808	0.537 ± 0.779	0.554 ± 0.843
	2 yrs	0.459 ± 0.773	0.451 ± 0.766	0.470 ± 0.783
	7 yrs	0.375 ± 0.789	0.381 ± 0.784	0.367 ± 0.796
	12 yrs	0.230 ± 0.802	0.214 ± 0.820	0.248 ± 0.780
Frequency: 6000 Hz				
	Baseline	0.802 ± 0.758	0.844 ± 0.730	0.759 ± 0.785
	2 yrs	0.709 ± 0.722	0.748 ± 0.702	0.668 ± 0.741
	7 yrs	0.591 ± 0.730	0.653 ± 0.734	0.526 ± 0.722
	12 yrs	0.468 ± 0.744	0.551 ± 0.754	0.369 ± 0.720

Data are mean ± SD

Figure 1 Scores (mean and standard deviations) of average hearing thresholds per frequency according to ISO 1999 over the 12 year study period

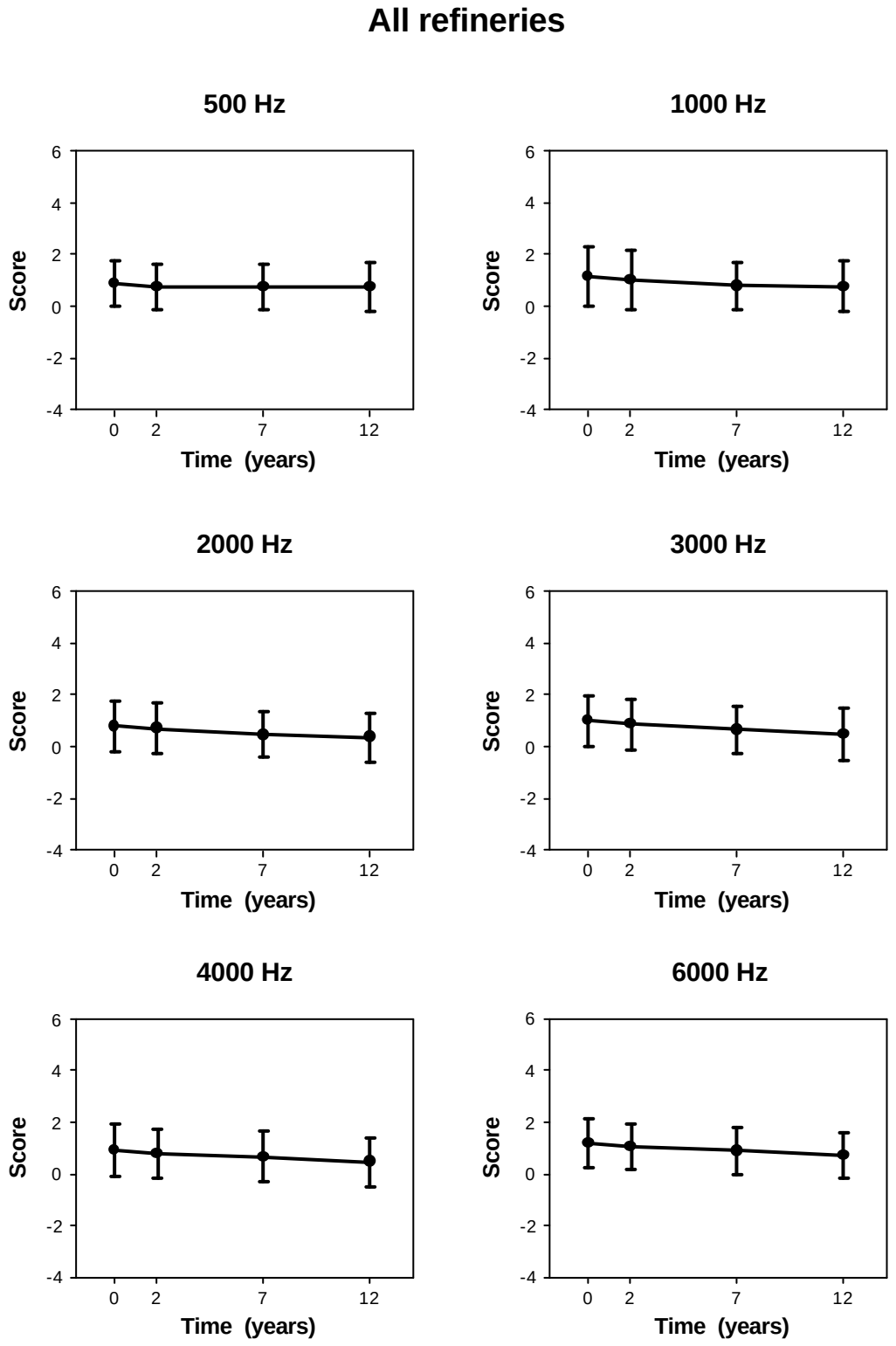
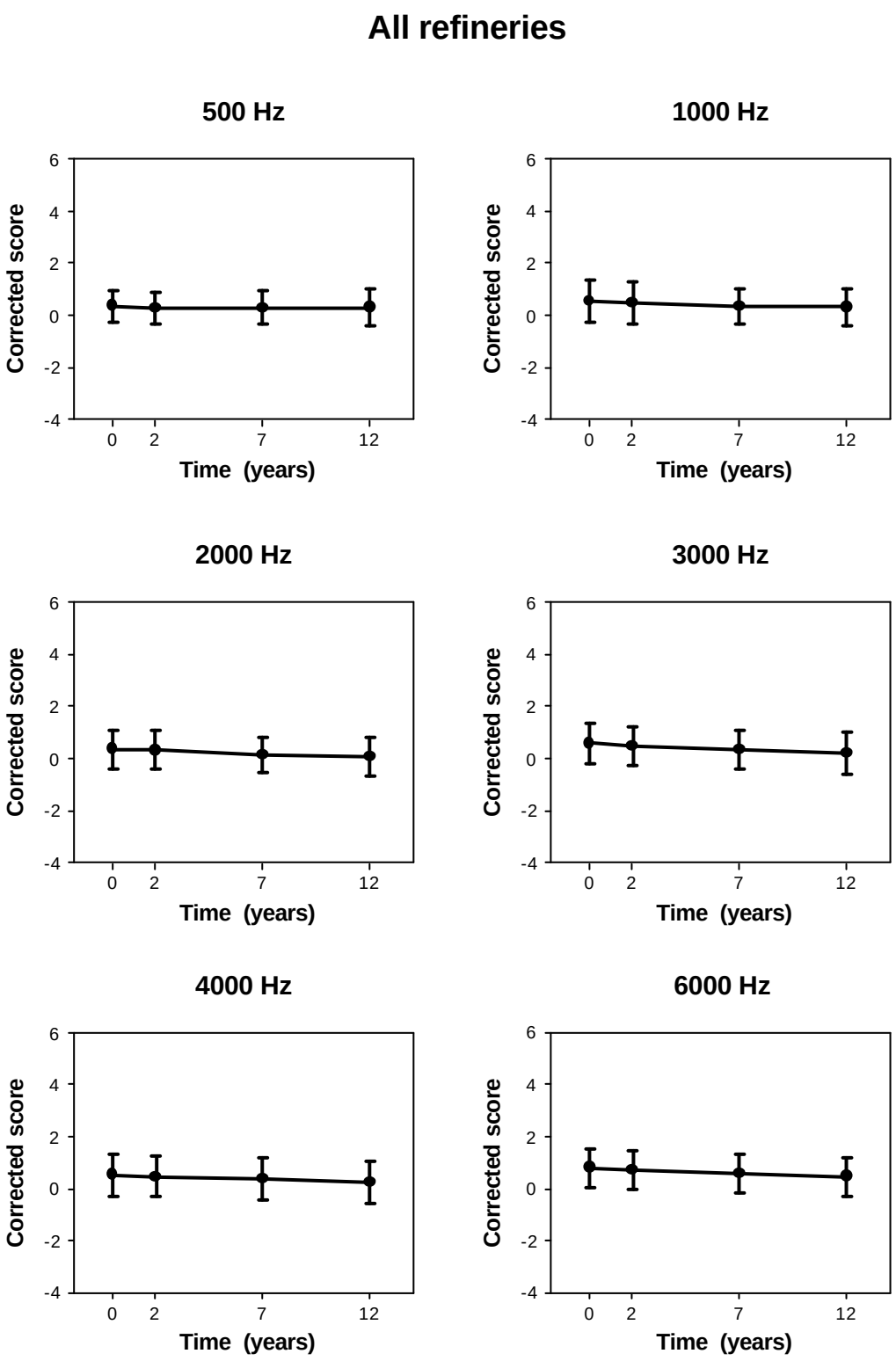


Figure 2 Scores (mean and standard deviations) of average hearing thresholds per frequency according to Passchier-Vermeer

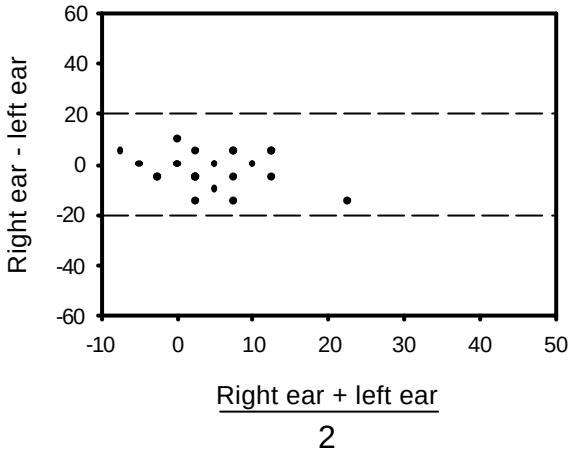


APPENDIX A

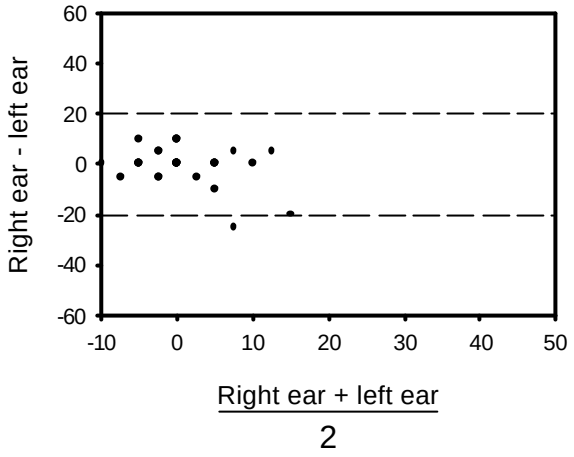
PLOTS OF THE DIFFERENCE BETWEEN THE HEARING THRESHOLDS OF THE TWO EARS VERSUS THE AVERAGE HEARING THRESHOLD (AHT) OF THE TWO EARS FOR EACH FREQUENCY AND REFINERY

REFINERY # 1

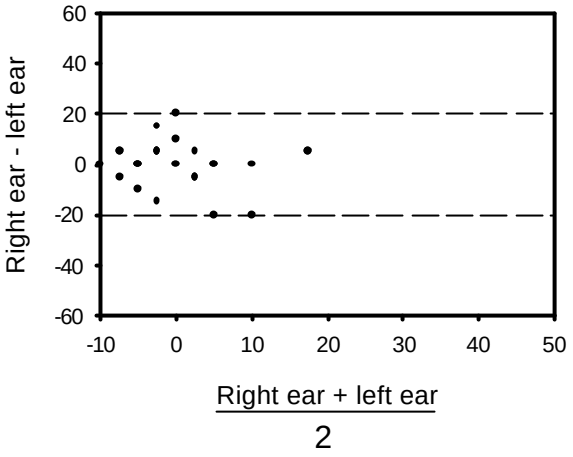
Frequency = 500 Hz



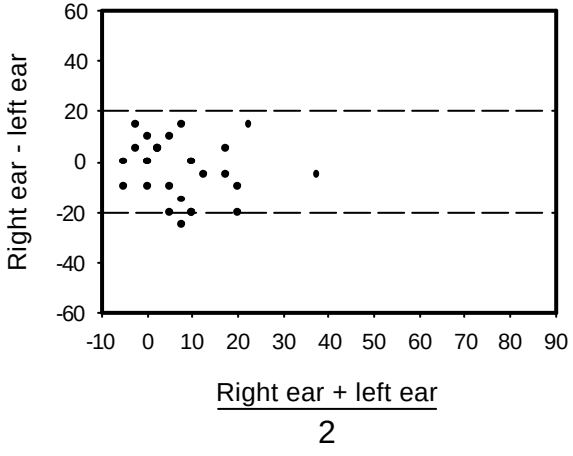
Frequency = 1000 Hz



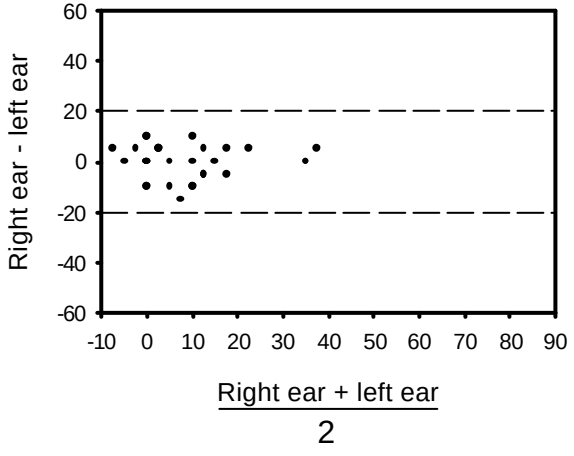
Frequency = 2000 Hz



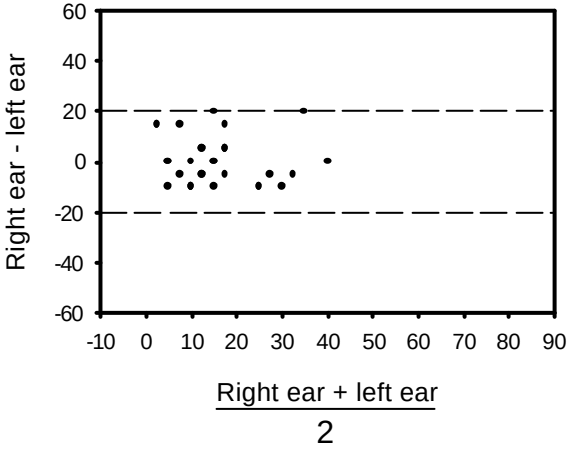
Frequency = 3000 Hz



Frequency = 4000 Hz

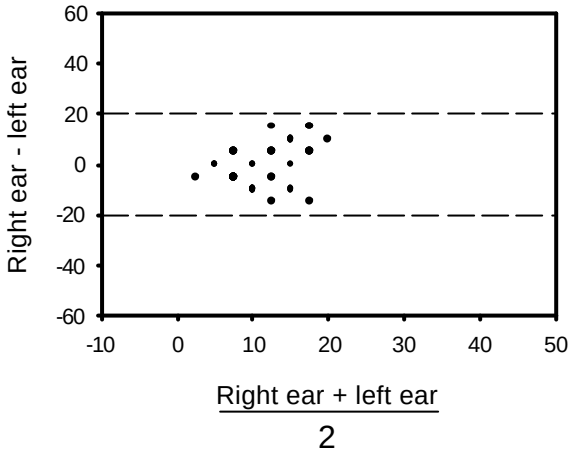


Frequency = 6000 Hz

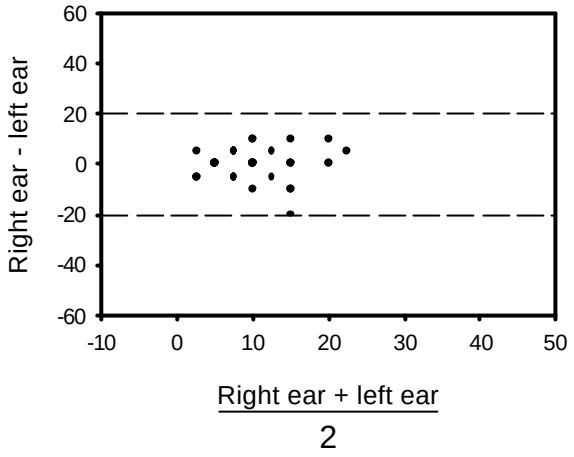


REFINERY # 2

Frequency = 500 Hz



Frequency = 1000 Hz



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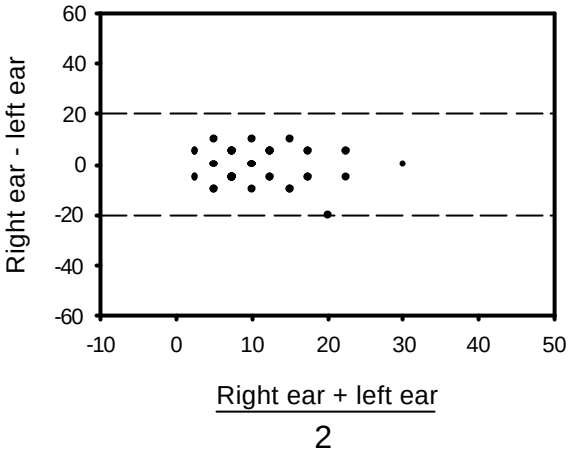
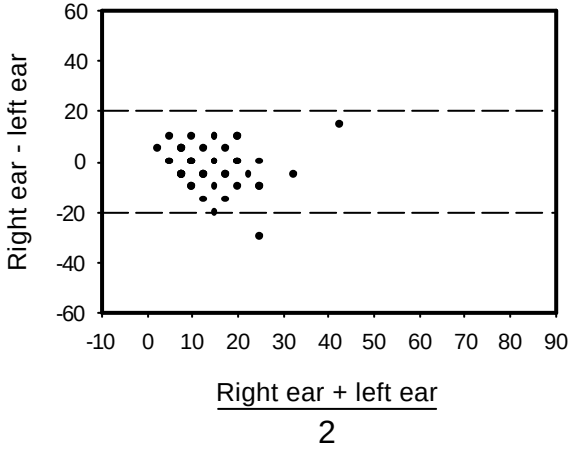
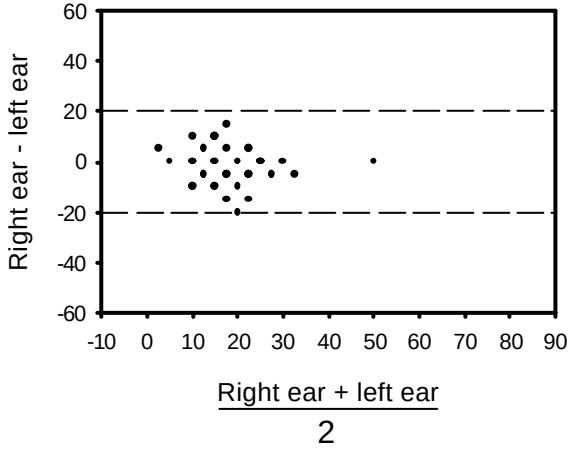


