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RESEARCH REPORT

Prevalence of Middle Ear Disorders in Coal Miners

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

PREVALENCE OF MIDDLE EAR DISORDERS

IN COAL MINERS

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ABSTRACT

Results are presented from a study of the prevalence of middle and external ear disorders in coal miners who work underground. The study followed from an earlier NIOSH report (1976) that indicated a possibly large number of otoscopic abnormalities in this population of workers. Otoscopic examinations, pure tone air- and bone-conduction audiometry tests, and impedance tests were administered to 350 underground miners and 150 industrial workers not associated with mining. The study was conducted completely within a hospital otolaryngology/audiology clinic setting.

Results of the investigation showed a highly similar prevalence of middle ear and ear canal abnormalities in the miner group and the control group (19 percent). Middle ear abnormalities observed in the miners were judged by the examining otolaryngologists to have preceded their experience in the mines and were not related solely to underground noise exposure or coal dust. Nearly half of the subjects who had an air-bone gap had no middle ear abnormality observable by otoscopic examination. There was substantial agreement between the finding of abnormal otoscopy and abnormal tympanometry. By itself, acoustic reflex was not useful in identifying middle ear disorders, since this reflex may be absent for other reasons, including presence of severe sensorineural hearing loss.

The results show a higher percentage of middle and external ear abnormalities among control subjects than would have been predicted by previous NIOSH studies (NIOSH 1973). Possible reasons for these findings, including differences among examiners, criteria, and subject selection, are discussed.

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INTRODUCTION

In recent years, extensive research has been devoted to studying and identifying the hazardous effects of occupational noise exposure on the hearing of coal miners. The preliminary results of these efforts indicate the rates of hearing loss among coal miners and basic data necessary to develop standards for coal mine noise. During one of these studies (NIOSH 1976), the survey team noted a large number of coal miners with otoscopic abnormalities. These survey findings included what appeared to be a large number of miners with moderate to severe middle ear abnormalities, such as inflamed ear drums, perforated ear drums, apparent otitis media, impacted wax, and even suspected cholesteatoma. Approximately 25 percent of the 1,300 miners surveyed had observable aural abnormalities, including 7 percent with impacted cerumen. These preliminary data suggest an unusually high incidence of otoscopically observable ear abnormalities among coal miners. An earlier study of workers in non-mine related industries excluded only about 8 percent of prospective subjects with apparent middle or external ear abnormalities, including 1 percent with severely impacted cerumen (NIOSH 1973).

The varying findings from these two studies indicated a need to evaluate the prevalence of middle and external ear disorders in coal miners and to investigate the effects that these disorders have on hearing. These data are necessary for the interpretation of hearing data obtained on unscreened miners (NIOSH 1976). A review of the literature indicated that there were no data available to supply the required information on the prevalence and effects of middle ear disorders in coal miners. The present study was designed to answer these questions.

PROCEDURES

SUBJECTS

Five hundred male subjects were tested; 350 of these were underground coal miners and 150 were a control group of non-miners who had not been exposed to underground coal mining and coal dust. An attempt was made to select an equal number of subjects in each of five age groups. The actual number of subjects in each age group is shown in Table 1.

Table 1. Distribution of subjects by age group (years).

	Age Group					
	I	I	III	IV	V	Total
Age range	16-25	26-35	36-45	46-55	56-65	
Miners	86	89	56	60	59	350
Controls	7	13	17	69	44	150

Coal Miners

Subjects for the study came from 12 coal companies in three states, including 10 counties in Pennsylvania as shown in Table 2.

Table 2. Sample sizes of miners selected by geographical location.

Location	Total Number Of Miners	Number of Miners by Company # 1	2	3	4	5	6	7	8	9	10	11	12
West Virginia. 51		29						22					
Ohio 54			54										
Pennsylvania (counties)													
Allegheny. 18		11									7		
Armstrong. 4										3		1	
Butler 3							3						
Cambria. 38								2	36				
Fayette. 1						1							
Greene 43					17	17							9
Indiana. 47				32						15			
Somerset 4		2							2				
Washington 82		24			16	12	26				4		
Westmoreland 5								1			4		
Totals	350	66	54	32	33	30	29	25	38	18	15	1	9

In order to recruit participants, union and management officials were contacted to obtain the names and addresses of miners. Three hundred and fifty miners and twice as many alternates were randomly selected for each of the five age groups. An effort was made to select an equal number of names for each geographic area (Appendix A). The alternates were selected so that names would be readily available if the first randomly selected miner could not be tested in the study because, for example, he did not meet the age requirements, was no longer employed by the mine, or was unwilling to participate.

Each prospective subject received a letter approved by the management of his company and the medical director of the United Mine Workers Welfare and Retirement Fund. The letter described the purpose of the study, included a consent form that provided details of the procedures and any potential hazards, and assured the subject of his right to withdraw consent at any time.

Controls

Names of subjects for the control group were obtained from 15 companies, none of which was associated with the mining industry. These companies were selected to obtain a control group with socio-economic factors and noise exposures similar to those of the miners. These companies were located in Allegheny, Butler, Washington, and Westmoreland counties of Pennsylvania. The types of industries employing the members of the control group, along with the noise sources to which those workers were exposed, are shown in Table 3.

Control subjects were randomly selected by the same procedure used to select miners, except that the specific geographical location of each company was not taken into account.

Non-miners also received a letter modified so that terminology that related to mining was replaced with terminology appropriate to the subject's own work.

All subjects were reimbursed for their travel and expenses. Miners were allowed time off from their jobs and they were all paid a participation allowance by the Keystone Bituminous Coal Operators Association of Pennsylvania to recompense for lost wages. Non-miners were not afforded a participation allowance nor were they allowed time off from their jobs to participate. Those who participated included only second shift workers (3-11 p.m.) who were tested before they went to work or on a week-day off from work.

Because the subjects were not compelled to participate in this study, the data are open to interpretation with regard to the possible self-selection of subjects. Each time a randomly selected subject chose <u>not</u> to participate, for whatever reason, the chance aspect of the subject selection grew smaller. These influences occurred in both groups, but they probably occurred more frequently among the controls because they were not paid for their participation. It may be assumed that control subjects participated more for reasons of self-interest than for financial reward.

Table 3. Sample sizes and sources of noise exposure for control group.

Noise Source	Number of Companies	Number of Subjects Tested (Total N=150)	Type of Industries
Punch press and metal fabrication	1	30	Office furniture manufacturer
Folding machines	1	4	Paper products manufacturer
Chipping and grinding	4	8	Foundries
Maintenance shop	1	4	Steel mill
Rolling mills and blast furnaces	3	43	Steel mill
Injection bolting machine	1	53	Steel product manufacturer
Filling cylinders	1	3	Bottled gas distributors
Machinery (generators)	2	2	Electrical power manufacturer; brake manufacturer
Forming machines	1	3	Vehicular body manufacturer

EQUIPMENT

This study was carried out at the Eye and Ear Hospital of Pittsburgh, Pennsylvania. Audiological testing was carried out in an IAC Model 1200 sound booth that met ANSI criteria for permissible ambient noise during audiometric testing (ANSI 1977).

Air and bone conduction thresholds, speech reception thresholds, and speech discrimination tests were conducted with a Grason-Stadler Model 1701 diagnostic audiometer through TDH-39 earphones with MX 41/AR cushions. A Grason-Stadler G-S 1720 otoadmittance meter was used for tympanometry, and a Model G-S 1721 was used for acoustic reflex measurements.

