Hearing Sensitivity in Farmers

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Synopsis **.................................**

Hearing sensitivity was measured for tones from 1,000 through 8,000 hertz (Hz) in 534 males and 278 females who resided in rural Wisconsin and ranged in age from 16 to 85 years. The hearing sensitivity for all subjects decreased with advancing age and at higher frequencies, but hearing loss over the range most susceptible to excessive noise exposure (3,000–6,000 Hz) was much greater for males than for females at all ages. The hearing loss was greater than could be accounted for by age and was similar whether the subject was a farmer or not.

The results suggested that approximately 25 percent of the males had a communication handicap due to hearing loss by age 30, and the proportion rose to 50 percent by age 50. Less than 20 percent of farmers reported consistent use of personal hearing protection in their farm-related duties.

Overall, the findings suggest that men who live in rural areas, including farmers, demonstrate a high prevalence of hearing loss and associated communication problems due to excessive noise exposure. This, in turn, clearly indicates a need for intensification of educational hearing conservation programs for the rural population.

In addition to accidents and ailments associated with exposure of the farming population to pesticides, vibration, and organic particles, exposure to excessive noise is common (*1*). Excessive noise exposure specifically is recognized as an occupational health problem based on the attention it has received in the scientific literature (*2–5*) and based on the development of Federal regulations regarding permissible occupational noise exposures and hearing-conservation programs (*6–8*).

Long-term noise exposure causes an insidious, bilateral high-frequency sensorineural hearing loss that typically affects, to some extent, a person's ability to communicate through hearing. The hearing loss for understanding speech will vary in degree depending on the noise intensity and duration. Suter (*9*) demonstrated that even persons with only mild high-frequency hearing losses experience speech-discrimination problems, particularly in demanding (noisy) listening situations.

The potential hazards associated with noise in farming are not new developments. Other studies noted that farming is an occupation that involves potentially excessive noise exposures (*1,10,11*), and several earlier reports documented the existence of significant hearing losses in farmers and farm workers (*12,13*). In spite of this earlier documentation and subsequent hearing conservation efforts, however, a recent report on hearing screening suggested that farmers continue to experience high-frequency hearing loss (*14*). The 1983 study was limited primarily because it screened at only three audiometric frequencies rather than making a complete hearing threshold assessment over a broad frequency range. Accordingly, the purpose of our research was to reevaluate the prevalence and characteristics of noise-induced hearing loss in a rural population.

Methods

Subjects. Pure-tone thresholds and case-history information were obtained over a 5-year period from 812 visitors who attended the annual Wiscon-

Table 1. Number of subjects classified according to age group and history of noise exposure

Age	Males: Farmers: Occupational exposure	Males: Nonfarmers: Occupational exposure	Males: Nonfarmers: No occupational exposure	Females: Occupational exposure	Females: No occupational exposure
16–25 years ...	24	36	12	19	12
26–35 years ...	34	9	16	18	16
36–45 years ...	58	22	16	22	32
46–55 years ...	69	21	17	30	49
56–65 years ...	77	26	19	21	36
66–75 years ...	35	13	11	7	13
76–85 years ...	19	0	0	0	3
Total	316	127	91	117	161

sin Farm Progress Days Expositions. The sample comprised 534 males and 278 females who were 16–85 years old. We made strong efforts to recruit subjects from all age categories and from both genders in an attempt to counteract the subject self-selection bias that inevitably exists in surveys of this nature. Accordingly, although our subject sample was not truly random, we believe it was reasonably representative of the age, gender, and hearing-loss distribution of people who attended the expositions.

Procedures. The test environment was an Otomobile—a mobile hearing test unit—provided by the Wisconsin Department of Public Instruction, Bureau for Children with Physical Needs. The unit contained one single-walled audiometric room and two other test areas. The Otomobile was located on the exposition site in an area remote from major noise sources. The ambient noise in the test environment was acceptable (*15*) for determining pure-tone air-conduction thresholds under earphones as low as a 0-decibel (dB) hearing level for audiometric test frequencies of 1,000–8,000 hertz (Hz).