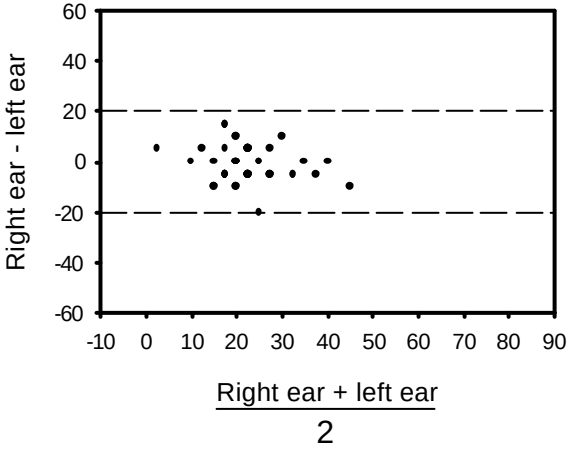
Frequency = 3000 Hz



Frequency = 4000 Hz

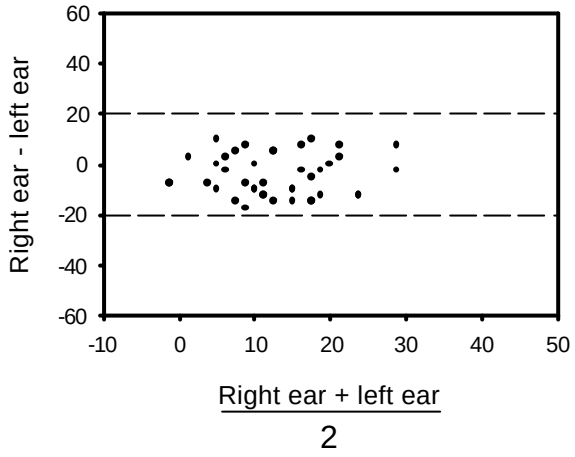


Frequency = 6000 Hz

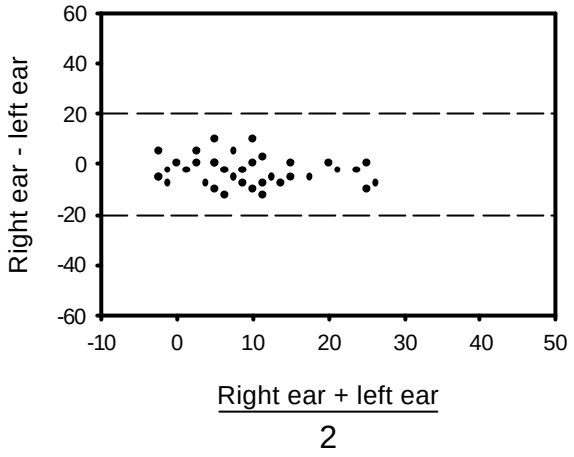


REFINERY # 3

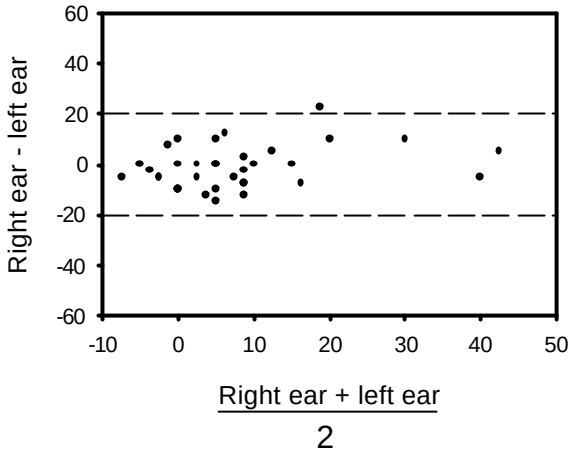
Frequency = 500 Hz



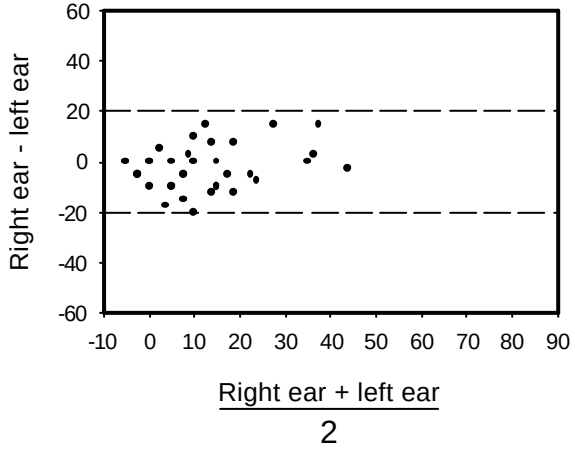
Frequency = 1000 Hz



Frequency = 2000 Hz



Frequency = 3000 Hz



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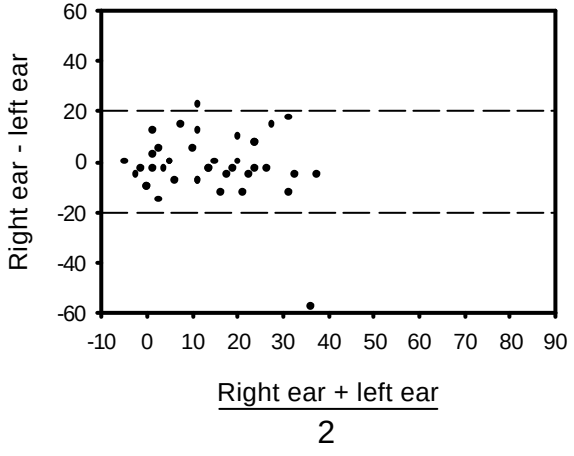

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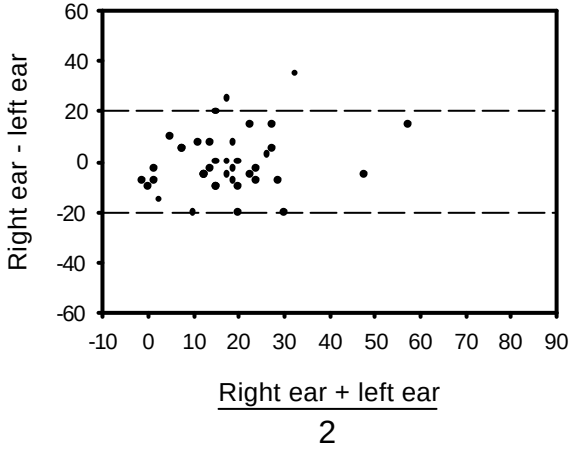

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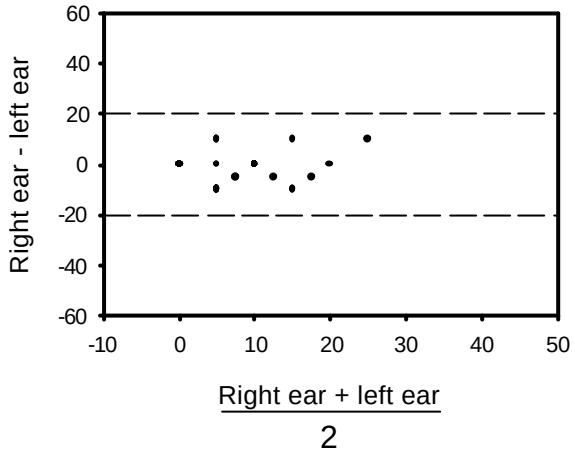

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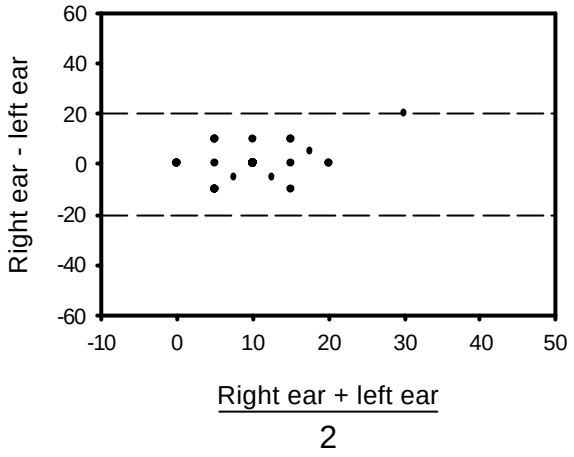

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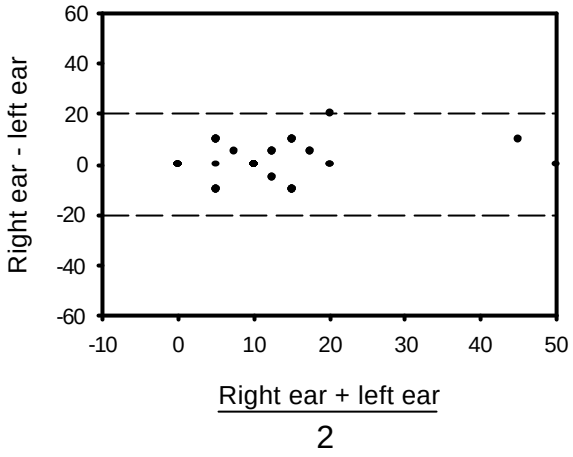

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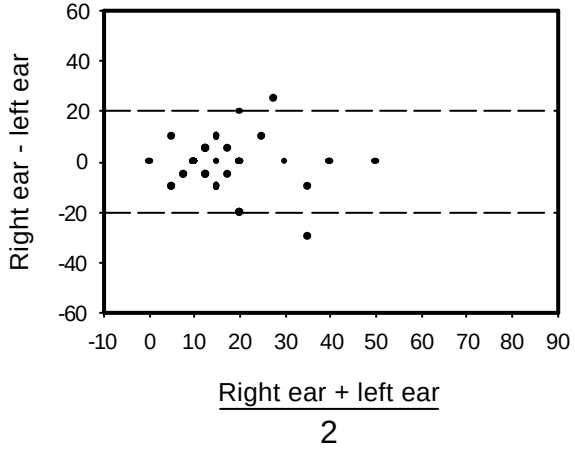

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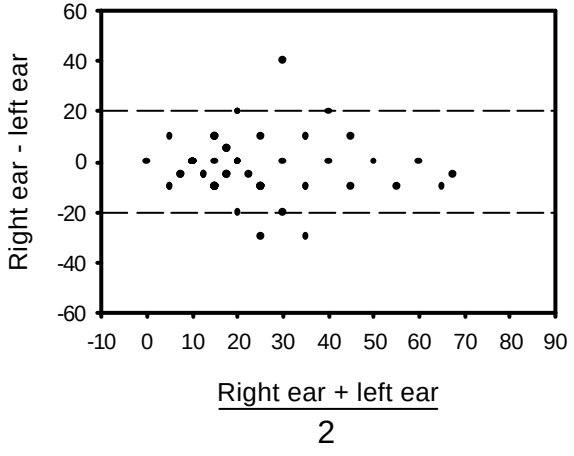

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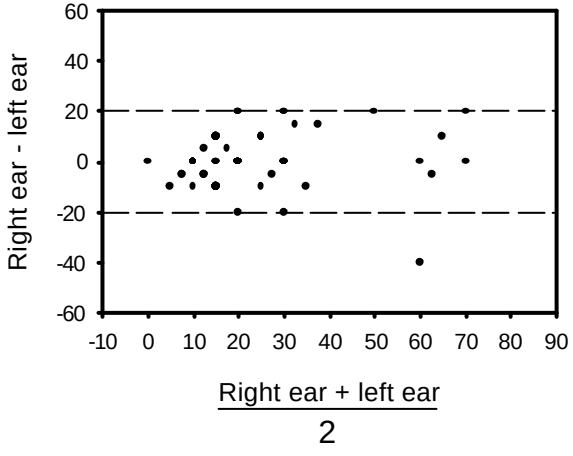

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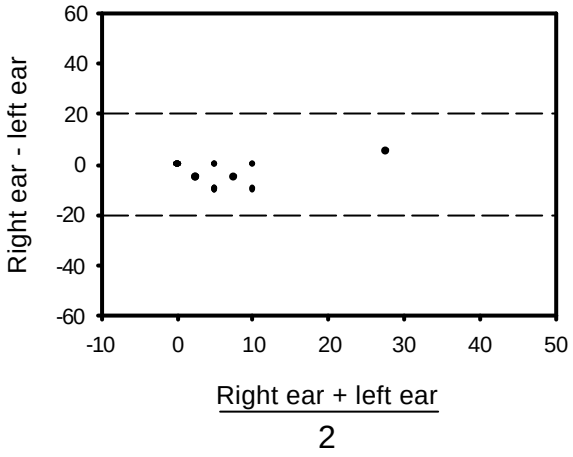

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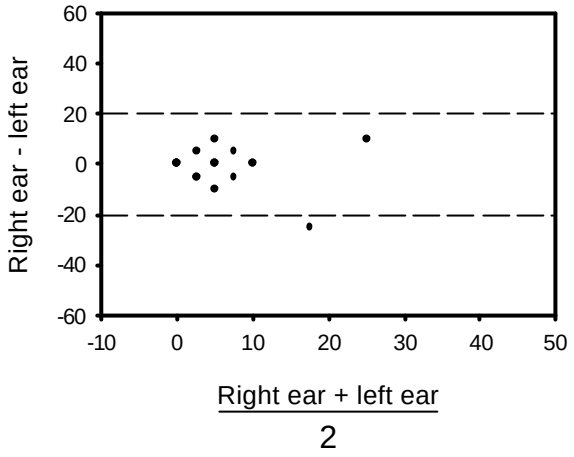
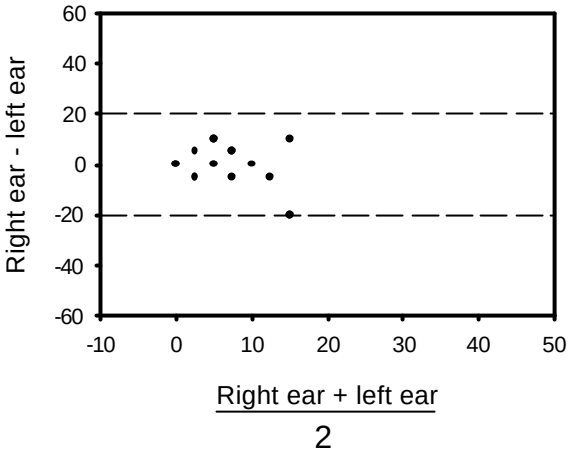


Frequency = 2000 Hz



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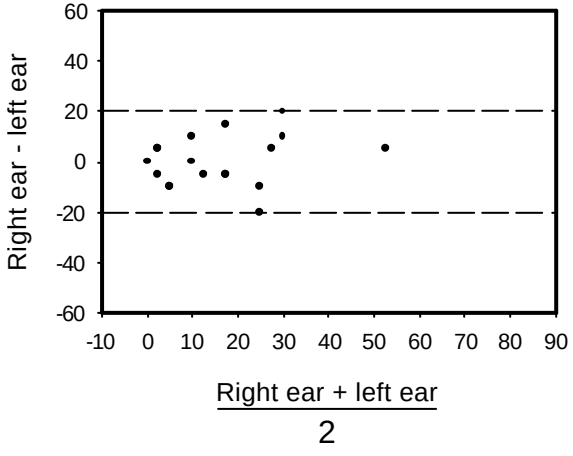

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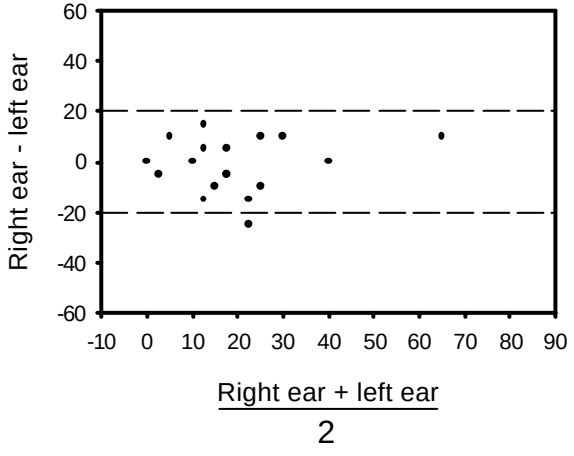

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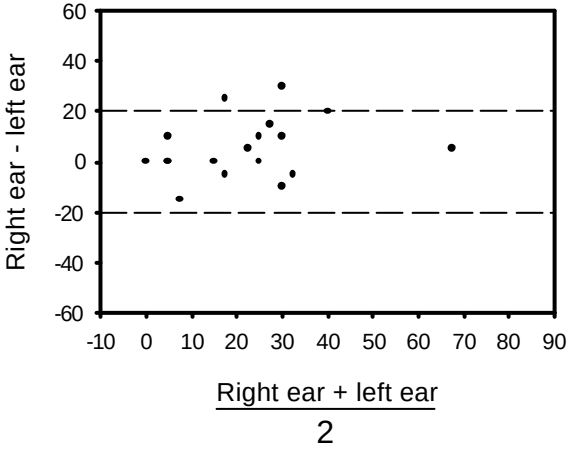

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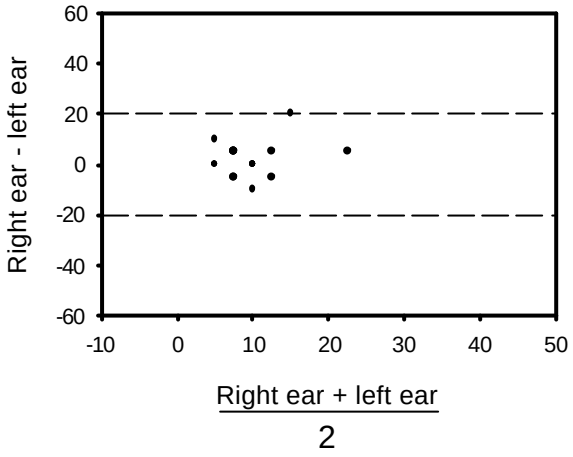

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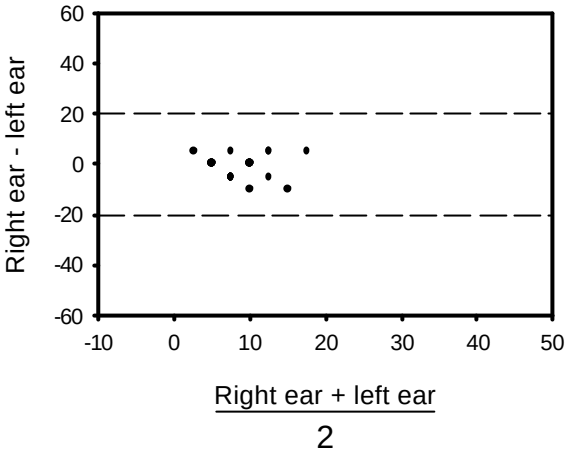