The otolaryngologist used standard instrumentation for otological examinations. Microscopic examination of the ear was done with a Zeiss operating microscope.

Audiometric equipment was calibrated with a Bruel and Kjaer precision sound level meter and octave filter set Models 2203/1613, which uses a one-inch condenser microphone, type 4132. Other calibration equipment included a Bruel

and Kjaer audio-frequency spectrometer and coupler Models 2113/4151 and a piston microphone kit Model 4220. Electroacoustic calibration was carried out at least once a week by a member of the technical staff. Standard procedures for electroacoustic calibration were used (ANSI 1970, ANSI 1973). In addition, a physical check of the equipment was performed each day by the audiologist doing the testing.

EXAMINATION PROCEDURES

Questionnaire

A detailed questionnaire soliciting information on each subject's job history, military service, non-occupational noise exposure, and relevant medical history was filled out by all subjects. A copy of this form is provided as Appendix B. Question 10 of the form was completed by the physician who conducted the otolaryngological examination. The examining physicians were blind to the group identity of each miner or control subject.

Pure Tone Audiogram

Air Conduction Thresholds were obtained at the following frequencies in the order listed: 1000, 2000, 3000, 4000, 6000, 8000, repeat 1000, 500, and 250 Hz. Thresholds were obtained in 5-decibel (dB) steps by standard audiometric procedures (ANSI 1978). Narrow band masking was used to mask the better ear if there was a difference of 35 dB or more between ears at any frequency.

Bone conduction was tested at 500, 1000, 2000, and 4000 Hz with a mastoid placement of the bone oscillator. Narrow band noise was always used to mask the non-test ear during bone conduction tests.

Speech Audiometry

Speech Reception Thresholds (SRT) were obtained from live voice presentations of spondaic words. Hirsh recordings of the CID-W-22 phonetically balanced (PB) word lists were used for speech discrimination tests. The PB words were presented at 40 dB above hearing threshold (40 dB Sensation Level {SL}).

Immittance Tests

Two measures were obtained with the otoadmittance meter: tympanometry and acoustic reflex. Tympanometry was obtained by means of 220 and 660 Hz probe tones for both Conductance (G) and Susceptance (B). Tympanometric peak pressures were measured from the maximum peak of the tympanogram. Acoustic susceptance and conductance in millimhos (mmho) were derived from the amplitude of the tympanogram.

Contralateral acoustic reflex thresholds were obtained from pure tones of 500, 1000, and 2000 Hz, a broadband noise, and a 2600 Hz low pass and 2600 Hz high pass filtered noise. Acoustic reflexes were obtained for the 220 Hz probe tone only.

Otolaryngological Examination

The otolaryngologist examined both ears of each subject, using pneumatic and microscopic otoscopy. During the otological examination the status of the external auditory canal and the middle ear was noted. The condition of the tympanic membrane, the mobility of the middle ear system, the presence or absence of fluid, and the color of the tympanic membrane, among other factors, were recorded on the questionnaire. The otolaryngologist also examined the nose and throat of each subject and noted any abnormality. At the time of his examination the otolaryngologist was unaware of the results from the audiological tests.

Reliability Study

Photographs of the tympanic membranes of 35 miners were taken at the time of the otological examinations. These photographs were reviewed later. In addition, independent otoscopic examinations of these 35 miners were performed by two physicians in order to determine interobserver reliability. The reliability study was conducted so that a second physician would be able to examine the subjects if the physician who normally conducted the examination was not present. The data (Appendix C) show a high degree of interobserver reliability between physicians.

ANALYSIS OF TEST FINDINGS

Tympanograms were assigned to one of four categories according to the shape of the tympanogram and middle ear pressure. Tympanograms indicating tympanometric peak pressures from -50 to +89 mm water were considered as the normal base. Those with tympanometric peak pressures equal to or less than -51 mm water, equal to or greater than +90 mm water, or <u>flat</u> tympanograms without a discernible peak were considered abnormal.

The normal ranges used for evaluating acoustic susceptance and conductance were as follows (Grason-Stadler 1975):

<u>Conductance (Ga)</u>

220 Hz	0 through 0.35 mmho
660 Hz	1.0 through 4.0 mmho

<u>Susceptance (Ba)</u>

220 Hz	0.3 through 0.75 mmho
660 Hz	0.85 through 2.50 mmho

For purposes of this study, an air-bone gap of 10 dB or greater at 500 or 1000 Hz was considered to be of clinical interest, indicating the possibility of middle ear pathology.

External and middle ear findings noted on otoscopic examination were put in order on the basis of their presumed influence on hearing. The findings were ranked as follows:

Abnormal middle ear/mastoid (great effect on hearing)

1. radical mastoidectomy
2. ossicular discontinuity
3. cholesteatoma
4. modified radical mastoidectomy
5. mastoidectomy with tympanoplasty
6. fenestration
7. retracted, hypomobile "transformer mechanism"
8. stapedectomy

Abnormal tympanic membrane (moderate effect on hearing)

1. perforation
2. healed perforation and retraction
3. tympanosclerosis
4. inflamed thickened tympanic membrane

Abnormal canal (little effect on hearing)

1. pseudomembrane
2. external otitis
3. osteoma
4. foreign body

RESULTS

PRESENTATION OF HEARING LEVELS

Air conduction hearing thresholds of coal miners and control subjects are shown for eight frequencies in each of the five age groups in Tables 4 through 8. The tables include threshold median, mean, and mean deviations for right ears and left ears in each group.

When there was no response to the tone at the maximum output of the audiometer, the total number of responses averaged at that frequency was reduced to reflect actual number of thresholds obtained. No arbitrary value was assigned to a "no response." The data in Table 9 summarize the number of "no responses" by ear and frequency for subjects in each age group.

In Table 4, a comparison of the mean thresholds and deviations around the mean shows the effect of the small number of control subjects in the youngest age group. Two of the seven control subjects had a severe loss of hearing in the left ear at 3000, 4000, 6000, and 8000 Hz. The means and mean deviations reflect the severity of the hearing loss. While the number of control subjects in Age Groups II (26-35 yr) and III (36-45 yr) was substantially smaller than the number of experimental subjects, there is not the disparity of thresholds as found in Age Group I. In fact, the differences between mean thresholds of miner and control groups never exceeded 7.5 dB for any of the other age groups.

COMPARISON WITH PREVIOUS DATA

Figure 1 displays the median hearing levels of miners in this study compared with median hearing levels of all working miners studied previously (NIOSH 1976). The data are separated into five age groups, with median hearing level for "better ear" as the parameter. (The term "better ear" refers to the use of the better hearing level [left or right] at each test frequency.) The two studies show comparable findings at each age level.

BONE CONDUCTION (AIR-BONE GAPS)

Results of air and bone conduction testing indicated that 9.4 percent of miners and 11.3 percent of control subjects had air-bone gaps equal to or greater than 10 dB at 500 or 1000 Hz. The otological findings of those subjects who showed air-bone gaps equal to or greater than 10 dB at 500 or 1000 Hz are listed in Table 10. Of 33 miners with air-bone gaps, 13 had normal otoscopic examinations, 4 had impacted cerumen, and 16 had middle ear abnormalities of various types. Of 17 control subjects, seven had normal otoscopic examinations, none had impacted cerumen, and 10 had observable middle ear abnormalities.

Table 4. Air conduction thresholds in dB hearing threshold level (HTL) for age group I (16-25 yrs).