Prior to assessing pure-tone thresholds, the test procedure was explained to the subjects. They completed a questionnaire that addressed the following areas: (*a*) identification by sex, age, and occupation; (*b*) existing hearing loss or family history of hearing loss; (*c*) current ear problems; (*d*) exposure to occupational and nonoccupational noise; and (*e*) use of hearing protectors. In the noise exposure history questions, subjects were asked to indicate whether they experienced frequent exposure to loud noise in their occupation or in selected nonoccupational activities.

Pure-tone air-conduction thresholds for the audiometric frequencies of 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz were obtained for each ear of the subjects using audiometers calibrated to current standards of the American National Standards Institute (ANSI) (*16*). Testing was performed by experienced graduate students from the Department of Communicative Disorders, University of Wisconsin-Madison. The students were under the direct supervision of faculty and staff who hold the Certificate of Clinical Competence in Audiology from the American Speech-Language-Hearing Association. Manual pure-tone audiometry incorporating conventional clinical procedures with 5-dB increments was used to measure hearing thresholds. Test results from persons whose histories suggested the possibility of hearing problems due to factors other than presbyacusis (age), socioacusis (nonoccupational noise exposure associated with daily activities), or occupational noise exposure were excluded from the data analysis.

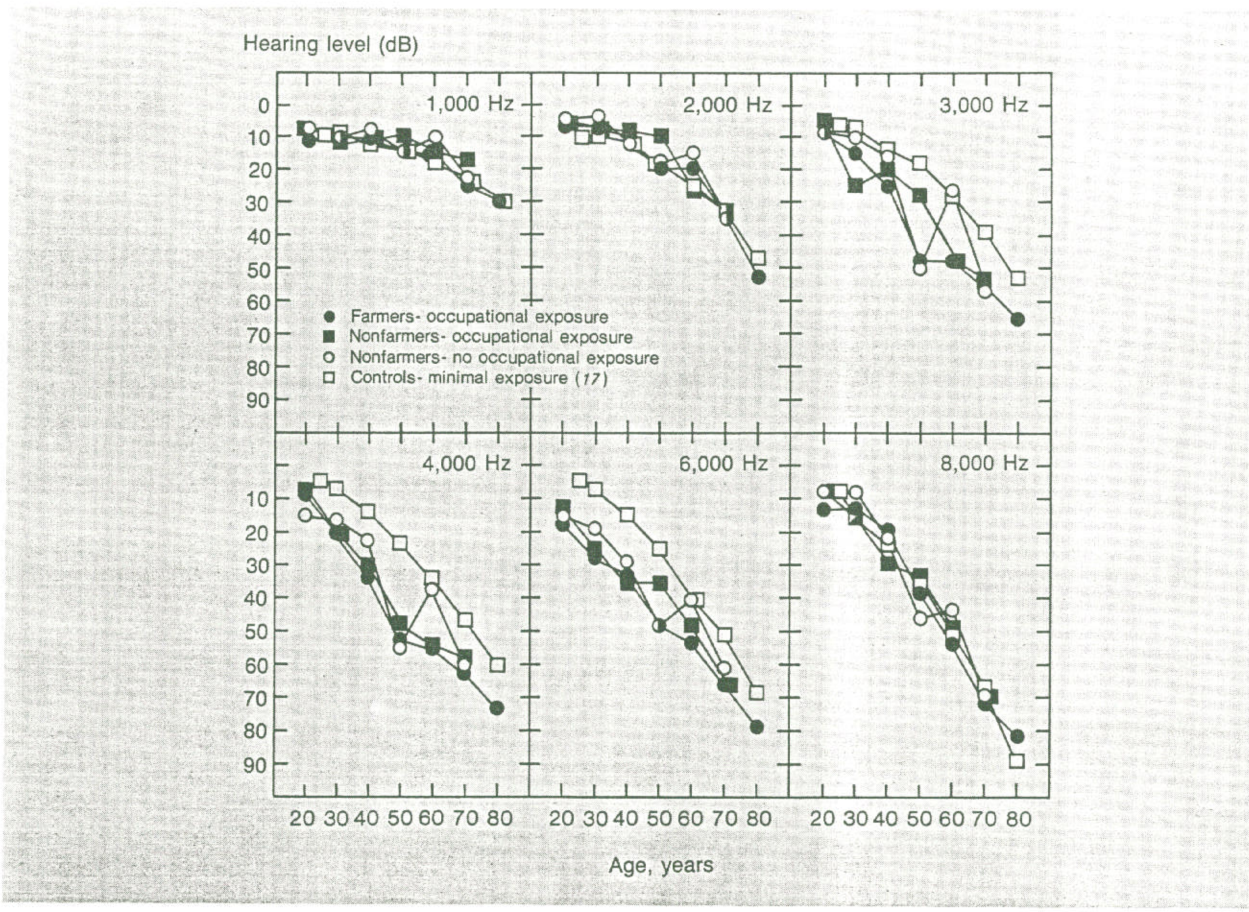
Results and Discussion

Table 1 summarizes the number of subjects classified by sex, age, occupation, and self-reported history of occupational noise exposure. The males were classified as farmers or nonfarmers. Each group was further subdivided according to a positive or negative history of occupational noise exposure. Because all farmers reported that they had a history of occupational