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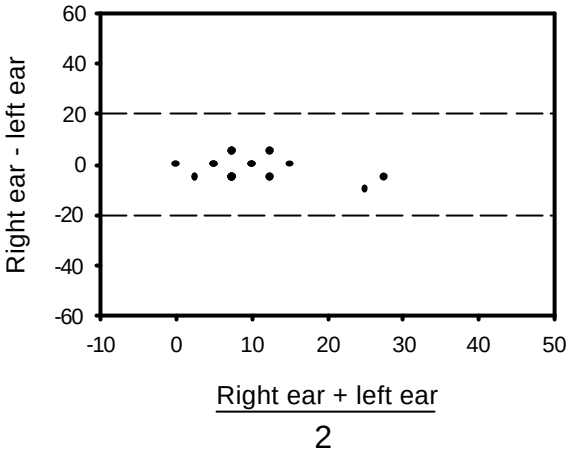

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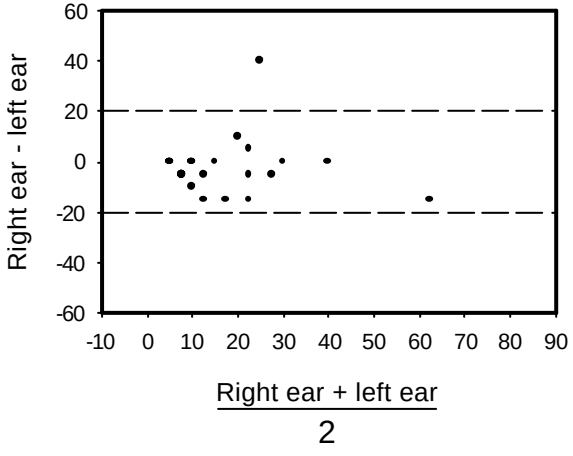
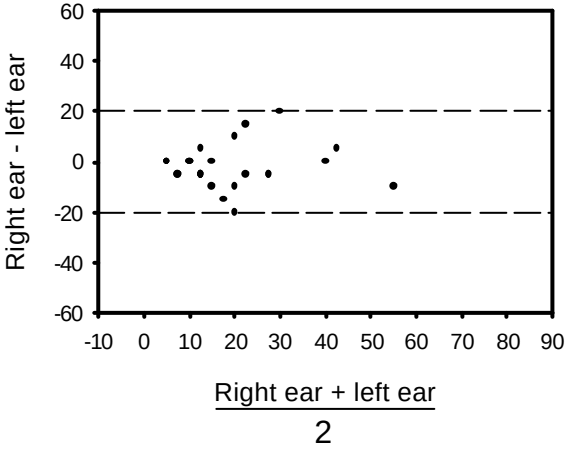


Frequency = 4000 Hz



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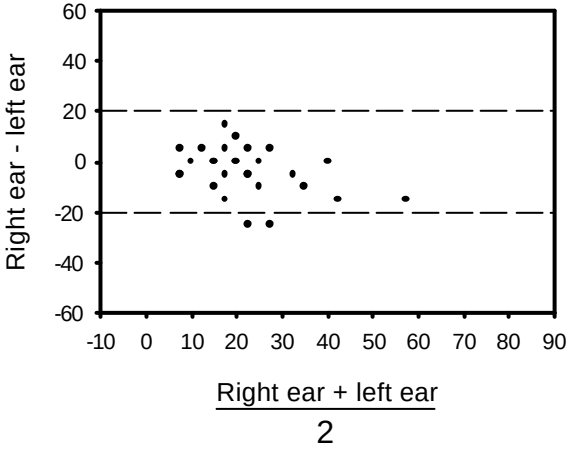

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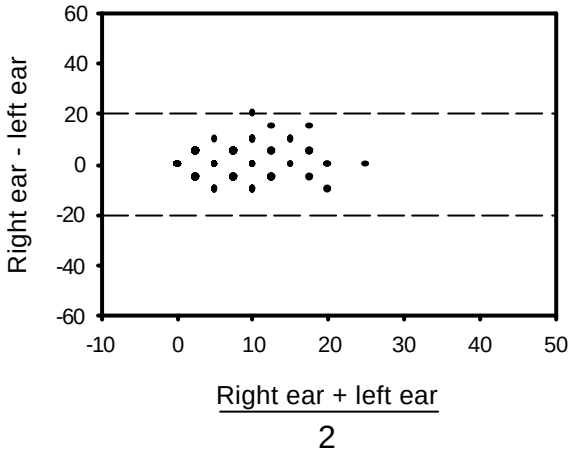

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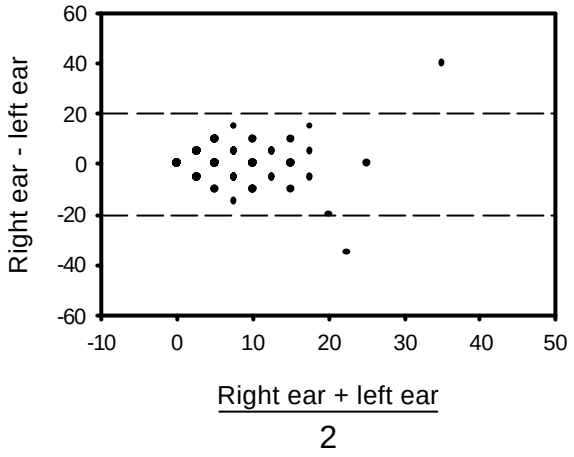

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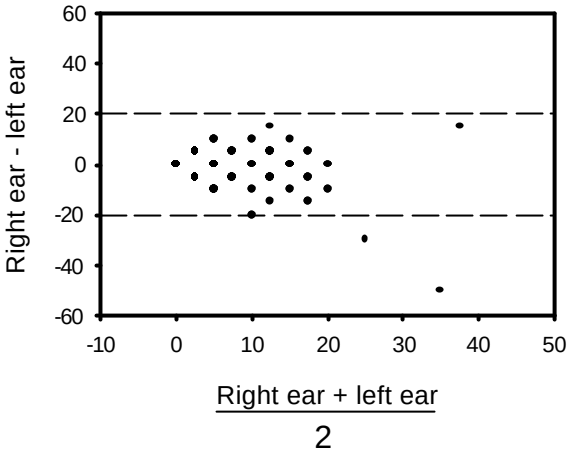

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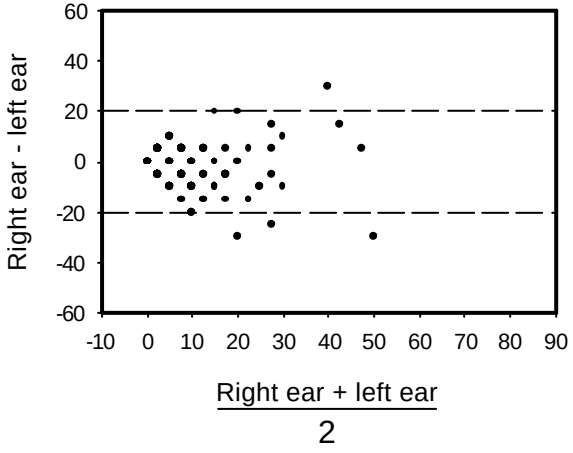

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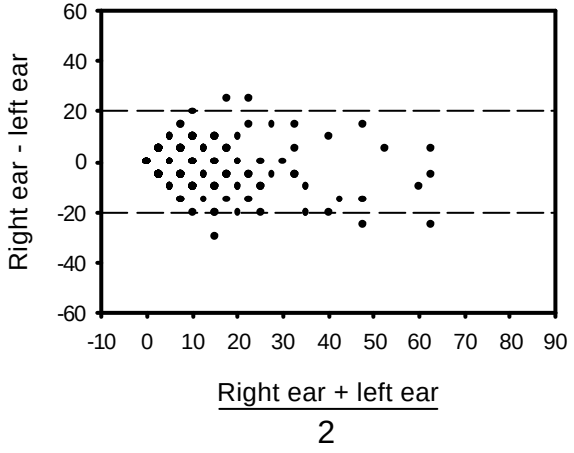

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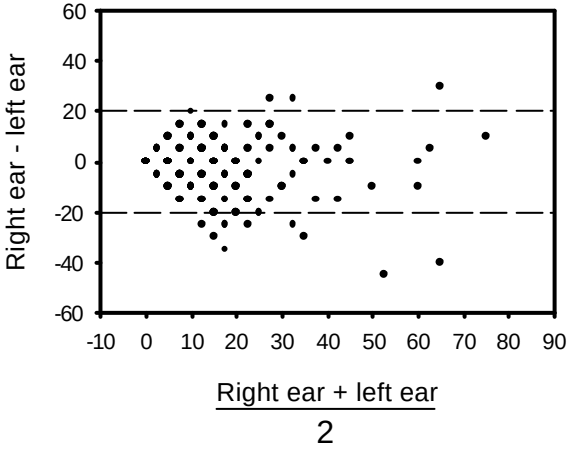

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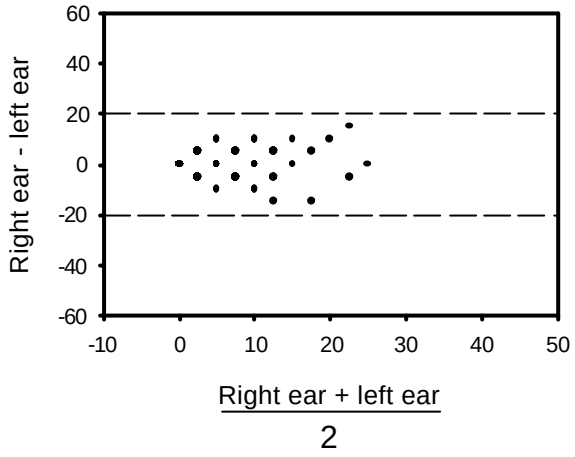

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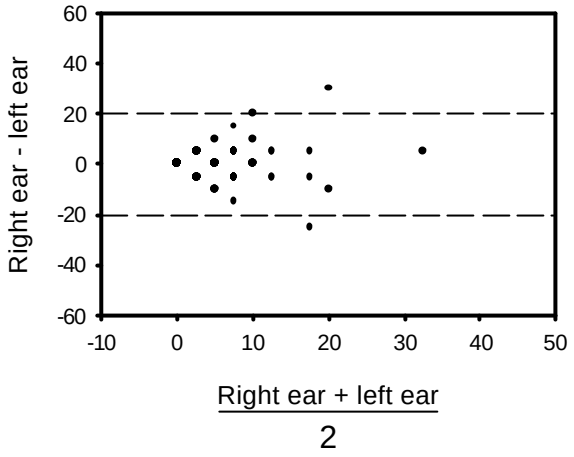

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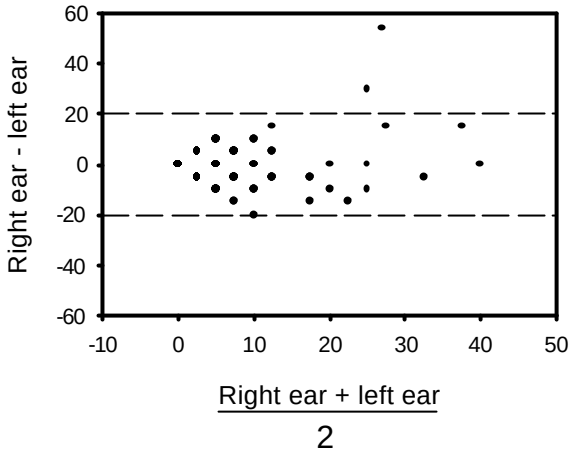

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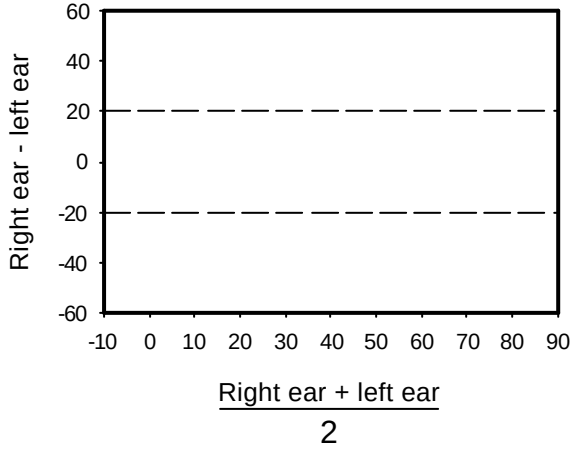

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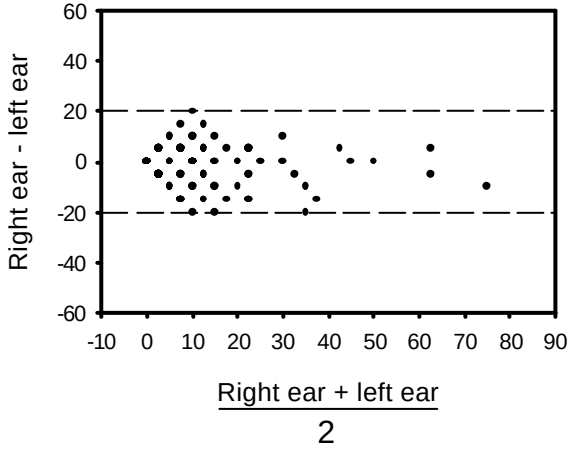

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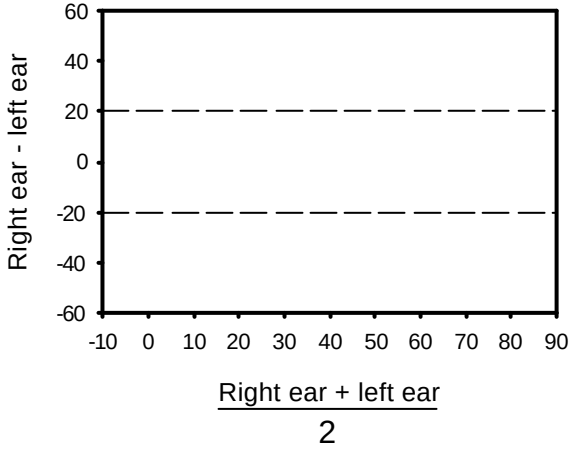

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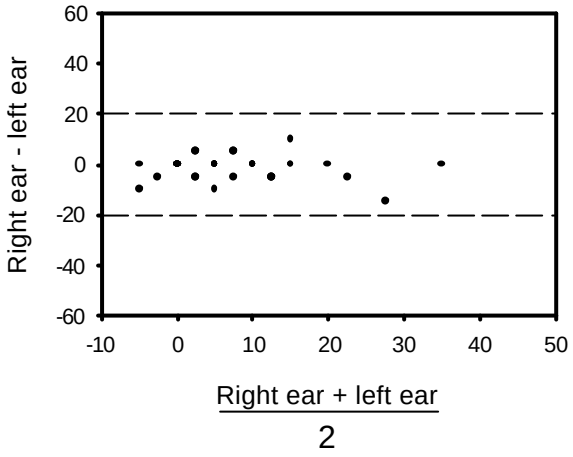
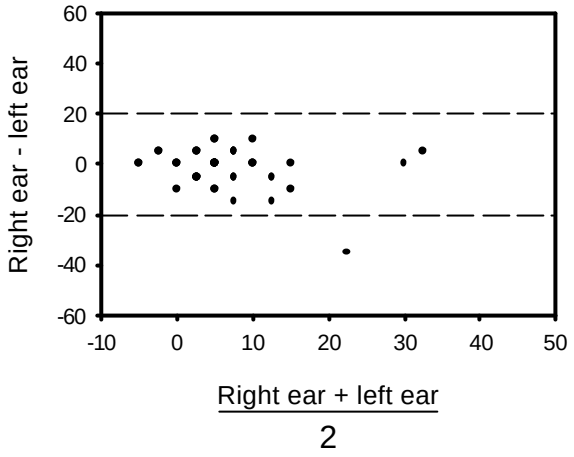


Frequency = 1000 Hz



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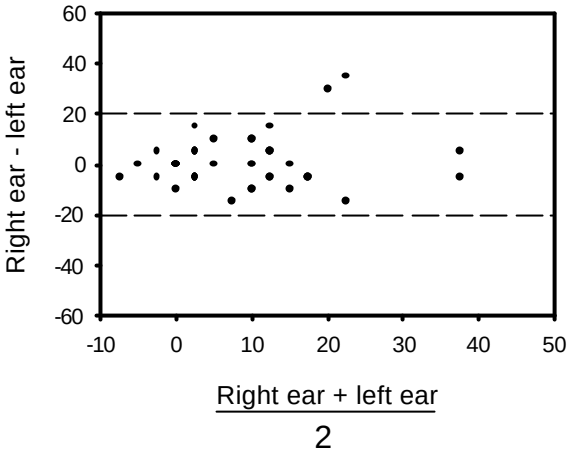

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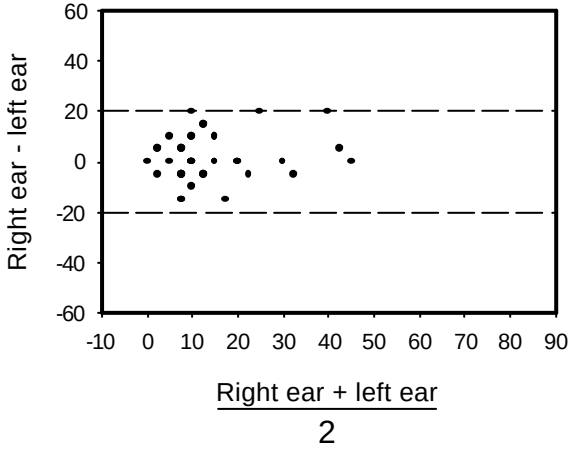

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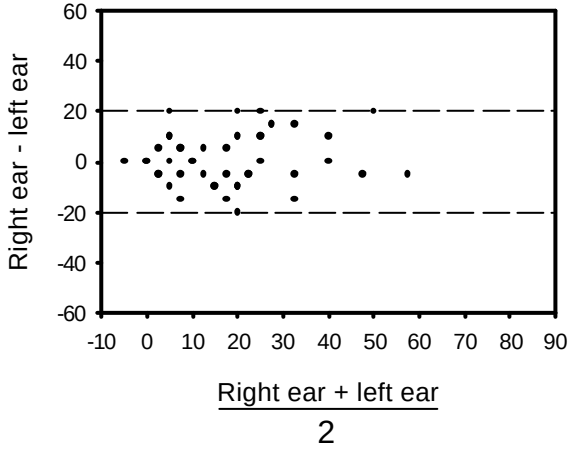