Miners (N = 86) (Age Group I)	Frequency (Hz) 250	500	1000	2000	3000	4000	6000	8000
Medians								
LE	10	5	5	5	5	10	15	10
RE	5	5	5	5	5	10	10	5
Means								
LE	12.56	9.86	7.46	7.88	9.78	14.05	17.62	11.88
RE	7.24	6.66	4.07	3.20	5.21	8.22	9.45	8.40
Mean Dev.								
LE	5.55	5.15	5.04	5.65	10.03	14.65	12.53	12.49
RE	4.55	4.38	4.23	5.21	6.85	10.45	8.78	8.84
Controls (N = 7) (Age Group I)								
Medians								
LE	10	10	5	5	10	10	20	15
RE	5	5	5	5	10	15	20	15
Means								
LE	11.50	11.00	10.50	8.00	28.50	35.00	42.50	19.00
RE	7.50	7.50	7.00	6.50	14.00	14.00	16.50	18.50
Mean Dev.								
LE	9.64	3.29	7.36	5.43	21.50	28.57	31.79	27.00
RE	2.50	3.93	3.14	3.93	8.43	3.57	6.21	12.79

Table 5. Air conduction thresholds in dB hearing threshold level (HTL) for age group II (26-35 yrs).

Miners (N = 89) (Age Group II)	Frequency (Hz) 250	500	1000	2000	3000	4000	6000	8000
Medians								
LE	10	5	5	5	5	15	20	10
RE	10	5	5	5	5	15	20	10
Means								
LE	9.56	7.35	5.76	7.41	15.06	24.48	30.78	18.94
RE	7.82	6.40	6.85	6.22	10.86	21.78	26.52	18.48
Mean Dev.								
LE	4.79	4.61	4.01	6.30	12.00	17.36	18.67	15.30
RE	3.26	3.87	2.91	5.06	8.59	15.37	17.67	14.93
Controls (N = 13) (Age Group II)								
Medians								
LE	10	5	5	5	15	20	25	15
RE	5	5	10	10	10	10	20	10
Means								
LE	10.74	7.93	5.86	6.22	16.74	21.50	25.14	18.98
RE	10.12	8.12	9.12	8.14	11.22	16.34	24.55	19.00
Mean Dev.								
LE	4.36	3.69	3.27	3.74	10.40	13.73	12.46	10.52
RE	6.62	6.87	4.70	5.14	7.96	14.92	11.35	15.50

Table 6. Air conduction thresholds in dB hearing threshold level (HTL) for age group III (36-45 yrs).

Miners (N =56) (Age Group III)	Frequency (Hz)							
	250	500	1000	2000	3000	4000	6000	8000
Medians								
LE	10	10	5	5	20	40	35	25
RE	10	10	10	10	20	35	30	25
Means								
LE	11.52	10.54	10.71	14.82	33.21	45.09	41.00	34.43
RE	11.34	12.23	13.04	13.48	26.79	38.48	36.30	29.26
Mean Dev.								
LE	6.77	6.85	7.60	11.03	21.07	20.18	21.02	20.91
RE	7.32	7.39	7.29	10.24	17.33	18.32	16.40	19.12
Controls (N = 17) (Age Group III)								
Medians								
LE	5	10	10	10	15	30	35	20
RE	10	10	10	5	15	25	30	25
Means								
LE	13.82	17.35	15.29	21.47	28.53	37.46	36.47	31.18
RE	12.35	11.47	11.18	11.18	20.59	30.88	32.94	25.94
Mean Dev.								
LE	8.77	13.60	12.83	19.72	20.03	22.20	19.38	20.21
RE	7.16	7.02	5.05	10.94	14.36	16.23	15.81	13.91

Table 7. Air conduction thresholds in dB hearing threshold level (HTL) for age group IV (46-55 yrs).

Miners (N = 60) (Age Group IV)	Frequency (Hz)							
	250	500	1000	2000	3000	4000	6000	8000
Medians								
LE	10	10	10	20	40	50	45	40
RE	10	10	15	20	40	55	50	45
Means								
LE	12.41	11.50	13.25	22.08	42.08	52.03	49.33	40.89
RE	11.10	11.95	15.51	22.29	40.76	53.47	50.95	42.95
Mean Dev.								
LE	5.74	5.96	8.01	11.93	19.32	18.65	18.31	19.53
RE	5.31	5.84	7.22	10.73	18.60	18.14	18.43	19.11
Controls (N = 69) (Age Group IV)								
Medians								
LE	10	10	15	25	50	60	55	50
RE	10	15	15	25	45	55	55	50
Means								
LE	15.36	16.09	17.03	29.27	46.59	56.59	56.32	46.82
RE	16.47	16.47	19.26	26.47	43.98	55.37	51.33	43.75
Mean Dev.								
LE	8.25	8.97	9.29	15.89	16.02	12.97	16.15	14.83
RE	9.32	9.62	8.88	13.88	17.44	13.22	14.72	15.21

Table 8. Air conduction thresholds in dB hearing threshold level (HTL) for age group V (56-65 yrs).

Miners (N = 59) (Age Group V)	Frequency (Hz)							
	250	500	1000	2000	3000	4000	6000	8000
Medians								
LE	20	20	20	35	55	60	65	55
RE	20	20	20	25	45	55	60	55
Means								
LE	20.69	21.38	22.59	37.24	48.51	56.43	57.13	51.47
RE	17.15	17.50	21.46	30.09	44.05	53.88	55.27	49.39
Mean Dev.								
LE	11.60	12.86	13.65	17.22	17.09	14.06	15.70	16.21
RE	8.93	9.57	11.21	16.15	15.66	15.20	16.81	15.05
Controls (N = 44) (Age Group V)								
Medians								
LE	15	15	15	30	50	60	65	65
RE	15	15	15	30	50	60	60	65
Means								
LE	18.98	20.00	20.00	35.00	51.02	60.73	63.25	56.67
RE	16.63	17.73	21.70	34.20	47.67	58.93	58.46	54.56
Mean Dev.								
LE	9.88	10.00	10.91	16.36	19.02	14.69	15.59	15.46
RE	7.86	9.96	11.87	16.14	18.66	16.60	16.53	19.02

Table 9. "No Response" data (distributed by ear and frequency) for miners and controls for each age group.

	Miners	Controls
Age Group I	0	1 8000 Hz L
Age Group II	1 3000 Hz R 1 4000 Hz R 1 6000 Hz L 2 6000 Hz R 1 8000 Hz R	0
Age Group III	1 6000 Hz L 2 6000 Hz R 3 8000 Hz L 2 8000 Hz R	1 8000 Hz R
Age Group IV	1 all freq. R 1 6000 Hz R 3 8000 Hz L 3 8000 Hz R	1 all freq. R 4 6000 Hz R 5 8000 Hz L 8 8000 Hz R
Age Group V	1 all freq. L 1 all freq. R 1 3000 Hz L 2 4000 Hz L 4 6000 Hz L 3 6000 Hz R 7 8000 Hz L 9 8000 Hz R	1 250 Hz R 1 3000 Hz R 3 4000 Hz L 2 4000 Hz R 4 6000 Hz L 5 6000 Hz R 8 8000 Hz L 10 8000 Hz R