noise exposure, a negative occupational noise exposure category was not necessary. The female participants were grouped according to age and occupational noise exposure history. No attempt was made to classify the females by occupation, although a large percentage identified themselves as farm wives. Females were classified according to whether they had a history of occupational noise exposure or not.

Pure-tone air-conduction thresholds were determined separately for the right and left ears. The data presented here, however, consist of pooled right and left ear thresholds, so the sample sizes or number of ears for each group is twice the number of subjects shown in table 1.

Male thresholds. Figure 1 illustrates median hearing levels in decibels (*16*) for the males as a function of age, occupational noise exposure history, and audiometric test frequency. Also shown are Spoor's presbyacusis functions for males in the general population with histories of minimal expo-

Figure 1. Median hearing thresholds levels for rural males by age, occupational noise exposure, and test frequency



sure to intense noise (*17*). Because it is known that hearing sensitivity becomes poorer with increased age even in the absence of ear disease or damage from exposure to excessive noise, we compared our data with Spoor's estimates of hearing loss as a function of age. Several studies in the literature described average hearing levels for males and females as a function of age for persons with minimal noise exposure histories (*18–20*); results from these studies are in good agreement with Spoor's data (*17*).

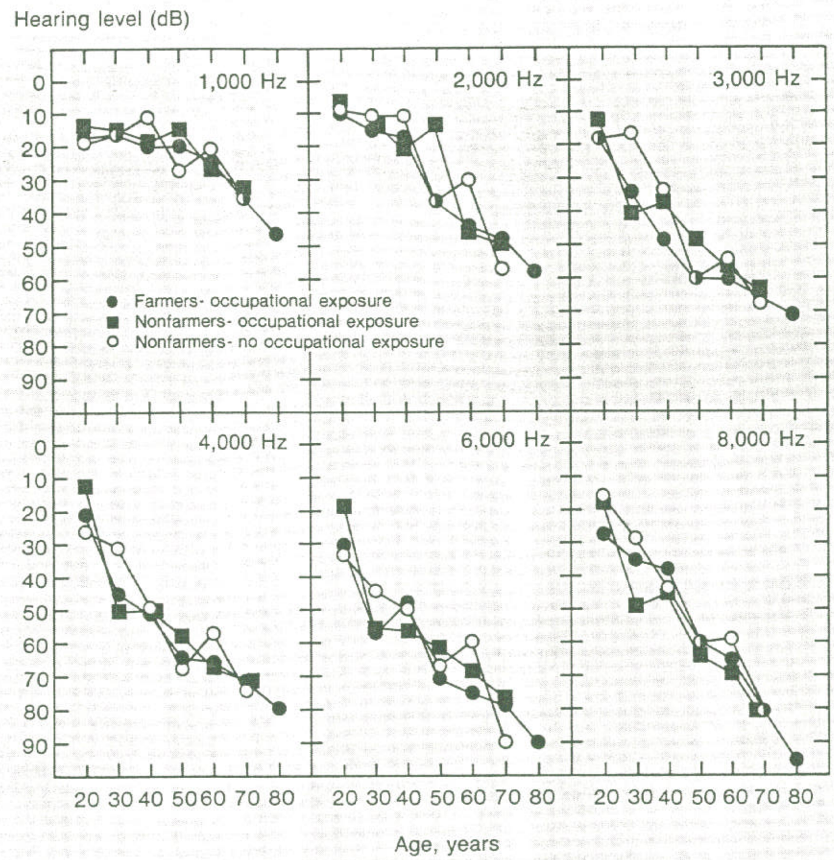
Hearing loss increased as a function of age for all subject groups tested, and the increase became greater at higher frequencies (fig. 1). Except for minor and nonsystematic deviations at several ages and test frequencies, hearing levels for the farmers were similar to the hearing levels of the nonfarmers both with and without a history of occupational noise exposure.