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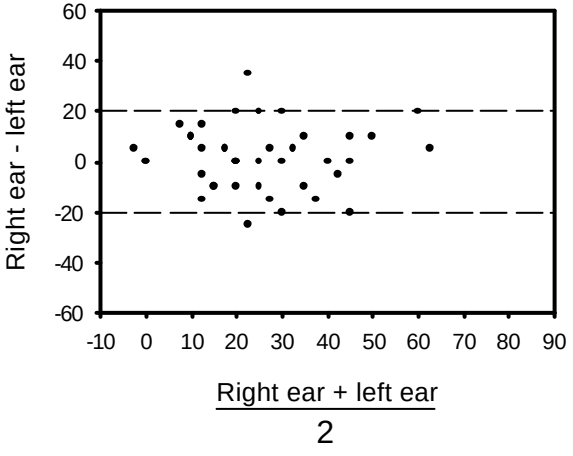

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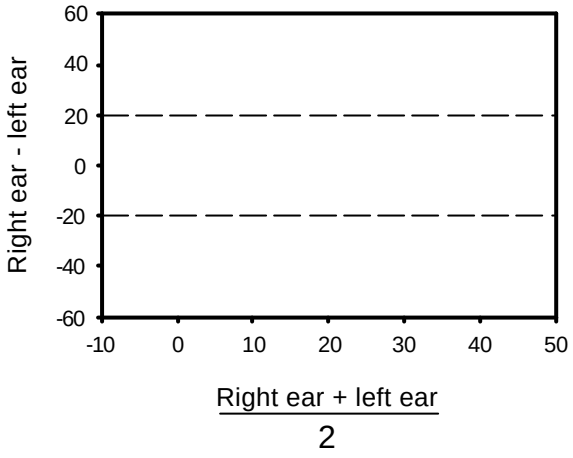

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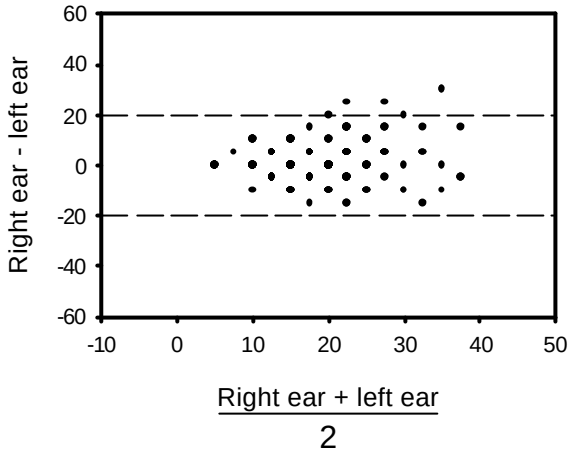

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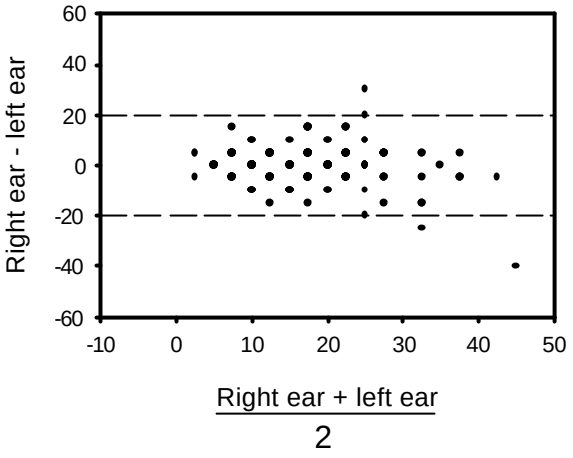

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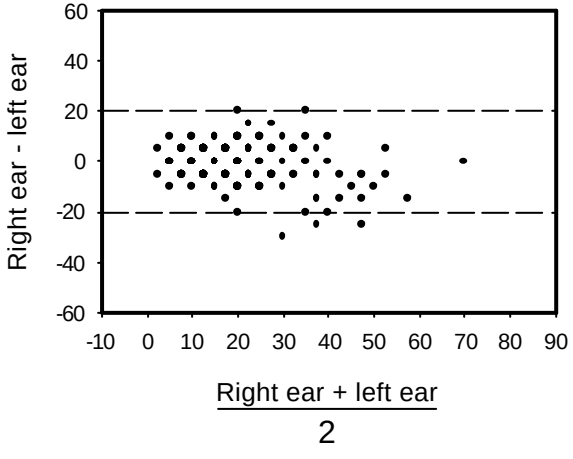

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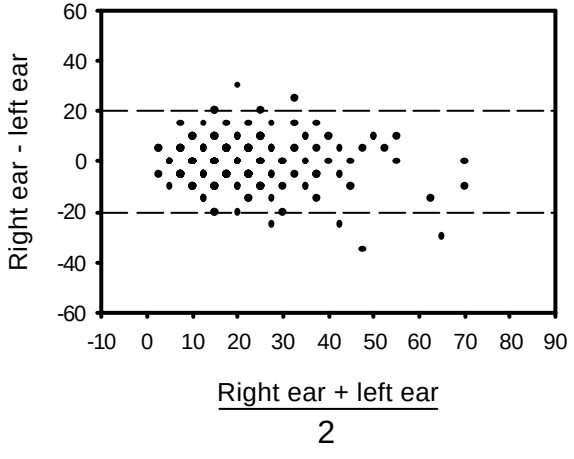

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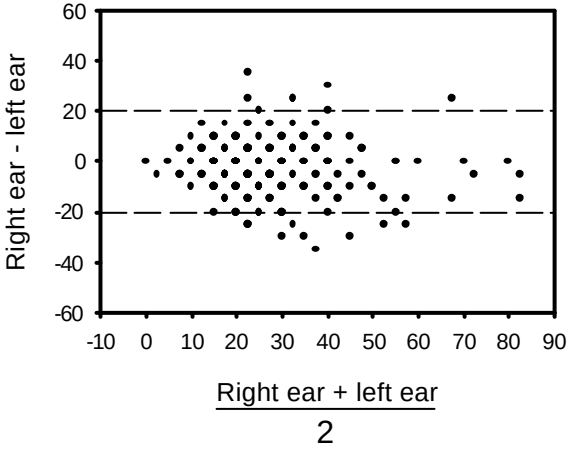

APPENDIX B

TIME TRENDS OF MEAN Z SCORES AND Z*, REPRESENTING NORMAL AND TYPICAL AHTs RESPECTIVELY FOR EACH FREQUENCY AND REFINERY, AND SUBDIVIDED FOR AGE GROUPS UNDER 35 YEARS AT BASELINE AND 35 AND OLDER AT BASELINE.

Table B-1 Time trends of Standardized AHT at each frequency:
Means in all refineries and within Age- and Refinery subgroups

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
All Refineries				
Z Scores				
500 Hz	0	750	0.872 ± 0.868	19.2
	2	744	0.752 ± 0.876	22.6
	7	758	0.730 ± 0.888	23.3
	12	745	0.741 ± 0.964	22.9
1000 Hz	0	1003	1.139 ± 1.150	12.7
	2	997	1.023 ± 1.157	15.3
	7	1011	0.786 ± 0.937	21.6
	12	998	0.747 ± 0.982	22.7
2000 Hz	0	1003	0.786 ± 0.977	21.6
	2	997	0.705 ± 0.986	24.1
	7	1011	0.448 ± 0.875	32.7
	12	998	0.358 ± 0.947	36.0
3000 Hz	0	738	1.001 ± 0.974	15.8
	2	800	0.862 ± 0.968	19.4
	7	842	0.644 ± 0.933	26.0
	12	982	0.469 ± 0.989	32.0
4000 Hz	0	1002	0.917 ± 1.028	18.0
	2	997	0.795 ± 0.972	21.3
	7	1011	0.662 ± 0.971	25.4
	12	998	0.462 ± 0.959	32.2
6000 Hz	0	797	1.190 ± 0.953	11.7
	2	803	1.058 ± 0.899	14.5
	7	844	0.885 ± 0.891	18.8
	12	980	0.714 ± 0.889	23.8
Z* Corrected Scores				
500 Hz	0	750	0.363 ± 0.617	35.8
	2	744	0.284 ± 0.629	38.8
	7	758	0.281 ± 0.645	38.9
	12	745	0.301 ± 0.710	38.2
1000 Hz	0	1003	0.550 ± 0.814	29.1
	2	997	0.475 ± 0.822	31.8
	7	1011	0.325 ± 0.686	37.3
	12	998	0.313 ± 0.729	37.7
2000 Hz	0	1003	0.368 ± 0.738	35.6
	2	997	0.313 ± 0.751	37.7
	7	1011	0.133 ± 0.684	44.7
	12	998	0.075 ± 0.758	47.0
3000 Hz	0	738	0.581 ± 0.752	28.1
	2	800	0.482 ± 0.757	31.5
	7	842	0.332 ± 0.749	37.0
	12	982	0.205 ± 0.810	41.9
4000 Hz	0	1002	0.545 ± 0.808	29.3
	2	997	0.459 ± 0.773	32.3
	7	1011	0.375 ± 0.789	35.4
	12	998	0.230 ± 0.802	40.9
6000 Hz	0	797	0.802 ± 0.758	21.1
	2	803	0.709 ± 0.722	23.9
	7	844	0.591 ± 0.730	27.7
	12	980	0.468 ± 0.744	32.0

Table B-2 Time trends of Standardized AHT at each frequency: All refineries, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
All Refineries, Age < 35 yrs				
Scores				
500 Hz	0	437	0.920 ± 0.874	17.9
	2	433	0.743 ± 0.865	22.9
	7	440	0.705 ± 0.871	24.0
	12	433	0.703 ± 0.956	24.1
1000 Hz	0	552	1.097 ± 1.146	13.6
	2	548	0.967 ± 1.160	16.7
	7	555	0.711 ± 0.894	23.9
	12	548	0.675 ± 0.955	25.0
2000 Hz	0	552	0.806 ± 0.937	21.0
	2	548	0.679 ± 0.956	24.9
	7	555	0.454 ± 0.811	32.5
	12	548	0.290 ± 0.915	38.6
3000 Hz	0	364	1.047 ± 0.911	14.7
	2	408	0.847 ± 0.911	19.8
	7	430	0.674 ± 0.836	25.0
	12	533	0.464 ± 0.970	32.1
4000 Hz	0	551	0.948 ± 1.018	17.2
	2	548	0.823 ± 0.989	20.5
	7	555	0.706 ± 0.990	24.0
	12	548	0.476 ± 1.002	31.7
6000 Hz	0	402	1.292 ± 0.937	9.8
	2	409	1.155 ± 0.898	12.4
	7	431	1.003 ± 0.916	15.8
	12	531	0.846 ± 0.918	19.9
Corrected Scores				
500 Hz	0	437	0.383 ± 0.612	35.1
	2	433	0.264 ± 0.612	39.6
	7	440	0.247 ± 0.623	40.2
	12	433	0.256 ± 0.693	39.9
1000 Hz	0	552	0.498 ± 0.800	30.9
	2	548	0.412 ± 0.810	34.0
	7	555	0.251 ± 0.643	40.1
	12	548	0.239 ± 0.696	40.6
2000 Hz	0	552	0.363 ± 0.692	35.8
	2	548	0.272 ± 0.714	39.3
	7	555	0.120 ± 0.621	45.2
	12	548	0.001 ± 0.719	50.0
3000 Hz	0	364	0.581 ± 0.683	28.1
	2	408	0.438 ± 0.689	33.1
	7	430	0.329 ± 0.650	37.1
	12	533	0.178 ± 0.774	42.9
4000 Hz	0	551	0.537 ± 0.779	29.6
	2	548	0.451 ± 0.766	32.6
	7	555	0.381 ± 0.784	35.2
	12	548	0.214 ± 0.820	41.5
6000 Hz	0	402	0.844 ± 0.730	19.9
	2	409	0.748 ± 0.702	22.7
	7	431	0.653 ± 0.734	25.7
	12	531	0.551 ± 0.754	29.1

Table B-3 Time trends of Standardized AHT at each frequency: All refineries, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
All Refineries, Age > 35 yrs				
Scores				
500 Hz	0	313	0.805 ± 0.856	21.0
	2	311	0.764 ± 0.893	22.3
	7	318	0.765 ± 0.910	22.2
	12	312	0.794 ± 0.973	21.3
1000 Hz	0	451	1.190 ± 1.155	11.7
	2	449	1.091 ± 1.150	13.8
	7	456	0.877 ± 0.979	19.0
	12	450	0.835 ± 1.008	20.2
2000 Hz	0	451	0.761 ± 1.025	22.3
	2	449	0.736 ± 1.020	23.1
	7	456	0.439 ± 0.947	33.0
	12	450	0.441 ± 0.979	33.0
3000 Hz	0	374	0.956 ± 1.031	16.9
	2	392	0.878 ± 1.025	19.0
	7	412	0.613 ± 1.025	27.0
	12	449	0.474 ± 1.013	31.8
4000 Hz	0	451	0.879 ± 1.040	19.0
	2	449	0.760 ± 0.951	22.4
	7	456	0.609 ± 0.946	27.1
	12	450	0.444 ± 0.905	32.8
6000 Hz	0	395	1.085 ± 0.959	13.9
	2	394	0.958 ± 0.891	16.9
	7	413	0.762 ± 0.849	22.3
	12	449	0.557 ± 0.828	28.9
Corrected Scores				
500 Hz	0	313	0.335 ± 0.623	36.9
	2	311	0.313 ± 0.651	37.7
	7	318	0.329 ± 0.673	37.1
	12	312	0.364 ± 0.730	35.8
1000 Hz	0	451	0.613 ± 0.828	27.0
	2	449	0.551 ± 0.831	29.1
	7	456	0.415 ± 0.726	33.9
	12	450	0.403 ± 0.759	34.3
2000 Hz	0	451	0.373 ± 0.791	35.4
	2	449	0.363 ± 0.792	35.8
	7	456	0.149 ± 0.755	44.1
	12	450	0.166 ± 0.794	43.4
3000 Hz	0	374	0.581 ± 0.814	28.1
	2	392	0.528 ± 0.819	29.9
	7	412	0.335 ± 0.841	36.9
	12	449	0.237 ± 0.850	40.6
4000 Hz	0	451	0.554 ± 0.843	29.0
	2	449	0.470 ± 0.783	31.9
	7	456	0.367 ± 0.796	35.7
	12	450	0.248 ± 0.780	40.2
6000 Hz	0	395	0.759 ± 0.785	22.4
	2	394	0.668 ± 0.741	25.2
	7	413	0.526 ± 0.722	29.9
	12	449	0.369 ± 0.720	35.6

Table B-4 Time trends of Standardized AHT at each frequency: Refinery 1

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 1				
Scores				
500 Hz	0	31	0.393 ± 0.993	34.7
	2	31	0.139 ± 1.129	44.5
	7	31	-0.268 ± 0.772	60.6
	12	31	-0.258 ± 0.758	60.2
1000 Hz	0	31	-0.206 ± 0.923	58.2
	2	31	-0.289 ± 0.959	61.4
	7	31	-0.502 ± 0.679	69.2
	12	31	-0.449 ± 0.758	67.3
2000 Hz	0	31	-0.420 ± 0.888	66.3
	2	31	-0.589 ± 0.993	72.2
	7	31	-0.672 ± 0.730	74.9
	12	31	-0.611 ± 0.794	73.0
3000 Hz	0	31	0.145 ± 0.978	44.2
	2	31	0.055 ± 0.975	47.8
	7	31	-0.293 ± 0.905	61.5
	12	31	-0.345 ± 0.918	63.5
4000 Hz	0	31	0.131 ± 1.061	44.8
	2	31	0.003 ± 0.983	49.9
	7	31	-0.125 ± 0.876	55.0
	12	31	-0.090 ± 0.936	53.6
6000 Hz	0	31	0.660 ± 0.818	25.5
	2	31	0.368 ± 0.775	35.6
	7	31	0.123 ± 0.944	45.1
	12	31	-0.051 ± 0.874	52.0
Corrected Scores				
500 Hz	0	31	0.022 ± 0.736	49.1
	2	31	-0.175 ± 0.842	57.0
	7	31	-0.474 ± 0.610	68.2
	12	31	-0.456 ± 0.601	67.6
1000 Hz	0	31	-0.439 ± 0.715	67.0
	2	31	-0.493 ± 0.748	68.9
	7	31	-0.656 ± 0.548	74.4
	12	31	-0.601 ± 0.620	72.6
2000 Hz	0	31	-0.576 ± 0.720	71.8
	2	31	-0.709 ± 0.820	76.1
	7	31	-0.777 ± 0.603	78.1
	12	31	-0.714 ± 0.675	76.2
3000 Hz	0	31	-0.098 ± 0.800	53.9
	2	31	-0.157 ± 0.808	56.2
	7	31	-0.433 ± 0.771	66.7
	12	31	-0.472 ± 0.791	68.2
4000 Hz	0	31	-0.091 ± 0.875	53.6
	2	31	-0.178 ± 0.830	57.1
	7	31	-0.276 ± 0.747	60.9
	12	31	-0.231 ± 0.807	59.1
6000 Hz	0	31	0.385 ± 0.668	35.0
	2	31	0.155 ± 0.665	43.9
	7	31	-0.042 ± 0.811	51.7
	12	31	-0.181 ± 0.769	57.2