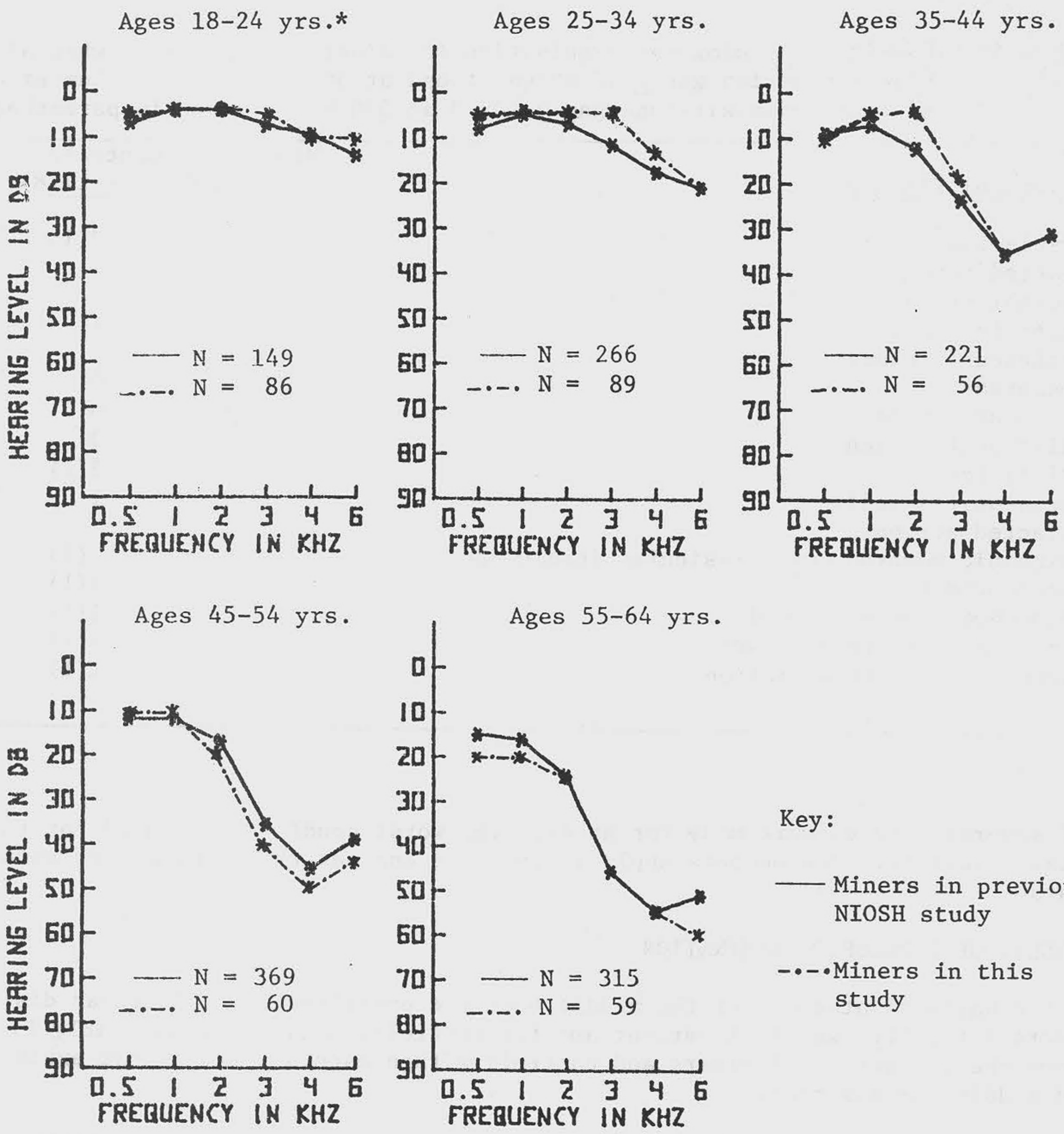

Figure 1. Median hearing levels for miners in this study compared with working miners tested in a NIOSH 1976 study and with National Health Survey general population, better ear at each test frequency.

*Age groups listed are for the NIOSH 1976 study. The age groups for this study are: Group I, 16-25; Group II, 26-35; Group III, 36-45; Group IV, 46-55; and Group V, 56-65.

Table 10. Results of otological examination for miners and controls when air-bone conduction gap ≥ 10 dB was found at 500 or 1000 Hz. Number of subjects with air-bone gap ≥ 10 dB at 500 Hz is shown in parentheses.

Otological Findings*	Miners N = 33(14)	Controls N = 17(8)
Normal--both ears	13(4)	7(1)
Impacted cerumen	4(1)	0
External otitis or clot in canal	2	1
Thickened tympanic membrane	2(2)	0
Tympanosclerosis	1(1)	0
Healed perforation	5	0
Perforation	2(2)	2(2)
Serous otitis media	1(1)	1
Retracted atrophic tympanic membrane with ossicular involvement	1(1)	1(1)
Mastoidectomy	2(2)	1(1)
Pseudo-membrane mid-canal	0	1(1)
Retracted tympanic membrane	0	1(1)
Stapedectomy or fenestration	0	2(1)

*If several entries were made for an ear, the worst condition was used for the classification. The numbers apply to subjects and may represent one or both ears.

RESULTS OF OTOSCOPIC EXAMINATION

On the basis of otoscopy of the middle ear, the prevalence of middle ear disorders for miners was 19.1 percent and for controls, 18.7 percent. Table 11 shows the percentage of miners and controls within each age group that exhibited middle ear disorders.

Table 11. Percentage of miners and controls within each age group exhibiting middle ear disorders.

	Age Group				
	I	II	III	IV	V
Miners	17.4% (15/86)	13.5% (12/89)	23.2% (13/56)	16.7% (10/60)	28.8% (17/59)
Controls	28.6% (2/7)	23.1% (3/13)	5.9% (1/17)	13.0% (9/69)	29.5% (13/44)

These data do not include the presence of cerumen in the external auditory canal as an otological abnormality. The otological examination found cerumen present in 6 percent of miners and 2 percent of controls. For purposes of comparison, the prevalence data reported in the antecedent study (NIOSH 1976) included miners with otoscopic findings of cerumen. In that study, 25 percent of miners had middle ear problems or enough cerumen to appear to affect hearing. This study also found 25 percent of miners with middle ear abnormalities or cerumen.

The most common tympanic findings were tympanosclerosis, healed perforations, hyper- and hypomobile tympanic membranes, retracted tympanic membranes, and thickened tympanic membranes. A listing of middle ear data for miners is shown in Tables 12 and 13. The otological data for miners with cerumen are listed in Table 14. For comparison, similar lists of findings on control subjects are shown in Tables 15, 16, and 17. In each of the most serious middle ear problems, the disorder or surgery preceded the miner's experience in the mines. The physicians responsible for the otological evaluations believed that the observed middle ear abnormalities were not related solely to underground exposure or coal dust. The controls were proportionately similar to miners in numbers of middle ear problems. In both miners and controls, the physicians noted the effects of cotton swabs used to clean the ear canals, including abrasion of the canal wall and remnants of cotton in the canal.

It should be noted that when subjects had impacted cerumen, the otologist attempted to remove it from the ear canal. Following cerumen removal, the subject's hearing was retested. Although test-retest data were not analyzed, it appeared that only in the most severe cases of impacted cerumen was there any obvious, pronounced effect on the audiological test results.

RESULTS OF IMPEDANCE TESTING

Middle Ear Pressure

Two hundred and sixty-eight of the miners (76.6 percent) had tympanometric peak pressure within the range considered normal (-50 to +89 mm water). Among the 268 miners with normal tympanometric peak pressure, 246 were also normal on otoscopic examination. The abnormal otoscopic findings of the 22 remaining subjects included eight thickened or inflamed tympanic membranes, eight healed perforations, five incidences of tympanosclerosis, and one instance of atrophic retracted membrane.