Threshold hearing levels for all male subject groups were consistently poorer than Spoor's data (*17*) for test frequencies of 3,000–6,000 Hz and were virtually identical to Spoor's data at other test frequencies. Because maximum hearing loss for the 3,000–6,000-Hz range is characteristically most reflective of excessive noise exposure, the data for our subjects suggest that all male groups, whether reporting a history of occupational noise exposure or not, experienced significant exposure to excessive noise.

Figure 2 illustrates third-quartile hearing level data for the males. These results imply that 25 percent of the subjects in each group had hearing thresholds equal to or poorer than those shown in the figure. The hearing-threshold relations among the subject groups are very similar to those described for the median data (fig. 1); the third-quartile data, however, highlight the 25 percent of the subjects in each group who probably were most susceptible to hearing loss from presbyacusis, socioacusis, occupational noise exposure, or a combination of those conditions.

Female thresholds. Figure 3 shows median hearing levels for females with and without a reported history of occupational noise exposure as a func-

Figure 2. Third-quartile hearing thresholds for rural males by age, occupational noise exposure, and test frequency

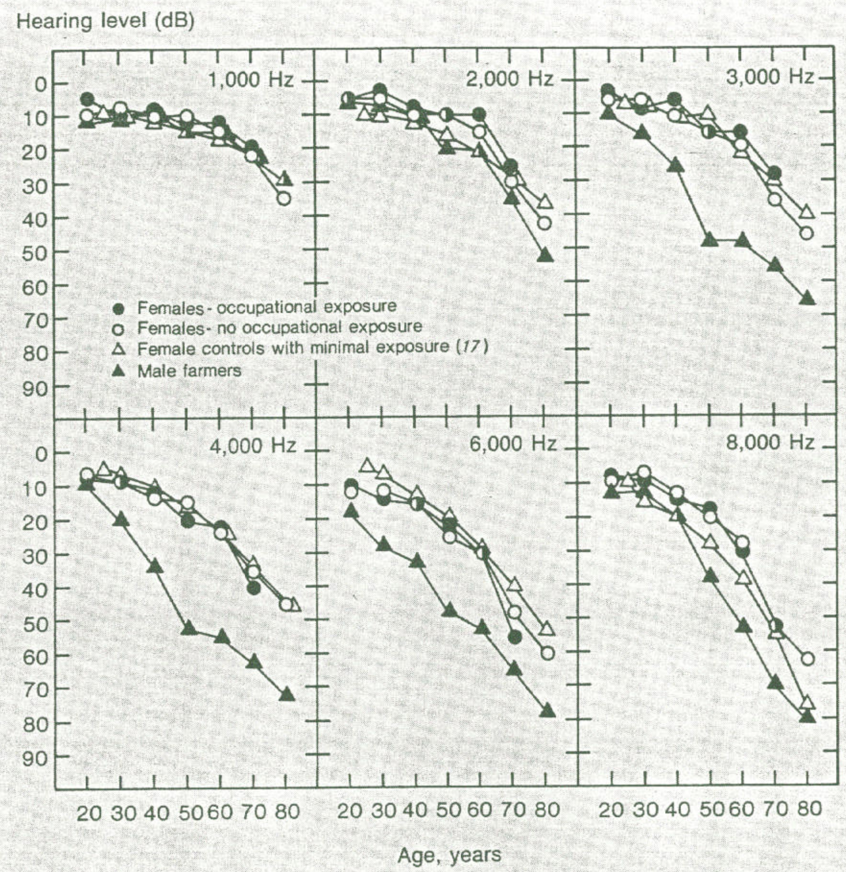


tion of age. Spoor's data for females with minimal noise exposure (*17*), as well as our results for the male farmers, are shown for comparison. As expected, the females showed increasing hearing loss with advanced age and with increasing audiometric frequency. Except for minor deviations at some ages and test frequencies, thresholds for the females who reported exposure to excessive noise in their occupations were highly similar to those of women who reported no occupational noise exposure history. Moreover, thresholds for both groups of females were in good agreement with Spoor's data at most test frequencies and ages; our subjects' thresholds were slightly better than Spoor's data at 2,000 and 8,000 Hz and slightly poorer at 6,000 Hz. Figure 4 depicts third-quartile data for the females with corresponding results for male farmers. The relations across age, test frequency, and occupational noise exposure history are similar to those for the median data (fig. 3).

Further inspection of figs. 3 and 4 indicates that thresholds of the male farmers were quite similar to the thresholds of females at 1,000 Hz. At higher test frequencies, however, thresholds of the male farmers were poorer than those of females, particularly for age groups of 30 years and older. The greatest threshold difference between the male farmers and the female subjects occurred at test frequencies (3,000–6,000 Hz) most reflective of noise exposure. This finding suggests that