Table B-5 Time trends of Standardized AHT at each frequency: Refinery 2

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 2				
Scores				
500 Hz	0	55	1.359 ± 0.633	8.7
	2	55	1.489 ± 0.708	6.8
	7	55	1.564 ± 0.682	5.9
	12	55	1.635 ± 0.819	5.1
1000 Hz	0	55	1.100 ± 0.710	13.6
	2	55	1.109 ± 0.757	13.4
	7	55	1.161 ± 0.777	12.3
	12	55	1.207 ± 0.768	11.4
2000 Hz	0	55	0.813 ± 0.706	20.8
	2	55	0.882 ± 0.720	18.9
	7	55	0.771 ± 0.737	22.0
	12	55	0.729 ± 0.661	23.3
3000 Hz	0	55	0.867 ± 0.735	19.3
	2	55	0.805 ± 0.803	21.0
	7	55	0.597 ± 0.763	27.5
	12	55	0.379 ± 0.708	35.2
4000 Hz	0	55	0.943 ± 0.681	17.3
	2	55	0.843 ± 0.697	20.0
	7	55	0.553 ± 0.612	29.0
	12	55	0.238 ± 0.583	40.6
6000 Hz	0	55	1.036 ± 0.588	15.0
	2	55	0.968 ± 0.639	16.6
	7	55	0.699 ± 0.606	24.2
	12	55	0.415 ± 0.582	33.9
Corrected Scores				
500 Hz	0	55	0.733 ± 0.434	23.2
	2	55	0.829 ± 0.487	20.4
	7	55	0.904 ± 0.476	18.3
	12	55	0.980 ± 0.582	16.3
1000 Hz	0	55	0.560 ± 0.484	28.8
	2	55	0.569 ± 0.524	28.5
	7	55	0.625 ± 0.549	26.6
	12	55	0.686 ± 0.548	24.7
2000 Hz	0	55	0.421 ± 0.525	33.7
	2	55	0.479 ± 0.538	31.6
	7	55	0.413 ± 0.567	34.0
	12	55	0.406 ± 0.517	34.2
3000 Hz	0	55	0.507 ± 0.569	30.6
	2	55	0.465 ± 0.629	32.1
	7	55	0.319 ± 0.620	37.5
	12	55	0.160 ± 0.596	43.6
4000 Hz	0	55	0.604 ± 0.538	27.3
	2	55	0.535 ± 0.554	29.6
	7	55	0.322 ± 0.508	37.4
	12	55	0.072 ± 0.504	47.1
6000 Hz	0	55	0.711 ± 0.474	23.8
	2	55	0.666 ± 0.522	25.3
	7	55	0.470 ± 0.509	31.9
	12	55	0.247 ± 0.505	40.2

Table B-6 Time trends of Standardized AHT at each frequency: Refinery 3

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 3				
Scores				
500 Hz	0	36	1.774 ± 1.116	3.8
	2	36	1.491 ± 0.962	6.8
	7	36	1.640 ± 0.925	5.0
	12	36	0.690 ± 1.001	24.5
1000 Hz	0	36	1.235 ± 1.192	10.8
	2	36	0.745 ± 1.027	22.8
	7	36	0.871 ± 0.976	19.2
	12	36	0.056 ± 0.982	47.8
2000 Hz	0	36	0.549 ± 1.238	29.2
	2	36	0.133 ± 1.160	44.7
	7	36	0.388 ± 1.075	34.9
	12	36	-0.029 ± 1.160	51.2
3000 Hz	0	36	0.943 ± 1.317	17.3
	2	36	0.586 ± 1.150	27.9
	7	36	0.687 ± 1.131	24.6
	12	36	0.359 ± 1.185	36.0
4000 Hz	0	36	0.992 ± 1.122	16.1
	2	36	0.730 ± 1.162	23.3
	7	36	0.773 ± 1.048	22.0
	12	36	0.070 ± 0.950	47.2
6000 Hz	0	36	1.147 ± 0.971	12.6
	2	36	0.931 ± 0.930	17.6
	7	36	0.670 ± 0.934	25.2
	12	36	0.138 ± 0.998	44.5
Corrected Scores				
500 Hz	0	36	0.977 ± 0.764	16.4
	2	36	0.799 ± 0.662	21.2
	7	36	0.926 ± 0.638	17.7
	12	36	0.261 ± 0.740	39.7
1000 Hz	0	36	0.603 ± 0.841	27.3
	2	36	0.272 ± 0.736	39.3
	7	36	0.385 ± 0.709	35.0
	12	36	-0.218 ± 0.767	58.6
2000 Hz	0	36	0.172 ± 0.943	43.2
	2	36	-0.143 ± 0.901	55.7
	7	36	0.079 ± 0.849	46.9
	12	36	-0.245 ± 0.942	59.7
3000 Hz	0	36	0.503 ± 1.010	30.7
	2	36	0.247 ± 0.896	40.3
	7	36	0.353 ± 0.903	36.2
	12	36	0.110 ± 0.984	45.6
4000 Hz	0	36	0.577 ± 0.878	28.2
	2	36	0.394 ± 0.932	34.7
	7	36	0.461 ± 0.858	32.2
	12	36	-0.102 ± 0.822	54.1
6000 Hz	0	36	0.743 ± 0.781	22.9
	2	36	0.591 ± 0.755	27.7
	7	36	0.404 ± 0.784	34.3
	12	36	-0.026 ± 0.875	51.1

Table B-7 Time trends of Standardized AHT at each frequency: Refinery 4

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 4				
Scores				
500 Hz	0	103	1.217 ± 0.582	11.2
	2	99	1.003 ± 0.717	15.8
	7	103	0.949 ± 0.601	17.1
	12	99	1.048 ± 0.646	14.7
1000 Hz	0	103	1.270 ± 0.587	10.2
	2	99	1.063 ± 0.741	14.4
	7	103	0.966 ± 0.611	16.7
	12	99	1.076 ± 0.709	14.1
2000 Hz	0	103	1.016 ± 0.771	15.5
	2	99	0.815 ± 0.820	20.8
	7	103	0.603 ± 0.808	27.3
	12	99	0.821 ± 0.739	20.6
3000 Hz	0	103	1.131 ± 0.798	12.9
	2	99	0.946 ± 0.742	17.2
	7	103	0.805 ± 0.757	21.0
	12	99	0.796 ± 0.795	21.3
4000 Hz	0	103	1.234 ± 0.881	10.9
	2	99	1.032 ± 0.776	15.1
	7	103	0.904 ± 0.791	18.3
	12	99	0.805 ± 0.742	21.0
6000 Hz	0	103	1.013 ± 0.804	15.6
	2	99	0.924 ± 0.694	17.8
	7	103	0.773 ± 0.705	22.0
	12	99	0.475 ± 0.653	31.7
Corrected Scores				
500 Hz	0	103	0.611 ± 0.412	27.1
	2	99	0.462 ± 0.521	32.2
	7	103	0.442 ± 0.439	32.9
	12	99	0.530 ± 0.453	29.8
1000 Hz	0	103	0.654 ± 0.408	25.7
	2	99	0.511 ± 0.532	30.5
	7	103	0.462 ± 0.438	32.2
	12	99	0.556 ± 0.499	28.9
2000 Hz	0	103	0.548 ± 0.572	29.2
	2	99	0.404 ± 0.626	34.3
	7	103	0.257 ± 0.629	39.9
	12	99	0.445 ± 0.566	32.8
3000 Hz	0	103	0.679 ± 0.610	24.9
	2	99	0.551 ± 0.579	29.1
	7	103	0.456 ± 0.587	32.4
	12	99	0.464 ± 0.621	32.1
4000 Hz	0	103	0.798 ± 0.691	21.2
	2	99	0.650 ± 0.615	25.8
	7	103	0.575 ± 0.631	28.3
	12	99	0.511 ± 0.596	30.5
6000 Hz	0	103	0.658 ± 0.636	25.5
	2	99	0.596 ± 0.554	27.5
	7	103	0.491 ± 0.562	31.2
	12	99	0.254 ± 0.530	40.0

Table B-8 Time trends of Standardized AHT at each frequency: Refinery 5

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 5				
Scores				
500 Hz	0	18	0.348 ± 0.839	36.4
	2	18	0.432 ± 0.899	33.3
	7	18	0.315 ± 0.927	37.6
	12	16	0.590 ± 1.076	27.8
1000 Hz	0	18	0.422 ± 0.853	33.7
	2	18	0.561 ± 0.886	28.7
	7	18	0.359 ± 0.868	36.0
	12	16	0.519 ± 1.015	30.2
2000 Hz	0	18	0.146 ± 0.643	44.2
	2	18	0.126 ± 0.852	45.0
	7	18	0.128 ± 0.809	44.9
	12	16	0.299 ± 0.930	38.3
3000 Hz	0	18	0.695 ± 1.262	24.4
	2	18	0.840 ± 1.292	20.1
	7	18	0.641 ± 1.182	26.1
	12	16	0.719 ± 1.340	23.6
4000 Hz	0	18	0.635 ± 1.264	26.3
	2	18	0.679 ± 1.297	24.9
	7	18	0.527 ± 1.176	29.9
	12	16	0.681 ± 1.215	24.8
6000 Hz	0	18	0.647 ± 1.192	25.9
	2	18	0.659 ± 1.160	25.5
	7	18	0.572 ± 1.072	28.4
	12	16	0.764 ± 1.009	22.2
Corrected Scores				
500 Hz	0	18	0.010 ± 0.633	49.6
	2	18	0.079 ± 0.679	46.8
	7	18	-0.009 ± 0.715	50.4
	12	16	0.208 ± 0.818	41.8
1000 Hz	0	18	0.076 ± 0.633	47.0
	2	18	0.184 ± 0.663	42.7
	7	18	0.037 ± 0.659	48.5
	12	16	0.156 ± 0.765	43.8
2000 Hz	0	18	-0.098 ± 0.521	53.9
	2	18	-0.118 ± 0.677	54.7
	7	18	-0.094 ± 0.654	53.8
	12	16	0.046 ± 0.735	48.2
3000 Hz	0	18	0.379 ± 0.997	35.2
	2	18	0.511 ± 1.033	30.5
	7	18	0.358 ± 0.966	36.0
	12	16	0.435 ± 1.088	33.2
4000 Hz	0	18	0.362 ± 1.015	35.9
	2	18	0.411 ± 1.057	34.1
	7	18	0.298 ± 0.977	38.3
	12	16	0.438 ± 1.005	33.1
6000 Hz	0	18	0.398 ± 0.977	34.5
	2	18	0.423 ± 0.966	33.6
	7	18	0.367 ± 0.911	35.7
	12	16	0.543 ± 0.858	29.4

Table B-9 Time trends of Standardized AHT at each frequency: Refinery 6

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 6				
Scores				
500 Hz	0	18	1.096 ± 0.291	13.6
	2	18	1.220 ± 0.730	11.1
	7	26	1.229 ± 0.816	11.0
	12	27	1.116 ± 0.720	13.2
1000 Hz	0	18	1.016 ± 0.473	15.5
	2	18	0.979 ± 0.611	16.4
	7	26	0.980 ± 0.796	16.4
	12	27	0.958 ± 0.638	16.9
2000 Hz	0	18	0.720 ± 0.544	23.6
	2	18	0.632 ± 0.770	26.4
	7	26	0.613 ± 0.827	27.0
	12	27	0.748 ± 0.645	22.7
3000 Hz	0	18	1.190 ± 1.164	11.7
	2	18	0.963 ± 0.974	16.8
	7	26	0.855 ± 0.735	19.6
	12	27	0.792 ± 0.801	21.4
4000 Hz	0	18	0.954 ± 0.931	17.0
	2	18	0.906 ± 0.686	18.2
	7	26	0.830 ± 0.671	20.3
	12	27	0.734 ± 0.689	23.1
6000 Hz	0	18	1.297 ± 0.817	9.7
	2	18	0.701 ± 0.480	24.2
	7	26	0.813 ± 0.657	20.8
	12	27	0.545 ± 0.604	29.3
Corrected Scores				
500 Hz	0	18	0.548 ± 0.198	29.2
	2	18	0.650 ± 0.505	25.8
	7	26	0.647 ± 0.579	25.9
	12	27	0.590 ± 0.528	27.8
1000 Hz	0	18	0.496 ± 0.320	31.0
	2	18	0.485 ± 0.432	31.4
	7	26	0.479 ± 0.577	31.6
	12	27	0.490 ± 0.458	31.2
2000 Hz	0	18	0.349 ± 0.419	36.3
	2	18	0.296 ± 0.601	38.4
	7	26	0.276 ± 0.652	39.1
	12	27	0.408 ± 0.510	34.2
3000 Hz	0	18	0.755 ± 0.926	22.5
	2	18	0.614 ± 0.786	26.9
	7	26	0.517 ± 0.588	30.3
	12	27	0.499 ± 0.665	30.9
4000 Hz	0	18	0.606 ± 0.771	27.2
	2	18	0.603 ± 0.577	27.3
	7	26	0.536 ± 0.552	29.6
	12	27	0.483 ± 0.587	31.4
6000 Hz	0	18	0.912 ± 0.670	18.1
	2	18	0.461 ± 0.398	32.3
	7	26	0.545 ± 0.553	29.3
	12	27	0.347 ± 0.516	36.4

Table B-10 Time trends of Standardized AHT at each frequency: Refinery 7
Means in all refineries and within Age- and Refinery subgroups

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 7				
Scores				
500 Hz	0	251	0.742 ± 0.743	22.9
	2	249	0.577 ± 0.720	28.2
	7	251	0.548 ± 0.739	29.2
	12	243	0.500 ± 0.820	30.8
1000 Hz	0	251	0.656 ± 0.787	25.6
	2	249	0.489 ± 0.761	31.3
	7	251	0.441 ± 0.767	33.0
	12	243	0.443 ± 0.825	32.9
2000 Hz	0	251	0.479 ± 0.791	31.6
	2	249	0.333 ± 0.731	37.0
	7	251	0.211 ± 0.767	41.6
	12	243	0.118 ± 0.746	45.3
3000 Hz	0	178	0.634 ± 0.855	26.3
	2	245	0.518 ± 0.901	30.2
	7	250	0.432 ± 0.909	33.3
	12	243	0.294 ± 0.891	38.4
4000 Hz	0	250	0.786 ± 0.979	21.6
	2	249	0.592 ± 1.003	27.7
	7	251	0.471 ± 0.980	31.9
	12	243	0.249 ± 0.937	40.2
6000 Hz	0	238	1.015 ± 0.950	15.5
	2	248	0.884 ± 0.909	18.8
	7	251	0.887 ± 0.942	18.8
	12	242	0.875 ± 0.952	19.1
Corrected Scores				
500 Hz	0	251	0.271 ± 0.526	39.3
	2	249	0.158 ± 0.518	43.7
	7	251	0.153 ± 0.537	43.9
	12	243	0.125 ± 0.608	45.0
1000 Hz	0	251	0.209 ± 0.560	41.7
	2	249	0.095 ± 0.549	46.2
	7	251	0.075 ± 0.565	47.0
	12	243	0.090 ± 0.612	46.4
2000 Hz	0	251	0.131 ± 0.598	44.8
	2	249	0.026 ± 0.562	49.0
	7	251	-0.056 ± 0.603	52.2
	12	243	-0.118 ± 0.600	54.7
3000 Hz	0	178	0.282 ± 0.660	38.9
	2	245	0.199 ± 0.709	42.1
	7	250	0.153 ± 0.736	43.9
	12	243	0.059 ± 0.741	47.6
4000 Hz	0	250	0.432 ± 0.768	33.3
	2	249	0.286 ± 0.802	38.7
	7	251	0.211 ± 0.805	41.6
	12	243	0.046 ± 0.792	48.2
6000 Hz	0	238	0.645 ± 0.758	25.9
	2	248	0.555 ± 0.731	29.0
	7	251	0.582 ± 0.772	28.0
	12	242	0.600 ± 0.790	27.4

Table B-11 Time trends of Standardized AHT at each frequency: Refinery 8

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 8				
Scores				
500 Hz	0	193	0.690 ± 0.847	24.5
	2	193	0.560 ± 0.734	28.8
	7	193	0.478 ± 0.715	31.6
	12	193	0.737 ± 0.962	23.0
1000 Hz	0	193	0.393 ± 0.725	34.7
	2	193	0.285 ± 0.646	38.8
	7	193	0.265 ± 0.709	39.5
	12	193	0.385 ± 0.932	35.0
2000 Hz	0	193	0.442 ± 0.838	32.9
	2	193	0.394 ± 0.783	34.7
	7	193	0.231 ± 0.838	40.9
	12	193	-0.092 ± 1.035	53.6
3000 Hz	0	1	0.112 ± 0.000	45.5
	2	0		
	7	25	0.398 ± 0.871	34.5
	12	177	0.219 ± 1.087	41.4
4000 Hz	0	193	0.676 ± 1.188	24.9
	2	193	0.685 ± 1.079	24.7
	7	193	0.562 ± 1.101	28.7
	12	193	0.408 ± 1.146	34.1
6000 Hz	0	0		
	2	0		
	7	26	0.889 ± 0.727	18.7
	12	176	0.824 ± 0.919	20.5
Corrected Scores				
500 Hz	0	193	0.223 ± 0.603	41.2
	2	193	0.142 ± 0.527	44.4
	7	193	0.088 ± 0.528	46.5
	12	193	0.289 ± 0.709	38.6
1000 Hz	0	193	0.010 ± 0.529	49.6
	2	193	-0.061 ± 0.476	52.4
	7	193	-0.068 ± 0.533	52.7
	12	193	0.032 ± 0.702	48.7
2000 Hz	0	193	0.100 ± 0.632	46.0
	2	193	0.072 ± 0.595	47.1
	7	193	-0.051 ± 0.651	52.0
	12	193	-0.299 ± 0.832	61.8
3000 Hz	0	1	-0.074 ± 0.000	52.9
	2	0		
	7	25	0.143 ± 0.710	44.3
	12	177	-0.011 ± 0.880	50.4
4000 Hz	0	193	0.335 ± 0.916	36.9
	2	193	0.357 ± 0.841	36.0
	7	193	0.274 ± 0.877	39.2
	12	193	0.173 ± 0.946	43.1
6000 Hz	0	0		
	2	0		
	7	26	0.603 ± 0.596	27.3
	12	176	0.557 ± 0.758	28.9

Table B-12 Time trends of Standardized AHT at each frequency: Refinery 9

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 9				
Scores				
500 Hz	0	45	0.722 ± 1.227	23.5
	2	45	0.864 ± 1.342	19.4
	7	45	1.149 ± 1.338	12.5
	12	45	0.850 ± 1.411	19.8
1000 Hz	0	45	0.604 ± 1.075	27.3
	2	45	0.877 ± 1.182	19.0
	7	45	0.763 ± 1.202	22.3
	12	45	0.690 ± 1.376	24.5
2000 Hz	0	45	0.369 ± 1.125	35.6
	2	45	0.559 ± 1.058	28.8
	7	45	0.302 ± 1.043	38.1
	12	45	0.429 ± 1.023	33.4
3000 Hz	0	45	0.708 ± 0.937	24.0
	2	45	0.835 ± 0.918	20.2
	7	45	0.667 ± 1.079	25.2
	12	45	0.596 ± 1.036	27.5
4000 Hz	0	45	0.708 ± 1.084	23.9
	2	45	0.740 ± 0.962	23.0
	7	45	0.621 ± 0.967	26.7
	12	45	0.544 ± 0.985	29.3
6000 Hz	0	45	0.952 ± 0.911	17.1
	2	45	0.966 ± 0.949	16.7
	7	45	0.715 ± 0.923	23.7
	12	45	0.708 ± 0.825	24.0
Corrected Scores				
500 Hz	0	45	0.265 ± 0.877	39.6
	2	45	0.377 ± 0.939	35.3
	7	45	0.608 ± 0.924	27.2
	12	45	0.388 ± 1.007	34.9
1000 Hz	0	45	0.196 ± 0.778	42.2
	2	45	0.405 ± 0.831	34.3
	7	45	0.321 ± 0.865	37.4
	12	45	0.274 ± 1.006	39.2
2000 Hz	0	45	0.057 ± 0.877	47.7
	2	45	0.218 ± 0.818	41.4
	7	45	0.024 ± 0.827	49.0
	12	45	0.139 ± 0.813	44.5
3000 Hz	0	45	0.381 ± 0.744	35.2
	2	45	0.499 ± 0.722	30.9
	7	45	0.366 ± 0.876	35.7
	12	45	0.324 ± 0.849	37.3
4000 Hz	0	45	0.410 ± 0.889	34.1
	2	45	0.452 ± 0.795	32.6
	7	45	0.363 ± 0.811	35.8
	12	45	0.316 ± 0.834	37.6
6000 Hz	0	45	0.650 ± 0.756	25.8
	2	45	0.673 ± 0.791	25.0
	7	45	0.476 ± 0.789	31.7
	12	45	0.483 ± 0.702	31.4