The abnormal tympanometric peak pressure findings included 25 miners with peak pressures greater than +89 mm water, 47 miners with tympanometric peak pressures between -60 and -340 mm water, and 10 miners with broad flat tympanograms showing no pressure peak. The otoscopic data from these 10 miners are shown in Table 18. The flat tympanogram was unilateral in eight miners and bilateral in two.

In the control group, 115 (76.7 percent) showed normal tympanometric peak pressure. Of the abnormals, pressure was greater than +89 mm water in 13, 10 were flat with no peak (Table 18), and 12 had tympanometric peak pressure less than -50 mm water. Six controls had normal tympanometry and abnormal otoscopic conditions, including one healed perforation, one stapedectomy, and four instances of tympanosclerosis.

Table 12. Miners with conductive pathology sufficiently serious to be expected to affect hearing, air-conduction, bone-conduction gap, tympanometric peak pressures, or acoustic reflex results. If only one ear is listed, opposite ear was normal. Age appears in parenthesis.

Miner Number		Miner Number	
8	L radical mastoidectomy cavity (23)	207	L healed perforation (54)
9	L healed posterior TM monomere; thickened TM (65)	211	L healed monomere (45)
10	Both sigmoid malleus (36)	216	L healed perforation--monomere; myringoplasty and erosion of long process; R retracted TM (25)
42	R central thin perforation (55)		
55	Both mild chronic external otitis with thickened TM; epithelium (40)	226	R chronic suppurative otitis media (also bloody ear) (36)
76	R healed perforation (48)	237	L anterior central dry perforation R posterior TM thickened (60)
85	R fibrous union of incus with stapes; long process of malleus absent; retracted, atrophic TM; Cerumen removed (41)	238	L healed posterior TM monomere (27)
97	L posterior TM healed perforation; R retraction of TM with cholesteatoma and some loss of body of malleus and incus (61)	243	Both small attic retraction; L healed perforation inferior TM (24)
101	L anterior thickened TM; R monomere; TM retracted (59)	247	L TM thickened and hypermobile; R small monomere TM and thickened TM (57)
119	L possibly serous otitis media; retracted TM without color (57)	300	L thickened TM; R healed perforation (28)
139	L central perforation--monomere; R slight tympanosclerosis (57)	331	L healed perforation with tympanosclerosis; R modified radical mastoidectomy cavity (26)
141	Both TMs atrophic and retracted (58)		
160	L TM adhering to incudostapedial joint with attic perforation (19)	340	R healed perforation (42)
167	L posterior TM monomere (24)	342	R serous otitis media (44)
187	L healed perforation with monomere; tympanosclerosis (59)	344	L perforated TM with tympanosclerosis (38)
194	L TM retracted with monomere (41)		

Total = 29 = 8%

Table 13. Miners with otological conditions that had minimal effects on hearing, air-conduction, bone-conduction gap, tympanometric peak pressures, or acoustic reflex results. If only one ear is listed, opposite ear was normal. Age appears in parenthesis.

Miner Number		Miner Number	
1	L minimal thickening TM (51)	173	Both TMs mildly thickened (28)
3	Both inflammation canals (46)	185	Both TMs hypomobile and minimally thickened (34)
6	Both dry crusty canals (25)	191	R mucopus and external otitis (49)
7	L mildly inflamed TM (24)	193	L canal stenosis (60)
12	Both tympanosclerosis and hypermobile (57)	197	L tympanosclerosis (46)
14	L squamous abnormal sulcus; Q-tip accumulation cerumen (30)	201	Both TMs thickened (61)
18	L coal flakes on TM (29)	229	L fungus, mild external otitis (61)
20	Both coal flakes on TM (23)	232	R old clot in canal (29)
22	Both tympanosclerosis but mobile TMs (53)	246	L posterior inferior TM thickened (20)
24	Both TMs slightly dull (60)	254	L thickened TM; tympanosclerosis (57)
47	Both tympanosclerosis (28)	265	L thickened TM; anterior reparative membrane (25)
64	R thickened TM but mobile (52)	266	R tympanosclerosis and retracted TM (23)
71	L 2 mm osteoma superior canal (57)	276	Both mild Q-tip external otitis (41)
96	L small amount coal dust (25)	294	Both thickened epithelium; mild external otitis (35)
102	Both tympanosclerosis (44)	298	Both dry canals; Q-tip clean; epithelial thickening TMs (20)
127	Both thin tympanosclerosis (26)	307	Both mild chronic external otitis (21)
133	R anterior thin tympanosclerosis (41)	313	Both tympanosclerosis (58)
142	Both slight retraction pocket (attic) (38)	324	L thin tympanosclerosis (25)
148	L mild external otitis (52)		
155	R slight retraction (45)		

Total = 38 = 11%

Table 14. Miners with otological conditions involving cerumen. If only one ear is listed, opposite ear was normal. Age appears in parenthesis.

Miner Number		Miner Number	
5	R cerumen post annulus (55)	210	Both cerumen (24)
32	Both partial cerumen impaction (55)	220	Both impacted cerumen (could not remove) (48)
62	Both cerumen impaction (60)	274	L cerumen (21)
66	Both soft cerumen impaction (47)	292	L cerumen impaction (32)
88	Both soft cerumen impaction (22)	308	R unable to see TM cerumen impaction (61)
94	Both cannot see TMs because of tortuous canal (41)	312	Both Q-tip dry canals; Q-tip cotton impacted against anterior TM (32)
108	Both partial cerumen impaction (56)	335	L cerumen impaction (39)
178	L cerumen against TM (22)	338	Both cerumen (25)
181	L thin cerumen on TM; secondary to Q-tip clean (23)	345	Both Q-tip canals; thickening of epithelial surface of TM (45)
200	L cerumen against TM; Q-tip (35)		
202	L dry canal; R partial Q-tip obstruction (29)		
208	Both cerumen (32)		
209	L cerumen (35)		

Total = 22 = 6%

Table 15. Controls with conductive pathology sufficiently serious to be expected to affect hearing, air-conduction, bone-conduction gap, tympanometric peak pressures, or acoustic reflex results. If only one ear is listed, opposite ear was normal. Age appears in parenthesis.

Control Number	
3	R tympanosclerosis; atrophic TM, mobile (59)
10	R stapedectomy (51)
19	Both central perforation (58)
51	R fenestration cavity; wire prosthesis from malleus to footplate (56)
91	L moist retraction granulation seen from TM to anterior canal (54)
101	R shallow anterior attic retraction (58)
115	L thick TM, healed perforation; R cerumen (59)
121	Both healed perforation (51)
125	Both modified radical mastoidectomy (55)
128	R tympanosclerosis and healed perforation (61)
129	L TM absent; ossicular chain intact (62)
138	R healed perforation (63)
140	R pseudo-membrane mid-canal (51)
143	R serous otitis media and thickened, healed TM perforation (60)
144	L retraction TM, ossicular mass against posterior superior wall; R monomere, retracted posterior TM under posterior superior canal; no malleus or incus (51)

Total = 15 = 10%

Table 16. Controls with otological conditions that had minimal effects on hearing, air-conduction, bone-conduction gap, tympanometric peak pressures, or acoustic reflex results. If only one ear is listed, the opposite ear was normal. Age appears in parenthesis.