the male farmers probably experienced a greater degree of noise exposure than the female subjects, a reasonable inference supported by Kryter's work (*21*). Kryter supported the idea that "a primary reason that the HLs [hearing levels] of females are generally of lower value than those for males in industrialized societies is that the males, whether at work or at play (especially hunting with firearms), are exposed to higher intensities of sound and noise than are the females and therefore suffer from more noise-induced hearing losses."

Estimated noise exposure levels. We also attempted to estimate the approximate daily noise exposure levels for the males and females based on mea-

Figure 3. Median hearing thresholds for rural females by age, occupational noise exposure, and test frequency



sured hearing levels. These estimates were obtained by the process presented in table 2. The median hearing levels of the male farmers (from fig. 1) and of the females who reported a history of occupational noise exposure (fig. 2) were used in the analysis and are shown on line 1 for each age example in table 2. Age corrections on line 2 for hearing loss in decibels, estimated by the National Institute for Occupational Safety and Health (NIOSH) (*20*), were subtracted from our hearing level data and resulted in an estimate of the hearing loss due solely to noise exposure in our subject sample. That is shown as the estimated noise-induced permanent threshold shift (NIPTS) on line 3 of table 2. Line 4 in the table for each of the male age groups shows the expected median NIPTS resulting from an 8-hour average daily sound level of 95 dBA and, for the females, line 4 shows analogous data for an average sound level of 80 dBA (*7*). The NIPTS data shown on line 4 for each age group in table 2 were taken from data presented by the Occupational Safety and Health Administration (OSHA) (*7*) for decades of exposure from 10 to 40 years. Those data are compared in table 2 with the age-corrected hearing levels for ages 30–60 years on the assumption that our subjects were first exposed to occupational noise at age 20.

The expected NIPTS from an equivalent 95-dBA 8-hour exposure is presented in table 2 because it most closely approximates the estimated NIPTS (age-corrected hearing levels) for most of our male farmer age groups. In general, this analysis suggests that the male farmers were exposed to noise that closely approximated an equivalent 8-hour 95-dBA average daily sound level. Furthermore, since our data (fig. 1) suggested that hearing thresholds for the male farmers were similar to nonfarmers reporting or not reporting a history of occupational noise exposure, it appears reasonable to infer that generally all males residing in rural areas in this survey were exposed to noise with an equivalent average daily sound level of 95 dBA.