Table B-13 Time trends of Standardized AHT at each frequency: Refinery 10

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 10				
Scores				
500 Hz	0	0		
	2	0		
	7	0		
	12	0		
1000 Hz	0	253	2.447 ± 0.861	0.7
	2	253	2.339 ± 0.896	1.0
	7	253	1.531 ± 0.752	6.3
	12	253	1.335 ± 0.814	9.1
2000 Hz	0	253	1.559 ± 0.816	5.9
	2	253	1.538 ± 0.827	6.2
	7	253	0.892 ± 0.741	18.6
	12	253	0.793 ± 0.826	21.4
3000 Hz	0	253	1.413 ± 0.887	7.9
	2	253	1.314 ± 0.893	9.5
	7	253	0.905 ± 0.890	18.3
	12	253	0.745 ± 0.958	22.8
4000 Hz	0	253	1.235 ± 0.889	10.8
	2	253	1.090 ± 0.818	13.8
	7	253	0.935 ± 0.893	17.5
	12	253	0.687 ± 0.866	24.6
6000 Hz	0	253	1.604 ± 0.951	5.4
	2	253	1.474 ± 0.860	7.0
	7	253	1.152 ± 0.879	12.5
	12	253	0.832 ± 0.850	20.3
Corrected Scores				
500 Hz	0	0		
	2	0		
	7	0		
	12	0		
1000 Hz	0	253	1.470 ± 0.587	7.1
	2	253	1.402 ± 0.611	8.1
	7	253	0.869 ± 0.530	19.2
	12	253	0.752 ± 0.585	22.6
2000 Hz	0	253	0.956 ± 0.589	17.0
	2	253	0.947 ± 0.600	17.2
	7	253	0.490 ± 0.555	31.2
	12	253	0.428 ± 0.644	33.4
3000 Hz	0	253	0.902 ± 0.667	18.4
	2	253	0.831 ± 0.678	20.3
	7	253	0.542 ± 0.702	29.4
	12	253	0.434 ± 0.776	33.2
4000 Hz	0	253	0.806 ± 0.688	21.0
	2	253	0.699 ± 0.637	24.2
	7	253	0.603 ± 0.715	27.3
	12	253	0.421 ± 0.719	33.7
6000 Hz	0	253	1.136 ± 0.740	12.8
	2	253	1.042 ± 0.672	14.9
	7	253	0.810 ± 0.706	20.9
	12	253	0.567 ± 0.710	28.5

Table B-14 Time trends of Standardized AHT at each frequency: Refinery 1, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 1, Age < 35 yrs at baseline				
Scores				
500 Hz	0	9	0.540 ± 1.422	29.5
	2	9	0.283 ± 1.887	38.9
	7	9	-0.418 ± 0.948	66.2
	12	9	-0.397 ± 1.024	65.4
1000 Hz	0	9	-0.353 ± 1.212	63.8
	2	9	-0.151 ± 1.203	56.0
	7	9	-0.617 ± 0.692	73.2
	12	9	-0.573 ± 0.721	71.7
2000 Hz	0	9	-0.390 ± 0.869	65.2
	2	9	-0.832 ± 0.819	79.7
	7	9	-0.775 ± 0.422	78.1
	12	9	-0.611 ± 0.629	72.9
3000 Hz	0	9	0.414 ± 0.710	34.0
	2	9	0.394 ± 0.585	34.7
	7	9	-0.114 ± 0.849	54.5
	12	9	-0.046 ± 0.880	51.8
4000 Hz	0	9	0.429 ± 1.102	33.4
	2	9	0.204 ± 0.772	41.9
	7	9	0.063 ± 0.739	47.5
	12	9	0.120 ± 0.993	45.2
6000 Hz	0	9	0.909 ± 0.563	18.2
	2	9	0.530 ± 0.482	29.8
	7	9	-0.015 ± 0.665	50.6
	12	9	-0.055 ± 0.545	52.2
Corrected Scores				
500 Hz	0	9	0.108 ± 1.037	45.7
	2	9	-0.121 ± 1.384	54.8
	7	9	-0.610 ± 0.726	72.9
	12	9	-0.597 ± 0.774	72.5
1000 Hz	0	9	-0.571 ± 0.913	71.6
	2	9	-0.416 ± 0.912	66.1
	7	9	-0.763 ± 0.541	77.7
	12	9	-0.724 ± 0.564	76.6
2000 Hz	0	9	-0.557 ± 0.703	71.1
	2	9	-0.916 ± 0.668	82.0
	7	9	-0.868 ± 0.344	80.7
	12	9	-0.718 ± 0.535	76.4
3000 Hz	0	9	0.114 ± 0.575	45.4
	2	9	0.116 ± 0.479	45.4
	7	9	-0.300 ± 0.711	61.8
	12	9	-0.228 ± 0.741	59.0
4000 Hz	0	9	0.133 ± 0.896	44.7
	2	9	-0.021 ± 0.647	50.9
	7	9	-0.130 ± 0.627	55.2
	12	9	-0.067 ± 0.843	52.7
6000 Hz	0	9	0.573 ± 0.439	28.3
	2	9	0.283 ± 0.397	38.8
	7	9	-0.171 ± 0.573	56.8
	12	9	-0.190 ± 0.484	57.5

Table B-15 Time trends of Standardized AHT at each frequency: Refinery 1, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 1, Age > 35 yrs				
Scores				
500 Hz	0	22	0.333 ± 0.790	37.0
	2	22	0.081 ± 0.672	46.8
	7	22	-0.206 ± 0.704	58.2
	12	22	-0.201 ± 0.641	58.0
1000 Hz	0	22	-0.146 ± 0.803	55.8
	2	22	-0.346 ± 0.866	63.5
	7	22	-0.455 ± 0.684	67.5
	12	22	-0.398 ± 0.783	65.5
2000 Hz	0	22	-0.432 ± 0.915	66.7
	2	22	-0.489 ± 1.057	68.8
	7	22	-0.629 ± 0.829	73.5
	12	22	-0.611 ± 0.866	73.0
3000 Hz	0	22	0.036 ± 1.063	48.6
	2	22	-0.084 ± 1.076	53.4
	7	22	-0.365 ± 0.936	64.3
	12	22	-0.468 ± 0.925	68.0
4000 Hz	0	22	0.008 ± 1.046	49.7
	2	22	-0.080 ± 1.063	53.2
	7	22	-0.202 ± 0.931	58.0
	12	22	-0.176 ± 0.922	57.0
6000 Hz	0	22	0.558 ± 0.894	28.8
	2	22	0.302 ± 0.868	38.1
	7	22	0.180 ± 1.045	42.9
	12	22	-0.050 ± 0.989	52.0
Corrected Scores				
500 Hz	0	22	-0.013 ± 0.600	50.5
	2	22	-0.197 ± 0.529	57.8
	7	22	-0.419 ± 0.565	66.2
	12	22	-0.399 ± 0.525	65.5
1000 Hz	0	22	-0.385 ± 0.634	65.0
	2	22	-0.525 ± 0.692	70.0
	7	22	-0.612 ± 0.557	73.0
	12	22	-0.551 ± 0.647	70.9
2000 Hz	0	22	-0.583 ± 0.743	72.0
	2	22	-0.625 ± 0.874	73.4
	7	22	-0.740 ± 0.685	77.0
	12	22	-0.712 ± 0.736	76.2
3000 Hz	0	22	-0.185 ± 0.873	57.3
	2	22	-0.268 ± 0.895	60.6
	7	22	-0.487 ± 0.804	68.7
	12	22	-0.572 ± 0.805	71.6
4000 Hz	0	22	-0.182 ± 0.871	57.2
	2	22	-0.242 ± 0.899	59.6
	7	22	-0.336 ± 0.796	63.2
	12	22	-0.298 ± 0.802	61.7
6000 Hz	0	22	0.308 ± 0.737	37.9
	2	22	0.102 ± 0.750	45.9
	7	22	0.010 ± 0.897	49.6
	12	22	-0.178 ± 0.869	57.1

Table B-16 Time trends of Standardized AHT at each frequency: Refinery 2, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 2, Age < 35 yrs				
Scores				
500 Hz	0	3	1.391 ± 0.698	8.2
	2	3	1.459 ± 0.910	7.2
	7	3	1.804 ± 0.859	3.6
	12	3	1.717 ± 0.924	4.3
1000 Hz	0	3	1.865 ± 1.191	3.1
	2	3	1.790 ± 1.172	3.7
	7	3	1.861 ± 0.763	3.1
	12	3	2.078 ± 0.393	1.9
2000 Hz	0	3	1.318 ± 0.617	9.4
	2	3	1.328 ± 0.642	9.2
	7	3	1.219 ± 0.688	11.1
	12	3	1.217 ± 0.611	11.2
3000 Hz	0	3	1.757 ± 0.076	3.9
	2	3	1.608 ± 0.268	5.4
	7	3	1.377 ± 0.377	8.4
	12	3	1.004 ± 0.306	15.8
4000 Hz	0	3	1.303 ± 0.746	9.6
	2	3	1.297 ± 0.815	9.7
	7	3	0.954 ± 0.746	17.0
	12	3	0.625 ± 0.571	26.6
6000 Hz	0	3	1.028 ± 0.543	15.2
	2	3	0.946 ± 0.574	17.2
	7	3	0.762 ± 0.630	22.3
	12	3	0.445 ± 0.430	32.8
Corrected Scores				
500 Hz	0	3	0.733 ± 0.468	23.2
	2	3	0.786 ± 0.614	21.6
	7	3	1.041 ± 0.589	14.9
	12	3	1.007 ± 0.644	15.7
1000 Hz	0	3	1.059 ± 0.804	14.5
	2	3	1.018 ± 0.795	15.4
	7	3	1.089 ± 0.521	13.8
	12	3	1.273 ± 0.276	10.2
2000 Hz	0	3	0.771 ± 0.446	22.0
	2	3	0.788 ± 0.465	21.5
	7	3	0.731 ± 0.504	23.3
	12	3	0.758 ± 0.459	22.4
3000 Hz	0	3	1.148 ± 0.066	12.6
	2	3	1.052 ± 0.205	14.6
	7	3	0.909 ± 0.293	18.2
	12	3	0.654 ± 0.247	25.7
4000 Hz	0	3	0.846 ± 0.561	19.9
	2	3	0.858 ± 0.620	19.5
	7	3	0.620 ± 0.581	26.8
	12	3	0.387 ± 0.458	35.0
6000 Hz	0	3	0.673 ± 0.423	25.1
	2	3	0.621 ± 0.454	26.7
	7	3	0.497 ± 0.509	31.0
	12	3	0.248 ± 0.380	40.2

Table B-17 Time trends of Standardized AHT at each frequency: Refinery 2, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 2, Age > 35 yrs				
Scores				
500 Hz	0	52	1.357 ± 0.636	8.7
	2	52	1.490 ± 0.706	6.8
	7	52	1.551 ± 0.679	6.1
	12	52	1.630 ± 0.823	5.2
1000 Hz	0	52	1.056 ± 0.664	14.5
	2	52	1.070 ± 0.723	14.2
	7	52	1.120 ± 0.765	13.1
	12	52	1.157 ± 0.756	12.4
2000 Hz	0	52	0.784 ± 0.705	21.6
	2	52	0.857 ± 0.721	19.6
	7	52	0.746 ± 0.737	22.8
	12	52	0.701 ± 0.658	24.2
3000 Hz	0	52	0.816 ± 0.723	20.7
	2	52	0.759 ± 0.800	22.4
	7	52	0.552 ± 0.757	29.1
	12	52	0.343 ± 0.709	36.6
4000 Hz	0	52	0.922 ± 0.679	17.8
	2	52	0.817 ± 0.690	20.7
	7	52	0.530 ± 0.604	29.8
	12	52	0.215 ± 0.581	41.5
6000 Hz	0	52	1.036 ± 0.596	15.0
	2	52	0.969 ± 0.648	16.6
	7	52	0.696 ± 0.610	24.3
	12	52	0.413 ± 0.593	34.0
Corrected Scores				
500 Hz	0	52	0.733 ± 0.436	23.2
	2	52	0.832 ± 0.486	20.3
	7	52	0.896 ± 0.475	18.5
	12	52	0.979 ± 0.585	16.4
1000 Hz	0	52	0.531 ± 0.455	29.8
	2	52	0.543 ± 0.503	29.3
	7	52	0.598 ± 0.543	27.5
	12	52	0.652 ± 0.542	25.7
2000 Hz	0	52	0.401 ± 0.525	34.4
	2	52	0.461 ± 0.541	32.2
	7	52	0.395 ± 0.569	34.6
	12	52	0.386 ± 0.516	35.0
3000 Hz	0	52	0.470 ± 0.563	31.9
	2	52	0.431 ± 0.630	33.3
	7	52	0.285 ± 0.618	38.8
	12	52	0.132 ± 0.598	44.8
4000 Hz	0	52	0.590 ± 0.539	27.7
	2	52	0.516 ± 0.551	30.3
	7	52	0.304 ± 0.504	38.0
	12	52	0.054 ± 0.504	47.8
6000 Hz	0	52	0.714 ± 0.480	23.8
	2	52	0.669 ± 0.529	25.2
	7	52	0.468 ± 0.514	32.0
	12	52	0.247 ± 0.515	40.3

Table B-18 Time trends of Standardized AHT at each frequency: Refinery 3, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 3, Age < 35 yrs				
Scores				
500 Hz	0	31	1.803 ± 1.116	3.6
	2	31	1.387 ± 0.933	8.3
	7	31	1.597 ± 0.862	5.5
	12	31	0.619 ± 0.925	26.8
1000 Hz	0	31	1.157 ± 1.117	12.4
	2	31	0.567 ± 0.930	28.5
	7	31	0.786 ± 0.787	21.6
	12	31	-0.044 ± 0.838	51.8
2000 Hz	0	31	0.310 ± 0.902	37.8
	2	31	-0.146 ± 0.731	55.8
	7	31	0.191 ± 0.749	42.4
	12	31	-0.241 ± 0.793	59.5
3000 Hz	0	31	0.804 ± 1.145	21.1
	2	31	0.395 ± 1.018	34.6
	7	31	0.589 ± 1.018	27.8
	12	31	0.239 ± 1.099	40.6
4000 Hz	0	31	0.986 ± 1.114	16.2
	2	31	0.617 ± 1.156	26.9
	7	31	0.733 ± 1.074	23.2
	12	31	-0.017 ± 0.923	50.7
6000 Hz	0	31	1.098 ± 0.951	13.6
	2	31	0.887 ± 0.911	18.8
	7	31	0.678 ± 0.947	24.9
	12	31	0.079 ± 0.991	46.9
Corrected Scores				
500 Hz	0	31	0.996 ± 0.756	16.0
	2	31	0.723 ± 0.639	23.5
	7	31	0.889 ± 0.588	18.7
	12	31	0.204 ± 0.684	41.9
1000 Hz	0	31	0.548 ± 0.783	29.2
	2	31	0.141 ± 0.665	44.4
	7	31	0.326 ± 0.564	37.2
	12	31	-0.293 ± 0.661	61.5
2000 Hz	0	31	-0.009 ± 0.700	50.3
	2	31	-0.361 ± 0.586	64.1
	7	31	-0.075 ± 0.597	53.0
	12	31	-0.414 ± 0.659	66.1
3000 Hz	0	31	0.392 ± 0.870	34.7
	2	31	0.090 ± 0.785	46.4
	7	31	0.268 ± 0.801	39.4
	12	31	0.007 ± 0.911	49.7
4000 Hz	0	31	0.567 ± 0.866	28.5
	2	31	0.295 ± 0.922	38.4
	7	31	0.421 ± 0.874	33.7
	12	31	-0.181 ± 0.795	57.2
6000 Hz	0	31	0.697 ± 0.762	24.3
	2	31	0.550 ± 0.734	29.1
	7	31	0.406 ± 0.791	34.2
	12	31	-0.083 ± 0.866	53.3

Table B-19 Time trends of Standardized AHT at each frequency: Refinery 3, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 3, Age > 35 yrs				
Scores				
500 Hz	0	5	1.598 ± 1.230	5.5
	2	5	2.134 ± 0.983	1.6
	7	5	1.908 ± 1.346	2.8
	12	5	1.134 ± 1.440	12.8
1000 Hz	0	5	1.722 ± 1.655	4.3
	2	5	1.848 ± 0.992	3.2
	7	5	1.395 ± 1.811	8.1
	12	5	0.677 ± 1.613	24.9
2000 Hz	0	5	2.030 ± 2.029	2.1
	2	5	1.864 ± 1.850	3.1
	7	5	1.607 ± 1.937	5.4
	12	5	1.288 ± 2.133	9.9
3000 Hz	0	5	1.809 ± 2.062	3.5
	2	5	1.774 ± 1.324	3.8
	7	5	1.295 ± 1.696	9.8
	12	5	1.105 ± 1.558	13.5
4000 Hz	0	5	1.027 ± 1.309	15.2
	2	5	1.435 ± 1.033	7.6
	7	5	1.022 ± 0.936	15.3
	12	5	0.608 ± 1.038	27.2
6000 Hz	0	5	1.446 ± 1.158	7.4
	2	5	1.202 ± 1.112	11.5
	7	5	0.617 ± 0.954	26.9
	12	5	0.509 ± 1.073	30.5
Corrected Scores				
500 Hz	0	5	0.862 ± 0.896	19.4
	2	5	1.270 ± 0.677	10.2
	7	5	1.153 ± 0.950	12.5
	12	5	0.610 ± 1.053	27.1
1000 Hz	0	5	0.949 ± 1.192	17.1
	2	5	1.082 ± 0.688	14.0
	7	5	0.757 ± 1.348	22.5
	12	5	0.246 ± 1.250	40.3
2000 Hz	0	5	1.288 ± 1.511	9.9
	2	5	1.210 ± 1.371	11.3
	7	5	1.035 ± 1.522	15.0
	12	5	0.802 ± 1.707	21.1
3000 Hz	0	5	1.190 ± 1.604	11.7
	2	5	1.216 ± 1.021	11.2
	7	5	0.879 ± 1.388	19.0
	12	5	0.748 ± 1.291	22.7
4000 Hz	0	5	0.642 ± 1.056	26.1
	2	5	1.006 ± 0.823	15.7
	7	5	0.712 ± 0.791	23.8
	12	5	0.386 ± 0.906	35.0
6000 Hz	0	5	1.032 ± 0.928	15.1
	2	5	0.844 ± 0.926	19.9
	7	5	0.389 ± 0.833	34.8
	12	5	0.322 ± 0.949	37.4