Control Number	
12	L small superior canal osteoma; R small canal osteoma and tympanosclerosis TM (63)
14	L Q-tip canal; R dry cotton foreign body removed; mild external otitis (58)
24	Both dust on TM (37)
25	R slightly thickened TM (33)
33	Both small canals with dry cerumen and canal hair (56)
60	Both scattered tympanosclerosis (22)
63	R mild posterior TM tympanosclerosis (35)
72	R posterior inferior TM abnormal (?) (22)
73	Both small thin areas tympanosclerosis TM (55)
84	R mild external otitis (56)
94	R small canal hematoma (48)
110	R mild external otitis (49)
124	Both resolving external otitis (31)

Total = 13 = 9%

Table 17. Controls with otological conditions involving cerumen. If only one ear is listed, the opposite ear was normal. Age appears in parenthesis.

Control Number	
9	Both cerumen (49)
39	L cerumen impaction (55)
131	Both cerumen impaction (57)

Total = 3 = 2%

Table 18. Otoscopic findings in miners and controls who showed no tympanometric pressure peak.

10 Miners (Number)	Otological Findings	10 Controls (Number)	Otological Findings
8	L mastoidectomy	2	Normal
22	Both tympanosclerosis but mobile TM's	19	Bilateral central perforation
		28	Normal
45, 57	Normal	51	R history of fenestration
85	R mastoidectomy retracted; atrophic TM	56	Normal
		91	L scarred TM to anterior canal; retraction
97	L healed perforation; R thickened TM retracted; cholesteatoma	125	Bilateral modified radical mastoidectomy
139	L central perforation mastoidectomy R tympanosclerosis	129	L no TM, ossicular chain intact; R normal
		140	R pseudo-membrane mid-canal
187	L surgery for cyst; healed perforation; tympanosclerosis; R normal	144	L retraction, ossicles against posterior superior wall; R monomere, retracted TM, no malleus or incus
237	L central dry perforation R posterior TM thickened		
344	L perforation and tympanosclerosis; R normal		

Relationship Between Tympanometry and Otoscopic Examination

The miners with negative tympanometric peak pressure less than -50 mm water are listed in Table 19. This table includes the results of otoscopic examinations. Table 20 shows similar data for the control subjects. There was no absolute relationship between a finding of high negative tympanometric peak pressure and abnormal otological findings. Approximately the same number of miners with high negative pressure had normal otological conditions as had abnormal otological conditions.

When all abnormal tympanograms were considered, however, a significant relationship was found for both miners and control subjects between tympanometric findings and the physician's findings of middle ear disorders (χ^2 $p<0.001$). When the otological examination findings were abnormal, 82.57 percent of miners' and 92 percent of control subjects' tympanometric conditions were abnormal.

Table 19. Number of miners in negative tympanometric peak pressure groups, ≤-51 mm water, with otological findings.

-mm Water	Number of Miners	Otological Findings	
		Yes	No
-51 to -80	8	4	4
-81 to -110	12	6	6
-111 to -140	6	4	2
-141 to -170	9	4	5
-171 to -200	3	1	2
-201 to -230	2	0	2
-231 to -260	4	2	2
<-260	3	3	0
Totals	47	24	23

Table 20. Number of controls in negative tympanometric peak pressure groups, ≤-51 mm water, with otological findings.

-mm Water	Number of Controls	Otological Findings	
		Yes	No
-51 to -80	3	0	3
-81 to -110	3	2	1
-111 to -140	4	4	0
-141 to -170	1	0	1
<-170	1	1	0
Totals	12	7	5

Acoustic Reflex

Acoustic reflex results are summarized in Table 21. In this study the acoustic reflex was present with all stimuli for 271 miners and 98 control subjects. The reflex was absent for some stimuli for 67 miners and 47 control subjects. During testing of a few subjects, erratic movement of the balance meter of the equipment obscured any acoustic reflex response.

Table 21. Acoustic reflex.

	Present All Freqs.	Absent Some Freqs.	Absent All Freqs.	Artifact Could Not Test
Miners	271 (77.4%)	51 (14.6%)	16 (4.6%)	12 (3.4%)
Controls	98 (63.3%)	32 (21.3%)	15 (10.0%)	5 (3.3%)

The acoustic reflex can be absent for many reasons, including: (1) presence of conductive pathology in at least one ear; (2) mixed conductive and sensorineural pathology; (3) severe sensorineural hearing loss; and (4) age of subjects. Therefore, the absence of an acoustic reflex does not necessarily indicate the presence of middle ear disease. In 10 miners an absent acoustic reflex could not be explained by any of the four factors mentioned above. All of the control subjects' acoustic reflex data could be explained by at least one contributing auditory test or history factor.

The well established relationship between absence of the acoustic reflex and increased age is shown in Table 22. There is a strong interaction between age and increased hearing loss that must be considered in interpretation of these data.

Table 22. Age distribution of miners and controls whose reflexes were not elicited.

	Age Groups				
	16-25	26-35	36-45	46-55	56-65
Miners	3.7% (13)	2.6% (9)	2.9% (10)	4.6% (16)	5.4% (19)
Controls	0.7% (1)	2.0% (3)	2.0% (3)	15.3% (23)	11.3% (17)

The relationship between acoustic reflex and acoustic susceptance (B) and conductance (G) was examined. Among the 67 miners with absent acoustic reflexes, 59 (88.1 percent) showed B and G values that were outside the range of normal (see Analysis of Test Findings). However, among the 271 miners with an acoustic reflex that was present, 205 (75.6 percent) also showed abnormal B and G values.

Table 23 shows the acoustic reflex results of miners with tympanometric peak pressures less than -50 mm water, and Table 24 shows results of control subjects. In general, as negative pressure increases, the incidence of absent acoustic reflexes increases. However, there are some clear exceptions with miners having negative tympanometric peak pressure of -160, -170, -200, -230,

and -270. It should be noted that for many subjects, the acoustic reflex was absent for isolated high frequency stimuli, and in only six subjects was the reflex absent for all stimuli.

Table 23. Acoustic reflex results for miners with negative pressures ≤-51 mm water. If an ear is not specified, following P (present) or Ab (absent), all stimuli for both ears are implied. If only one ear is listed as Ab, reflexes for opposite ear were elicited.

Negative Pressure	Number of Miners	Miners P, Ab*	Acoustic Reflex Response		Stimuli
-60	3	3	P		
-70	2	1	Ab	L	2000, HiP
			Ab	R	1000, 2000, HiP, BBN
		1	Ab	L	HiP
-80	3	2	P		
		1	Movement artifact		
-90	3	2	P		
		1	Movement artifact		
-100	7	3	P		
		3	Ab	R	2000
		1	Movement artifact		
-110	2	1	P		
		1	Ab		all stimuli
-120	1	1	P		
-130	3	1	P		
		1	Ab	R	2000
		1	Ab		all stimuli
-140	2	1	P		
		1	Ab	L	2000
-150	2	1	P		
		1	Ab	R	2000
-160	3	1	P		
		1	Ab	L	2000
		1	Ab		all stimuli
-170	4	1	P		
		1	Ab	L	2000, HiP
		1	Ab	R	HiP, BBN
		1	Ab	L	HiP
-180	1	1	Ab	R	2000
-200 (opp. -160)	2	1	P (elevated L)		
		1	Ab		all stimuli
-220	1	1	Ab	L	2000, HiP, BBN
			Ab	R	HiP
-230	1	1	P		
-240 (opp. -180) (opp. +290)	2	1	Ab		4000, HiP
		1	Ab	L	2000
			Ab	R	HiP
-250	2	1	Ab	L	1000
			Ab	R	2000, HiP
		1	Ab		all stimuli
-270	1	1	P		(elevated 500, 1000 R)
-290 (opp. -290)	1	1	Ab	L	500, 1000
			Ab	R	500, 1000, HiP, BBN
-340 (opp. -330)	1	1	Ab		all stimuli

*Number of miners with present and/or absent acoustic reflexes within each negative pressure category.