Table B-20 Time trends of Standardized AHT at each frequency: Refinery 4, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 4, Age < 35 yrs				
Scores				
500 Hz	0	54	1.342 ± 0.474	9.0
	2	54	1.030 ± 0.662	15.2
	7	54	0.983 ± 0.646	16.3
	12	51	1.164 ± 0.653	12.2
1000 Hz	0	54	1.404 ± 0.478	8.0
	2	54	1.117 ± 0.588	13.2
	7	54	1.020 ± 0.624	15.4
	12	51	1.204 ± 0.616	11.4
2000 Hz	0	54	1.124 ± 0.533	13.0
	2	54	0.812 ± 0.611	20.8
	7	54	0.702 ± 0.577	24.1
	12	51	0.905 ± 0.677	18.3
3000 Hz	0	54	1.196 ± 0.482	11.6
	2	54	0.924 ± 0.523	17.8
	7	54	0.962 ± 0.694	16.8
	12	51	0.958 ± 0.730	16.9
4000 Hz	0	54	1.250 ± 0.535	10.6
	2	54	1.040 ± 0.644	14.9
	7	54	0.927 ± 0.673	17.7
	12	51	0.911 ± 0.683	18.1
6000 Hz	0	54	1.113 ± 0.502	13.3
	2	54	1.045 ± 0.463	14.8
	7	54	0.986 ± 0.539	16.2
	12	51	0.722 ± 0.574	23.5
Corrected Scores				
500 Hz	0	54	0.675 ± 0.337	25.0
	2	54	0.456 ± 0.480	32.4
	7	54	0.433 ± 0.476	33.2
	12	51	0.577 ± 0.455	28.2
1000 Hz	0	54	0.720 ± 0.335	23.6
	2	54	0.524 ± 0.424	30.0
	7	54	0.465 ± 0.453	32.1
	12	51	0.612 ± 0.421	27.0
2000 Hz	0	54	0.596 ± 0.397	27.6
	2	54	0.371 ± 0.462	35.5
	7	54	0.304 ± 0.444	38.0
	12	51	0.470 ± 0.507	31.9
3000 Hz	0	54	0.688 ± 0.355	24.6
	2	54	0.495 ± 0.388	31.0
	7	54	0.539 ± 0.521	29.5
	12	51	0.551 ± 0.545	29.1
4000 Hz	0	54	0.762 ± 0.404	22.3
	2	54	0.611 ± 0.483	27.1
	7	54	0.546 ± 0.509	29.2
	12	51	0.547 ± 0.524	29.2
6000 Hz	0	54	0.699 ± 0.381	24.2
	2	54	0.656 ± 0.346	25.6
	7	54	0.628 ± 0.403	26.5
	12	51	0.426 ± 0.446	33.5

Table B-21 Time trends of Standardized AHT at each frequency: Refinery 4, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 4, Age > 35 yrs				
Scores				
500 Hz	0	49	1.080 ± 0.659	14.0
	2	45	0.971 ± 0.784	16.6
	7	49	0.912 ± 0.550	18.1
	12	48	0.926 ± 0.621	17.7
1000 Hz	0	49	1.123 ± 0.661	13.1
	2	45	0.999 ± 0.894	15.9
	7	49	0.907 ± 0.597	18.2
	12	48	0.940 ± 0.779	17.4
2000 Hz	0	49	0.897 ± 0.960	18.5
	2	45	0.818 ± 1.023	20.7
	7	49	0.494 ± 0.998	31.1
	12	48	0.732 ± 0.798	23.2
3000 Hz	0	49	1.059 ± 1.043	14.5
	2	45	0.973 ± 0.946	16.5
	7	49	0.633 ± 0.792	26.3
	12	48	0.623 ± 0.832	26.7
4000 Hz	0	49	1.216 ± 1.154	11.2
	2	45	1.022 ± 0.916	15.3
	7	49	0.879 ± 0.910	19.0
	12	48	0.693 ± 0.791	24.4
6000 Hz	0	49	0.901 ± 1.034	18.4
	2	45	0.779 ± 0.881	21.8
	7	49	0.539 ± 0.793	29.5
	12	48	0.212 ± 0.633	41.6
Corrected Scores				
500 Hz	0	49	0.540 ± 0.475	29.5
	2	45	0.468 ± 0.571	32.0
	7	49	0.452 ± 0.400	32.6
	12	48	0.480 ± 0.450	31.6
1000 Hz	0	49	0.581 ± 0.469	28.1
	2	45	0.496 ± 0.643	31.0
	7	49	0.458 ± 0.426	32.3
	12	48	0.497 ± 0.569	31.0
2000 Hz	0	49	0.496 ± 0.718	31.0
	2	45	0.443 ± 0.783	32.9
	7	49	0.204 ± 0.786	41.9
	12	48	0.418 ± 0.628	33.8
3000 Hz	0	49	0.669 ± 0.807	25.2
	2	45	0.619 ± 0.747	26.8
	7	49	0.365 ± 0.645	35.8
	12	48	0.372 ± 0.686	35.5
4000 Hz	0	49	0.837 ± 0.912	20.1
	2	45	0.698 ± 0.747	24.3
	7	49	0.607 ± 0.748	27.2
	12	48	0.472 ± 0.667	31.9
6000 Hz	0	49	0.614 ± 0.834	27.0
	2	45	0.525 ± 0.729	30.0
	7	49	0.341 ± 0.668	36.7
	12	48	0.071 ± 0.555	47.2

Table B-22 Time trends of Standardized AHT at each frequency: Refinery 5, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 5, Age < 35 yrs				
Scores				
500 Hz	0	3	0.062 ± 0.258	47.5
	2	3	0.024 ± 0.252	49.1
	7	3	-0.171 ± 0.037	56.8
	12	3	0.311 ± 0.925	37.8
1000 Hz	0	3	0.052 ± 0.261	47.9
	2	3	0.008 ± 0.253	49.7
	7	3	-0.054 ± 0.268	52.2
	12	3	-0.098 ± 0.270	53.9
2000 Hz	0	3	0.333 ± 0.440	36.9
	2	3	0.257 ± 0.790	39.9
	7	3	0.176 ± 0.545	43.0
	12	3	0.114 ± 0.550	45.5
3000 Hz	0	3	0.346 ± 0.684	36.5
	2	3	0.244 ± 0.668	40.3
	7	3	0.092 ± 0.902	46.3
	12	3	0.216 ± 0.694	41.4
4000 Hz	0	3	0.444 ± 0.761	32.9
	2	3	0.509 ± 0.960	30.5
	7	3	0.431 ± 0.647	33.3
	12	3	0.432 ± 1.366	33.3
6000 Hz	0	3	0.536 ± 0.955	29.6
	2	3	0.495 ± 0.607	31.0
	7	3	0.170 ± 0.460	43.3
	12	3	0.644 ± 0.423	26.0
Corrected Scores				
500 Hz	0	3	-0.237 ± 0.228	59.4
	2	3	-0.262 ± 0.226	60.3
	7	3	-0.427 ± 0.025	66.5
	12	3	-0.067 ± 0.688	52.7
1000 Hz	0	3	-0.244 ± 0.231	59.6
	2	3	-0.272 ± 0.228	60.7
	7	3	-0.314 ± 0.241	62.3
	12	3	-0.343 ± 0.245	63.4
2000 Hz	0	3	0.018 ± 0.360	49.3
	2	3	-0.062 ± 0.613	52.5
	7	3	-0.087 ± 0.438	53.4
	12	3	-0.129 ± 0.446	55.1
3000 Hz	0	3	0.048 ± 0.525	48.1
	2	3	-0.022 ± 0.529	50.9
	7	3	-0.162 ± 0.722	56.4
	12	3	-0.048 ± 0.559	51.9
4000 Hz	0	3	0.139 ± 0.597	44.5
	2	3	0.202 ± 0.741	42.0
	7	3	0.158 ± 0.508	43.7
	12	3	0.133 ± 1.094	44.7
6000 Hz	0	3	0.236 ± 0.755	40.7
	2	3	0.222 ± 0.492	41.2
	7	3	-0.029 ± 0.397	51.1
	12	3	0.377 ± 0.329	35.3

Table B-23 Time trends of Standardized AHT at each frequency: Refinery 5, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 5, Age > 35 yrs				
Scores				
500 Hz	0	15	0.405 ± 0.908	34.3
	2	15	0.514 ± 0.965	30.4
	7	15	0.412 ± 0.991	34.0
	12	13	0.654 ± 1.131	25.6
1000 Hz	0	15	0.496 ± 0.915	31.0
	2	15	0.672 ± 0.930	25.1
	7	15	0.441 ± 0.928	33.0
	12	13	0.661 ± 1.077	25.4
2000 Hz	0	15	0.109 ± 0.682	45.7
	2	15	0.100 ± 0.888	46.0
	7	15	0.118 ± 0.867	45.3
	12	13	0.341 ± 1.011	36.6
3000 Hz	0	15	0.765 ± 1.355	22.2
	2	15	0.959 ± 1.368	16.9
	7	15	0.751 ± 1.226	22.6
	12	13	0.835 ± 1.444	20.2
4000 Hz	0	15	0.674 ± 1.360	25.0
	2	15	0.713 ± 1.380	23.8
	7	15	0.546 ± 1.272	29.3
	12	13	0.738 ± 1.231	23.0
6000 Hz	0	15	0.670 ± 1.262	25.2
	2	15	0.692 ± 1.255	24.4
	7	15	0.653 ± 1.151	25.7
	12	13	0.792 ± 1.113	21.4
Corrected Scores				
500 Hz	0	15	0.060 ± 0.680	47.6
	2	15	0.147 ± 0.723	44.1
	7	15	0.075 ± 0.759	47.0
	12	13	0.271 ± 0.857	39.3
1000 Hz	0	15	0.140 ± 0.673	44.4
	2	15	0.275 ± 0.687	39.2
	7	15	0.107 ± 0.698	45.7
	12	13	0.271 ± 0.803	39.3
2000 Hz	0	15	-0.121 ± 0.554	54.8
	2	15	-0.129 ± 0.709	55.1
	7	15	-0.096 ± 0.701	53.8
	12	13	0.086 ± 0.795	46.6
3000 Hz	0	15	0.445 ± 1.067	32.8
	2	15	0.618 ± 1.088	26.8
	7	15	0.462 ± 0.994	32.2
	12	13	0.547 ± 1.165	29.2
4000 Hz	0	15	0.407 ± 1.090	34.2
	2	15	0.452 ± 1.125	32.6
	7	15	0.326 ± 1.057	37.2
	12	13	0.508 ± 1.017	30.6
6000 Hz	0	15	0.430 ± 1.035	33.4
	2	15	0.463 ± 1.043	32.2
	7	15	0.446 ± 0.972	32.8
	12	13	0.581 ± 0.946	28.1

Table B-24 Time trends of Standardized AHT at each frequency: Refinery 6, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 6, Age < 35 yrs				
Scores				
500 Hz	0	6	1.193 ± 0.141	11.6
	2	3	1.654 ± 0.416	4.9
	7	9	1.430 ± 0.400	7.6
	12	9	1.135 ± 0.703	12.8
1000 Hz	0	6	1.235 ± 0.370	10.9
	2	3	1.490 ± 0.832	6.8
	7	9	1.180 ± 0.519	11.9
	12	9	1.084 ± 0.766	13.9
2000 Hz	0	6	0.739 ± 0.280	23.0
	2	3	0.501 ± 0.674	30.8
	7	9	0.573 ± 0.355	28.3
	12	9	0.698 ± 0.438	24.2
3000 Hz	0	6	0.901 ± 0.519	18.4
	2	3	0.414 ± 0.227	34.0
	7	9	0.819 ± 0.508	20.7
	12	9	0.497 ± 0.431	31.0
4000 Hz	0	6	0.718 ± 0.296	23.6
	2	3	0.651 ± 0.198	25.7
	7	9	0.740 ± 0.536	23.0
	12	9	0.732 ± 0.561	23.2
6000 Hz	0	6	1.407 ± 0.451	8.0
	2	3	0.725 ± 0.602	23.4
	7	9	0.733 ± 0.501	23.2
	12	9	0.474 ± 0.440	31.8
Corrected Scores				
500 Hz	0	6	0.593 ± 0.102	27.6
	2	3	0.910 ± 0.283	18.1
	7	9	0.765 ± 0.265	22.2
	12	9	0.585 ± 0.492	27.9
1000 Hz	0	6	0.624 ± 0.253	26.6
	2	3	0.804 ± 0.570	21.1
	7	9	0.601 ± 0.354	27.4
	12	9	0.555 ± 0.536	28.9
2000 Hz	0	6	0.345 ± 0.196	36.5
	2	3	0.158 ± 0.518	43.7
	7	9	0.231 ± 0.275	40.9
	12	9	0.348 ± 0.324	36.4
3000 Hz	0	6	0.494 ± 0.378	31.1
	2	3	0.143 ± 0.169	44.3
	7	9	0.455 ± 0.384	32.5
	12	9	0.235 ± 0.334	40.7
4000 Hz	0	6	0.387 ± 0.223	35.0
	2	3	0.349 ± 0.176	36.4
	7	9	0.427 ± 0.416	33.5
	12	9	0.451 ± 0.456	32.6
6000 Hz	0	6	0.951 ± 0.340	17.1
	2	3	0.425 ± 0.446	33.5
	7	9	0.447 ± 0.390	32.7
	12	9	0.260 ± 0.340	39.7

Table B-25 Time trends of Standardized AHT at each frequency: Refinery 6, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 6, Age > 35 yrs				
Scores				
500 Hz	0	12	1.048 ± 0.338	14.7
	2	15	1.133 ± 0.758	12.9
	7	17	1.122 ± 0.962	13.1
	12	18	1.107 ± 0.748	13.4
1000 Hz	0	12	0.907 ± 0.495	18.2
	2	15	0.876 ± 0.535	19.0
	7	17	0.874 ± 0.906	19.1
	12	18	0.895 ± 0.579	18.5
2000 Hz	0	12	0.711 ± 0.649	23.9
	2	15	0.658 ± 0.807	25.5
	7	17	0.634 ± 1.002	26.3
	12	18	0.772 ± 0.737	22.0
3000 Hz	0	12	1.335 ± 1.380	9.1
	2	15	1.073 ± 1.033	14.2
	7	17	0.874 ± 0.845	19.1
	12	18	0.940 ± 0.908	17.3
4000 Hz	0	12	1.073 ± 1.119	14.2
	2	15	0.957 ± 0.741	16.9
	7	17	0.878 ± 0.743	19.0
	12	18	0.736 ± 0.761	23.1
6000 Hz	0	12	1.242 ± 0.963	10.7
	2	15	0.696 ± 0.477	24.3
	7	17	0.854 ± 0.737	19.6
	12	18	0.581 ± 0.680	28.1
Corrected Scores				
500 Hz	0	12	0.525 ± 0.233	30.0
	2	15	0.598 ± 0.530	27.5
	7	17	0.584 ± 0.691	27.9
	12	18	0.593 ± 0.559	27.7
1000 Hz	0	12	0.432 ± 0.341	33.3
	2	15	0.421 ± 0.392	33.7
	7	17	0.415 ± 0.667	33.9
	12	18	0.457 ± 0.427	32.4
2000 Hz	0	12	0.352 ± 0.504	36.3
	2	15	0.324 ± 0.628	37.3
	7	17	0.301 ± 0.791	38.2
	12	18	0.438 ± 0.588	33.1
3000 Hz	0	12	0.886 ± 1.097	18.8
	2	15	0.709 ± 0.830	23.9
	7	17	0.549 ± 0.680	29.1
	12	18	0.631 ± 0.753	26.4
4000 Hz	0	12	0.715 ± 0.925	23.7
	2	15	0.653 ± 0.619	25.7
	7	17	0.594 ± 0.616	27.6
	12	18	0.500 ± 0.655	30.9
6000 Hz	0	12	0.892 ± 0.801	18.6
	2	15	0.468 ± 0.405	32.0
	7	17	0.596 ± 0.627	27.6
	12	18	0.391 ± 0.589	34.8

Table B-26 Time trends of Standardized AHT at each frequency: Refinery 7, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 7, Age < 35 yrs				
Scores				
500 Hz	0	184	0.783 ± 0.736	21.7
	2	183	0.605 ± 0.692	27.3
	7	184	0.570 ± 0.720	28.4
	12	180	0.528 ± 0.809	29.9
1000 Hz	0	184	0.678 ± 0.815	24.9
	2	183	0.522 ± 0.779	30.1
	7	184	0.451 ± 0.736	32.6
	12	180	0.450 ± 0.821	32.7
2000 Hz	0	184	0.503 ± 0.775	30.8
	2	183	0.348 ± 0.715	36.4
	7	184	0.220 ± 0.721	41.3
	12	180	0.109 ± 0.716	45.7
3000 Hz	0	134	0.624 ± 0.823	26.6
	2	181	0.497 ± 0.809	30.9
	7	184	0.435 ± 0.802	33.2
	12	180	0.278 ± 0.830	39.1
4000 Hz	0	183	0.759 ± 0.943	22.4
	2	183	0.590 ± 0.960	27.8
	7	184	0.473 ± 0.946	31.8
	12	180	0.248 ± 0.928	40.2
6000 Hz	0	172	1.037 ± 0.892	15.0
	2	182	0.925 ± 0.860	17.8
	7	184	0.931 ± 0.933	17.6
	12	179	0.929 ± 0.940	17.6
Corrected Scores				
500 Hz	0	184	0.293 ± 0.519	38.5
	2	183	0.170 ± 0.495	43.3
	7	184	0.160 ± 0.520	43.6
	12	180	0.137 ± 0.594	44.5
1000 Hz	0	184	0.213 ± 0.579	41.6
	2	183	0.109 ± 0.556	45.7
	7	184	0.076 ± 0.535	47.0
	12	180	0.084 ± 0.603	46.6
2000 Hz	0	184	0.141 ± 0.576	44.4
	2	183	0.029 ± 0.541	48.8
	7	184	-0.056 ± 0.560	52.2
	12	180	-0.133 ± 0.571	55.3
3000 Hz	0	134	0.264 ± 0.623	39.6
	2	181	0.174 ± 0.625	43.1
	7	184	0.146 ± 0.638	44.2
	12	180	0.035 ± 0.681	48.6
4000 Hz	0	183	0.395 ± 0.728	34.6
	2	183	0.271 ± 0.754	39.3
	7	184	0.198 ± 0.764	42.1
	12	180	0.032 ± 0.774	48.7
6000 Hz	0	172	0.647 ± 0.701	25.9
	2	182	0.572 ± 0.679	28.4
	7	184	0.602 ± 0.753	27.4
	12	179	0.627 ± 0.769	26.5

Table B-27 Time trends of Standardized AHT at each frequency: Refinery 7, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 7, Age > 35 yrs				
Scores				
500 Hz	0	67	0.629 ± 0.756	26.5
	2	66	0.498 ± 0.792	30.9
	7	67	0.488 ± 0.789	31.3
	12	63	0.421 ± 0.853	33.7
1000 Hz	0	67	0.598 ± 0.704	27.5
	2	66	0.395 ± 0.708	34.6
	7	67	0.412 ± 0.852	34.0
	12	63	0.424 ± 0.842	33.6
2000 Hz	0	67	0.413 ± 0.835	34.0
	2	66	0.291 ± 0.780	38.6
	7	67	0.187 ± 0.886	42.6
	12	63	0.144 ± 0.829	44.3
3000 Hz	0	44	0.667 ± 0.955	25.2
	2	64	0.576 ± 1.128	28.2
	7	66	0.424 ± 1.164	33.6
	12	63	0.342 ± 1.051	36.6
4000 Hz	0	67	0.862 ± 1.076	19.4
	2	66	0.597 ± 1.122	27.5
	7	67	0.465 ± 1.076	32.1
	12	63	0.252 ± 0.970	40.0
6000 Hz	0	66	0.957 ± 1.091	16.9
	2	66	0.773 ± 1.031	22.0
	7	67	0.765 ± 0.964	22.2
	12	63	0.722 ± 0.976	23.5
Corrected Scores				
500 Hz	0	67	0.213 ± 0.546	41.6
	2	66	0.126 ± 0.579	45.0
	7	67	0.132 ± 0.585	44.7
	12	63	0.092 ± 0.651	46.3
1000 Hz	0	67	0.200 ± 0.510	42.1
	2	66	0.058 ± 0.531	47.7
	7	67	0.072 ± 0.643	47.1
	12	63	0.105 ± 0.643	45.8
2000 Hz	0	67	0.103 ± 0.656	45.9
	2	66	0.018 ± 0.620	49.3
	7	67	-0.057 ± 0.712	52.3
	12	63	-0.074 ± 0.680	52.9
3000 Hz	0	44	0.339 ± 0.765	36.7
	2	64	0.270 ± 0.907	39.3
	7	66	0.173 ± 0.963	43.1
	12	63	0.129 ± 0.892	44.9
4000 Hz	0	67	0.533 ± 0.865	29.7
	2	66	0.329 ± 0.927	37.1
	7	67	0.246 ± 0.914	40.3
	12	63	0.084 ± 0.846	46.6
6000 Hz	0	66	0.641 ± 0.894	26.1
	2	66	0.508 ± 0.861	30.6
	7	67	0.529 ± 0.824	29.8
	12	63	0.522 ± 0.846	30.1

Table B-28 Time trends of Standardized AHT at each frequency: Refinery 8, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 8, Age < 35 yrs				
Scores				
500 Hz	0	138	0.738 ± 0.833	23.0
	2	138	0.625 ± 0.763	26.6
	7	138	0.521 ± 0.722	30.1
	12	138	0.765 ± 0.957	22.2
1000 Hz	0	138	0.410 ± 0.714	34.1
	2	138	0.329 ± 0.642	37.1
	7	138	0.264 ± 0.702	39.6
	12	138	0.416 ± 0.922	33.9
2000 Hz	0	138	0.506 ± 0.791	30.6
	2	138	0.459 ± 0.781	32.3
	7	138	0.317 ± 0.859	37.6
	12	138	-0.025 ± 1.041	51.0
3000 Hz	0	0		
	2	0		
	7	13	0.670 ± 0.670	25.2
	12	123	0.303 ± 1.120	38.1
4000 Hz	0	138	0.751 ± 1.250	22.6
	2	138	0.772 ± 1.139	22.0
	7	138	0.668 ± 1.156	25.2
	12	138	0.498 ± 1.206	30.9
6000 Hz	0	0		
	2	0		
	7	14	1.057 ± 0.698	14.5
	12	122	0.925 ± 1.000	17.7
Corrected Scores				
500 Hz	0	138	0.250 ± 0.589	40.1
	2	138	0.183 ± 0.542	42.7
	7	138	0.113 ± 0.528	45.5
	12	138	0.302 ± 0.698	38.1
1000 Hz	0	138	0.016 ± 0.515	49.3
	2	138	-0.034 ± 0.469	51.3
	7	138	-0.077 ± 0.521	53.1
	12	138	0.049 ± 0.686	48.1
2000 Hz	0	138	0.145 ± 0.588	44.2
	2	138	0.117 ± 0.585	45.3
	7	138	0.009 ± 0.658	49.6
	12	138	-0.251 ± 0.827	59.9
3000 Hz	0	0		
	2	0		
	7	13	0.357 ± 0.520	36.0
	12	123	0.049 ± 0.892	48.0
4000 Hz	0	138	0.382 ± 0.950	35.1
	2	138	0.415 ± 0.877	33.9
	7	138	0.349 ± 0.909	36.4
	12	138	0.236 ± 0.985	40.7
6000 Hz	0	0		
	2	0		
	7	14	0.721 ± 0.554	23.5
	12	122	0.626 ± 0.820	26.6

Table B-29 Time trends of Standardized AHT at each frequency: Refinery 8, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 8, Age > 35 yrs				
Scores				
500 Hz	0	55	0.570 ± 0.878	28.4
	2	55	0.394 ± 0.634	34.7
	7	55	0.367 ± 0.692	35.7
	12	55	0.667 ± 0.979	25.2
1000 Hz	0	55	0.352 ± 0.758	36.2
	2	55	0.173 ± 0.649	43.1
	7	55	0.270 ± 0.733	39.4
	12	55	0.309 ± 0.961	37.9
2000 Hz	0	55	0.279 ± 0.934	39.0
	2	55	0.230 ± 0.771	40.9
	7	55	0.015 ± 0.746	49.4
	12	55	-0.257 ± 1.011	60.2
3000 Hz	0	1	0.112 ± 0.000	45.5
	2	0		
	7	12	0.104 ± 0.993	45.8
	12	54	0.027 ± 0.992	48.9
4000 Hz	0	55	0.489 ± 1.001	31.2
	2	55	0.468 ± 0.884	32.0
	7	55	0.294 ± 0.905	38.5
	12	55	0.184 ± 0.951	42.7
6000 Hz	0	0		
	2	0		
	7	12	0.692 ± 0.740	24.4
	12	54	0.595 ± 0.655	27.6
Corrected Scores				
500 Hz	0	55	0.154 ± 0.637	43.9
	2	55	0.037 ± 0.477	48.5
	7	55	0.027 ± 0.527	48.9
	12	55	0.256 ± 0.743	39.9
1000 Hz	0	55	-0.008 ± 0.565	50.3
	2	55	-0.130 ± 0.492	55.2
	7	55	-0.046 ± 0.567	51.8
	12	55	-0.009 ± 0.746	50.4
2000 Hz	0	55	-0.013 ± 0.724	50.5
	2	55	-0.042 ± 0.611	51.7
	7	55	-0.201 ± 0.610	58.0
	12	55	-0.420 ± 0.839	66.3
3000 Hz	0	1	-0.074 ± 0.000	52.9
	2	0		
	7	12	-0.088 ± 0.831	53.5
	12	54	-0.149 ± 0.842	55.9
4000 Hz	0	55	0.216 ± 0.818	41.4
	2	55	0.211 ± 0.730	41.6
	7	55	0.088 ± 0.765	46.5
	12	55	0.014 ± 0.829	49.4
6000 Hz	0	0		
	2	0		
	7	12	0.465 ± 0.637	32.1
	12	54	0.401 ± 0.570	34.4

Table B-30 Time trends of Standardized AHT at each frequency: Refinery 9, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 9, Age < 35 yrs				
Scores				
500 Hz	0	9	1.273 ± 1.750	10.1
	2	9	1.581 ± 2.245	5.7
	7	9	1.877 ± 2.267	3.0
	12	9	1.383 ± 2.563	8.3
1000 Hz	0	9	0.874 ± 1.239	19.1
	2	9	1.275 ± 1.833	10.1
	7	9	1.434 ± 1.729	7.6
	12	9	1.422 ± 1.703	7.8
2000 Hz	0	9	0.834 ± 1.023	20.2
	2	9	0.884 ± 1.120	18.8
	7	9	0.950 ± 0.998	17.1
	12	9	0.968 ± 0.980	16.7
3000 Hz	0	9	0.806 ± 0.694	21.0
	2	9	0.970 ± 0.869	16.6
	7	9	0.608 ± 0.919	27.1
	12	9	0.608 ± 1.048	27.2
4000 Hz	0	9	0.508 ± 1.027	30.6
	2	9	0.518 ± 0.908	30.2
	7	9	0.448 ± 1.053	32.7
	12	9	0.430 ± 1.021	33.4
6000 Hz	0	9	0.528 ± 0.918	29.9
	2	9	0.805 ± 1.233	21.0
	7	9	0.227 ± 1.057	41.0
	12	9	0.498 ± 1.004	30.9
Corrected Scores				
500 Hz	0	9	0.628 ± 1.174	26.5
	2	9	0.839 ± 1.507	20.1
	7	9	1.062 ± 1.518	14.4
	12	9	0.694 ± 1.778	24.4
1000 Hz	0	9	0.354 ± 0.865	36.1
	2	9	0.633 ± 1.245	26.3
	7	9	0.751 ± 1.186	22.6
	12	9	0.761 ± 1.167	22.3
2000 Hz	0	9	0.384 ± 0.763	35.0
	2	9	0.417 ± 0.835	33.8
	7	9	0.488 ± 0.741	31.3
	12	9	0.522 ± 0.747	30.1
3000 Hz	0	9	0.412 ± 0.514	34.0
	2	9	0.549 ± 0.630	29.2
	7	9	0.264 ± 0.710	39.6
	12	9	0.278 ± 0.803	39.1
4000 Hz	0	9	0.183 ± 0.791	42.7
	2	9	0.214 ± 0.700	41.5
	7	9	0.149 ± 0.824	44.1
	12	9	0.164 ± 0.803	43.5
6000 Hz	0	9	0.233 ± 0.732	40.8
	2	9	0.460 ± 0.990	32.3
	7	9	0.003 ± 0.865	49.9
	12	9	0.234 ± 0.810	40.8

Table B-31 Time trends of Standardized AHT at each frequency: Refinery 9, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 9, Age > 35 yrs				
Scores				
500 Hz	0	36	0.584 ± 1.047	28.0
	2	36	0.684 ± 0.973	24.7
	7	36	0.967 ± 0.952	16.7
	12	36	0.717 ± 0.955	23.7
1000 Hz	0	36	0.537 ± 1.039	29.6
	2	36	0.778 ± 0.968	21.8
	7	36	0.595 ± 0.994	27.6
	12	36	0.508 ± 1.244	30.6
2000 Hz	0	36	0.253 ± 1.133	40.0
	2	36	0.478 ± 1.043	31.6
	7	36	0.140 ± 1.003	44.4
	12	36	0.294 ± 1.002	38.4
3000 Hz	0	36	0.683 ± 0.995	24.7
	2	36	0.802 ± 0.939	21.1
	7	36	0.682 ± 1.126	24.8
	12	36	0.593 ± 1.048	27.6
4000 Hz	0	36	0.758 ± 1.106	22.4
	2	36	0.795 ± 0.979	21.3
	7	36	0.664 ± 0.955	25.3
	12	36	0.572 ± 0.988	28.4
6000 Hz	0	36	1.058 ± 0.890	14.5
	2	36	1.006 ± 0.881	15.7
	7	36	0.837 ± 0.859	20.1
	12	36	0.760 ± 0.782	22.4
Corrected Scores				
500 Hz	0	36	0.174 ± 0.781	43.1
	2	36	0.261 ± 0.723	39.7
	7	36	0.495 ± 0.694	31.0
	12	36	0.311 ± 0.722	37.8
1000 Hz	0	36	0.157 ± 0.763	43.8
	2	36	0.347 ± 0.705	36.4
	7	36	0.213 ± 0.748	41.5
	12	36	0.152 ± 0.940	44.0
2000 Hz	0	36	-0.025 ± 0.894	51.0
	2	36	0.169 ± 0.819	43.3
	7	36	-0.092 ± 0.816	53.6
	12	36	0.043 ± 0.810	48.3
3000 Hz	0	36	0.373 ± 0.797	35.4
	2	36	0.486 ± 0.751	31.3
	7	36	0.392 ± 0.919	34.8
	12	36	0.335 ± 0.870	36.9
4000 Hz	0	36	0.466 ± 0.913	32.1
	2	36	0.511 ± 0.815	30.5
	7	36	0.417 ± 0.811	33.8
	12	36	0.354 ± 0.849	36.2
6000 Hz	0	36	0.754 ± 0.735	22.6
	2	36	0.726 ± 0.740	23.4
	7	36	0.594 ± 0.735	27.6
	12	36	0.546 ± 0.671	29.3

Table B-32 Time trends of Standardized AHT at each frequency: Refinery 10, age group under 35 yrs at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 10, Age < 35 yrs				
Scores				
500 Hz	0	0		
	2	0		
	7	0		
	12	0		
1000 Hz	0	115	2.564 ± 0.840	0.5
	2	115	2.531 ± 0.862	0.6
	7	115	1.499 ± 0.731	6.7
	12	115	1.290 ± 0.774	9.8
2000 Hz	0	115	1.730 ± 0.826	4.2
	2	115	1.730 ± 0.789	4.2
	7	115	0.985 ± 0.682	16.2
	12	115	0.787 ± 0.786	21.6
3000 Hz	0	115	1.613 ± 0.830	5.3
	2	115	1.518 ± 0.832	6.5
	7	115	0.997 ± 0.772	15.9
	12	115	0.789 ± 0.956	21.5
4000 Hz	0	115	1.425 ± 0.798	7.7
	2	115	1.281 ± 0.778	10.0
	7	115	1.083 ± 0.872	13.9
	12	115	0.756 ± 0.870	22.5
6000 Hz	0	115	1.920 ± 0.912	2.7
	2	115	1.753 ± 0.850	4.0
	7	115	1.394 ± 0.925	8.2
	12	115	1.036 ± 0.807	15.0
Corrected Scores				
500 Hz	0	0		
	2	0		
	7	0		
	12	0		
1000 Hz	0	115	1.509 ± 0.564	6.6
	2	115	1.491 ± 0.581	6.8
	7	115	0.812 ± 0.501	20.8
	12	115	0.686 ± 0.540	24.6
2000 Hz	0	115	1.042 ± 0.586	14.9
	2	115	1.047 ± 0.563	14.7
	7	115	0.531 ± 0.494	29.8
	12	115	0.391 ± 0.596	34.8
3000 Hz	0	115	1.005 ± 0.608	15.7
	2	115	0.940 ± 0.610	17.4
	7	115	0.578 ± 0.579	28.2
	12	115	0.433 ± 0.749	33.3
4000 Hz	0	115	0.903 ± 0.595	18.3
	2	115	0.802 ± 0.587	21.1
	7	115	0.678 ± 0.672	24.9
	12	115	0.437 ± 0.700	33.1
6000 Hz	0	115	1.331 ± 0.696	9.2
	2	115	1.210 ± 0.654	11.3
	7	115	0.959 ± 0.728	16.9
	12	115	0.698 ± 0.654	24.3

Table B-33 Time trends of Standardized AHT at each frequency: Refinery 10, age group 35 yrs and older at baseline

Frequency	Time (yrs)	Workers (n)	Mean ± SD (standard: no unit)	Fractile (%)
Refinery no. 10, Age > 35 yrs				
Scores				
500 Hz	0	0		
	2	0		
	7	0		
	12	0		
1000 Hz	0	138	2.349 ± 0.869	0.9
	2	138	2.179 ± 0.895	1.5
	7	138	1.558 ± 0.771	6.0
	12	138	1.372 ± 0.846	8.5
2000 Hz	0	138	1.417 ± 0.782	7.8
	2	138	1.378 ± 0.827	8.4
	7	138	0.814 ± 0.782	20.8
	12	138	0.798 ± 0.862	21.2
3000 Hz	0	138	1.246 ± 0.902	10.6
	2	138	1.143 ± 0.910	12.6
	7	138	0.829 ± 0.974	20.4
	12	138	0.707 ± 0.962	24.0
4000 Hz	0	138	1.078 ± 0.931	14.1
	2	138	0.932 ± 0.819	17.6
	7	138	0.813 ± 0.894	20.8
	12	138	0.629 ± 0.861	26.5
6000 Hz	0	138	1.340 ± 0.904	9.0
	2	138	1.242 ± 0.800	10.7
	7	138	0.951 ± 0.786	17.1
	12	138	0.662 ± 0.850	25.4
Corrected Scores				
500 Hz	0	0		
	2	0		
	7	0		
	12	0		
1000 Hz	0	138	1.438 ± 0.605	7.5
	2	138	1.327 ± 0.627	9.2
	7	138	0.917 ± 0.550	18.0
	12	138	0.806 ± 0.616	21.0
2000 Hz	0	138	0.884 ± 0.583	18.8
	2	138	0.863 ± 0.618	19.4
	7	138	0.456 ± 0.601	32.4
	12	138	0.459 ± 0.682	32.3
3000 Hz	0	138	0.816 ± 0.703	20.7
	2	138	0.739 ± 0.719	23.0
	7	138	0.513 ± 0.791	30.4
	12	138	0.435 ± 0.802	33.2
4000 Hz	0	138	0.724 ± 0.749	23.4
	2	138	0.613 ± 0.665	27.0
	7	138	0.540 ± 0.746	29.5
	12	138	0.409 ± 0.737	34.1
6000 Hz	0	138	0.973 ± 0.739	16.5
	2	138	0.903 ± 0.658	18.3
	7	138	0.687 ± 0.665	24.6
	12	138	0.458 ± 0.738	32.4