Table 24. Acoustic reflex results for controls with negative pressures ≤-51 mm water. If an ear is not specified, following P (present) or Ab (absent), all stimuli for both ears are implied. If only one ear is listed as Ab, reflexes for opposite ear were elicited.

Negative Pressure	Number of Controls	Controls P, Ab*	Acoustic Reflex Response		Stimuli
-60	2	1	Movement artifact		
		1	Ab	L	2000
			Ab	R	all stimuli
-80	1	1	P		
-90	1	1	Ab	R	2000, HiP
-100	1	1	Ab	R	HiP
-110	1	1	Ab		2000, HiP
-120	2	2	P		
-140	2	2	P		
-170	1	1	Ab	L	2000, HiP
			Ab	R	1, 2000, HiP
-270	1	1	Ab	R	HiP, BBN

*Number of controls with present and/or absent acoustic reflexes within each negative pressure category.

SUMMARY AND DISCUSSION

Results of this investigation failed to confirm a higher prevalence of middle ear disorders among the coal miners than among the control subjects. Both groups had approximately the same percentage of middle ear disorders, as shown by otoscopic examination (19.1 percent for miners, 18.7 percent for control subjects). Audiometric testing yielded the same percentage of low frequency air-bone gaps for the two groups, and there was little difference in hearing thresholds between groups at the various ages. Some of the differences in hearing levels that did occur appear to be related to a skewed distribution of subjects by age group. That factor is discussed further in subsequent paragraphs.

Tympanometric findings indicated the same percentage of normal tympanometric peak pressure among miners (76.6 percent) and control subjects (76.7 percent). The acoustic reflex was "absent at some or all frequencies" in a higher percentage of control subjects, but the difference between groups does not seem meaningful.

This study separated middle ear disorders from the presence of cerumen in the external ear canal. When these otoscopic findings are combined, the present study obtained the same percentage of findings (25 percent of miners) as reported previously (NIOSH 1976).

The types of middle ear disorders identified were similar for both miners and control subjects. In addition, the physicians responsible for the otoscopic examinations believed that the most serious middle ear problems of miners preceded their work in the mines and were not related to their work environment.

Obtaining subjects was the greatest problem encountered in this study. In the original design, an equal number of subjects in each age group was planned, but that was not achieved. Most men entering the mines are younger than 35 (Bensman 1978). However, most union members in the cooperating control companies were over 40 years of age. The result is a skewing of subjects (miners) towards the younger age, and union members (controls) towards the older age.

A second factor affecting random geographic distribution of miners occurred as a result of critical floods in the Johnstown area. Several mines in the area were closed and never reopened. Some of the miners who had been selected moved away and were not available for testing.

The managers from the industries providing the control subjects were initially interested in the study. As time passed, however, managers began to fear litigation, even in those companies in which pre-employment and monitoring audiometry were conducted. This response limited the representative companies to 15, and the unions provided the list of names. This led not only to a

skewing of control subjects by age, but also to a certain amount of self-selection among these subjects. That is, certain subjects among the control groups may have volunteered either knowing or suspecting that they had auditory disorders. Naturally, this non-random situation could have deleterious effects on the outcome of the research. However, it appears not to have actually affected the results, since the otolaryngologists found that middle ear disease usually preceded employment and was not related to the work environment.

Further difficulties in the completely random selection of miners resulted from three external factors. First, a coal miner strike occurred during the peak months of testing. Second, the strike was resolved with substantial pay increases. (Following the strike, miners were less willing to be absent from work or sacrifice the wage increase for the smaller research fee.) Third, data collection took place during the most severe winter weather in many years. The effects of these factors on the results are unknown.

This investigation showed no difference in prevalence of middle ear disorders between the miners and control subjects studied. This finding was not expected in view of the previous NIOSH study (1973) that found approximately 8 percent of prospective subjects with apparent middle or external ear abnormalities, including impacted cerumen, on otoscopic examination. These differences in findings may be due to a number of factors, including training of persons doing otoscopy, and evaluation criteria. For example, in the 1973 study, otoscopic examination was made by a staff physician or by trained audiologists using hand-held otoscopes. In the present study, board-certified otolaryngologists performed the otoscopic examination, which included pneumatic otoscopy (microscopic examination of the ear with an operating microscope). Also, in the 1973 study, there was no mention of tympanic membrane color or mobility. The examiners noted only "congenital or acquired ear malformations, almost total occlusion of the ear canal by cerumen, perforated or scarred tympanic membrane, or active ear involvement." Given these differences, the present study would be expected to find a substantially higher percentage of abnormalities. The agreement of findings among miners in this study and those reported in the NIOSH 1976 study may have been due to the use of a single examiner (an audiologist) who applied a more stringent criterion for "normal."

Finally, the self-selection of control subjects mentioned in the previous paragraphs may have led to a greater number of subjects with middle or external ear disorders. In order to determine whether there is an increase in middle ear disorders of miners compared to the general population, it would be necessary to design a prevalence study that further examined middle ear disorders in the general population, with examiners and criteria similar to those used in the present study.

The observations made in this investigation strongly suggest that it would be very worthwhile to study "ear hygiene" among workers in industry. This study found abraded external auditory canals, impacted cerumen, and cotton in external canals. These are the results of self-cleaning with cotton swabs. This finding suggests that workers feel a need to clear dirt, debris, and cerumen from their ear canals, but they cause minor damage to their canals when doing so.

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APPENDIX A: SAMPLE DESIGN FOR HEARING STUDY SUBJECT SELECTION

A sample size of 350 miners and 150 non-miners was considered satisfactory for the purposes of this study. The sample specifications were as follows:

1. Sample size--350 underground miners.

2. Geographical areas--A total of 12 mining companies in the geographical areas identified below agreed to participate:

   a. Pittsburgh and surrounding counties (Fayette, Greene, Washington, Allegheny, Indiana, Westmoreland, Beaver, Butler, and Armstrong)

   b. Johnstown, PA (Cambria County)

   c. Morgantown and Fairmont, WV area

   d. Bellaire region of Ohio

3. Other characteristics of sample--An equal number of miners in each of five age groups 15-24, 25-34, 35-44, 45-54, 55-64.

Equal proportions and unequal numbers of miners were selected from each of the 12 mining companies that agreed to participate, making this sample a self-weighted sample. Sampling proportional to size of mine results in a sample in which the geographical distribution of miners from each mine is the same as their distributions in the population.

Lists of miners' names in alphabetical order or in order by date of employment were provided by the mines. These lists had been numbered previously in order to provide a count of the total number of miners in each mine. The same numbers were used to make a random selection of miners from each list from each mine. Simple random sampling was used.

The name and age of each miner whose number coincided with the random number was recorded in the first column of a sample list. The names of two alternate miners whose names appeared directly before and after the miner whose number coincided with the random number were recorded in the second and third columns of the sample list. Alternates were selected to have names readily available if the first randomly selected miner could not be used in the study because he did not meet the age requirements, was no longer employed by the mine, etc. The following table shows both the number and percent of total miners and of sampled miners from each mine.

NUMBER OF MINERS BY MINE AND NUMBER OF SAMPLED MINERS

County in PA	Total Miners Number (%)	S* M**	Company 1 Number (%)	S* M**	Company 2 Number (%)	S* M**	Company 3 Number (%)	S* M**	Company 4 Number (%)	S* M**	Company 5 Number (%)	S* M**	Company 6 Number (%)	S* M**
Greene	2574	43							1038	17	994	17		
	(12.2)	7							(4.9)	2	(4.7)	4		
Fayette	88	1									88	1		
	(.4)	1									(.4)	1		
Somerset	281	4	151	2										
	(1.3)	2	(.7)	1										
Westmoreland	294	5												
	(1.4)	2												
Allegheny	1032	18	625	11										
	(4.9)	5	(3.0)	3										
Cambria	2288	38												
	(10.8)	8												
Indiana	2879	47					1947	32						
	(13.7)	10					(9.2)	8						
Armstrong	236	4												
	(1.1)	3												
Butler	184	3											184	3
	(.9)	1											(.9)	1
Washington	4907	82	1389	24					980	16	733	12	1567	26
	(23.3)	13	(6.6)	5					(4.6)	2	(3.5)	2	(7.4)	3
States														
OH	3248	54			3248	54								
	(15.4)	7			(15.4)	7								
WV	3079	51	1744	29										
	(14.6)	6	(8.3)	3										
Totals	21090	350	3909	66	3248	54	1947	32	2018	33	1815	30	1751	29
	(100.0)	(6.5)	(18.5)	12	(15.4)	7	(9.2)	8	(9.6)	4	(8.6)	7	(8.3)	4

*S = Number of mines sampled
**M = Number of mines

NUMBER OF MINERS BY MINE AND NUMBER OF SAMPLED MINERS (continued)

County in PA	Total Miners Number (%)	S* M**	Company 7 Number (%)	S* M**	Company 8 Number (%)	S* M**	Company 9 Number (%)	S* M**	Company 10 Number (%)	S* M**	Company 11 Number (%)	S* M**	Company 12 Number (%)	S* M**
Greene	2574	43											542	9
	(12.2)	7											(2.6)	1
Fayette	88	1												
	(.4)	1												
Somerset	281	4			130	2								
	(1.3)	2			(.6)	1								
Westmoreland	294	5	62	1					232	4				
	(1.4)	2	(.3)	1					(1.1)	1				
Allegheny	1032	18							407	7				
	(4.9)	5							(1.9)	2				
Cambria	2288	38	121	2	2167	36								
	(10.8)	8	(.6)	1	(10.3)	7								
Indiana	2879	47					932	15						
	(13.7)	10					(4.4)	2						
Armstrong	236	4					159	3			77	1		
	(1.1)	3					(.8)	2			(.4)	1		
Butler	184	3												
	(.9)	1												
Washington	4907	82							238	4				
	(23.3)	13							(1.1)	1				
States														
OH	3248	54												
	(15.4)	7												
WV	3079	51	1335	22										
	(14.6)	6	(6.3)	3										
Totals	21090	350	1518	25	2297	38	1091	18	877	15	77	1	542	9
	(100.0)	(6.5)	(7.2)	5	(10.9)	8	(5.2)	4	(4.2)	4	(.4)	1	(2.6)	1

*S = Number of mines sampled
**M = Number of mines

APPENDIX B

Plant Name_____
Worker Number_____

(Note: Questions 1 - 9 are to be completed with help of staff interviewer.)

1. NAME: _____ 2. SEX: _____ 3. AGE: _____

4. ADDRESS: _____

5. JOB HISTORY:

   a. Present Job Description _____

      No. of Years _____ Full-time: yes - no
      Ear Protection: yes - no - sometimes

   b. Other Job Descriptions with Same Employer _____

      No. of Years _____ Full-time: yes - no
      Ear Protection: yes - no - sometimes

   c. Other Noisy Jobs with Different Employer _____

      No. of Years _____ Full-time: yes - no
      Ear Protection: yes - no - sometimes

6. MILITARY SERVICE:

   a. Circle the number of years you were on active duty in the military service. 0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 - more
      (If you were not in the military, continue to the next page)

   b. What Branch? Army Navy Marines Air Force Coast Guard

   c. Circle the number of years you were in combat. 0 - 1 - 2 - 3 - 4 - 5 - more

d. List in the following blanks the job or jobs you had in the military.

_____ Ear Protection: yes - no - sometimes

_____ Ear Protection: yes - no - sometimes

_____ Ear Protection: yes - no - sometimes

_____ Ear Protection: yes - no - sometimes

e. Did you fire weapons for more than 100 days? yes - no

f. What kinds of weapons did you fire? individual crew both

7. NONOCCUPATIONAL NOISE EXPOSURE:

a. Have you used firearms as a civilian? yes - no
If yes, do you wear ear protection? yes - no - sometimes

b. How many years have you been shooting? _____

c. How many rounds per year? 100 or less 500 1000 or more

d. Do you participate in any of the following hobbies or off-job activities? (Circle yes or no for EACH item)

(1) Rock Band yes no No. of Years____ daily weekly monthly

(2) Motorbike riding yes no No. of Years____ daily weekly monthly

(3) Machine workshop yes no No. of Years____ daily weekly monthly

(4) Automobile racing yes no No. of Years____ daily weekly monthly

(5) Flying yes no No. of Years____ daily weekly monthly

(6) Mechanized farming (tractor) yes no No. of Years____ daily weekly monthly

(7) Chain saws yes no No. of Years____ daily weekly monthly

Plant Name _____
Worker Number _____

(8) Others _____ No. of Years____ daily weekly monthly

8. LAST NOTABLE EXPOSURE:

a. Have you been exposed to a loud noise since leaving your job yesterday? yes - no
(If no, please continue to next page)

b. If yes, what was the nature of your exposure (specify, e.g., horn, airplane, workplace, gunshot, etc.)? _____

c. How many hours ago did this exposure take place? _____

d. How long did this exposure last? (In minutes or hours) _____

9. RELEVANT MEDICAL HISTORY:

Have you had any of the following:
(Circle yes or no for EACH item - if yes, elaborate in the space provided)

a. Severe blow to head yes no _____

b. Head noises yes no _____

c. Medical treatment for ears yes no _____

d. Running ears yes no _____

e. Earaches yes no _____

f. Hearing aid yes no _____

g. Medication yes no _____

h. Deafness in the family yes no _____

i. Do you think you have normal hearing? yes - no

10. OTOLOGIC CHECK

(This question will be completed by staff medical officer)

a. Perforation R _____ L _____

Plant Name _____
Worker Number _____

b. Drainage R_____ L_____

c. Malformation R_____ L_____

d. Occlusion R_____ L_____

e. Disease R_____ L_____

f. Scars R_____ L_____

g. Others. R_____ L_____

APPENDIX C: RELIABILITY STUDY

Photographs of the tympanic membrane were taken only of the first 35 miners tested. They were seen by two physicians so that the degree of interjudge reliability could be determined. The table below shows a summary of the results on 35 miners.

Normal TM Both physicians and film	Both physicians		
	Normal TM	Abnormal TM	Differed
17	25	7	3

Although the films and their reproductions on slides are of value in reminding the observer what was observed, there is no opportunity to make judgements of mobility from a still slide, which is a primary method of determining normal function. In spite of this restriction, the degree of agreement was exceptional.

Both of the live otoscopic examinations and the film judgement agreed that 17 miners had normal tympanic membranes. The films could not be interpreted because of various artifacts on six miners. The films, because of their static characteristic, were misleading on five miners.

If only the judgments of both physicians are inspected and the films are omitted, both physicians agreed that 25 miners had normal tympanic membranes. They agreed on the pathology in seven miners. There were three miners about whom the physicians differed. Differences in physical findings did not alter recommended disposition or patient management from a medical point of view.

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