The expected NIPTS resulting from an average 80-dBA 8-hour daily exposure most closely ap-

Table 2. Computation of estimated noise-induced permanent threshold shifts (NIPTS) for male farmers and for females who reported a history of occupational noise exposure

NIPTS calculations at 4 ages	Males (frequency, Hz)					Females (frequency, Hz)				
	1,000	2,000	3,000	4,000	6,000	1,000	2,000	3,000	4,000	6,000
1. Median hearing level (dB) at age 30	10	8	15	20	28	10	3	8	9	13
2. NIOSH age correction	6	4	6	9	12	8	6	5	5	9
3. Estimated NIPTS (1 minus 2)	4	4	9	11	16	2	−3	3	4	4
4. Expected NIPTS:										
10 years at 80 dBA	...	...	...	...	...	0	0	2	3	2
10 years at 95 dBA	3	6	16	20	14	...	...	...	...	...
1. Median hearing level (dB) at age 40	10	10	25	33	32	10	7	5	12	14
2. NIOSH age correction	7	6	10	14	19	10	7	8	8	13
3. Estimated NIPTS (1 minus 2)	3	4	15	19	13	0	0	−3	4	1
4. Expected NIPTS:										
20 years at 80 dBA	...	...	...	...	...	0	0	2	3	2
20 years at 95 dBA	4	9	19	22	16	...	...	...	...	...
1. Median hearing level (dB) at age 50	12	20	48	55	48	12	10	14	19	21
2. NIOSH age correction	9	9	16	22	27	12	10	11	12	17
3. Estimated NIPTS (1 minus 2)	3	11	32	33	21	0	0	3	7	4
4. Expected NIPTS:										
30 years at 80 dBA	...	...	...	...	...	0	0	3	4	3
30 years at 95 dBA	5	12	21	24	17	...	...	...	...	...
1. Median hearing level (dB) at age 60	15	20	48	57	53	11	10	13	22	30
2. NIOSH age correction	11	13	23	33	38	14	12	16	17	22
3. Estimated NIPTS (1 minus 2)	4	7	25	24	15	−3	−2	−3	5	8
4. Expected NIPTS:										
40 years at 80 dBA	...	...	...	...	...	0	0	3	4	3
40 years at 95 dBA	5	15	23	25	18	...	...	...	...	...

NOTE: Hz = hertz, dB = decibels, dBA = decibels on the A scale.

'Considering a 25-dB hearing level as a low-fence estimate of a beginning handicap in communication, our findings suggest that a large number of males from rural communities, including farmers, have hearing losses that impair everyday communication.'

proximated the estimated NIPTS for the data of females shown in table 2. Note that exposure to an 80-dBA average sound level results in a negligible NIPTS for the female age groups (line 4). This is consistent with our finding that female subjects showed a negligible estimated NIPTS (see table 2, line 3, for each age group).

Hearing loss and speech perception. A major concern with noise-induced hearing loss is its effect on the perception of speech in everyday listening situations. The frequency range important for understanding speech has in the past often been considered to range from 500 through 2,000 Hz. More recent data (*9*), however, suggest that higher frequencies, at least up to 3,000 Hz, also are important in the perception of speech. Suter, for example, concluded that estimates of hearing loss that include thresholds for frequencies above 2,000 Hz improve predictions of speech discrimination for persons with noise-induced hearing loss (*9*). In addition, OSHA has adopted the frequency range of 1,000–3,000 Hz in its definition of material hearing impairment (*7*). Accordingly, we have averaged hearing level data over the 1,000–3,000-Hz range to estimate the potential effects of hearing loss on communication.

Figure 5 displays first-quartile, median, and third-quartile hearing levels averaged over 1,000–3,000 Hz for the males as a function of age and occupational noise exposure classifications. Spoor's (*17*) median data are shown for comparison in the middle panel. The hearing levels as a function of age are quite similar for the three subject groups. Spoor's median thresholds were slightly but consistently better than those shown for our subjects. This difference was particularly influenced by the use of 3,000 Hz in the three-

Figure 4. Third-quartile hearing thresholds for rural females by age, occupational noise exposure, and test frequency

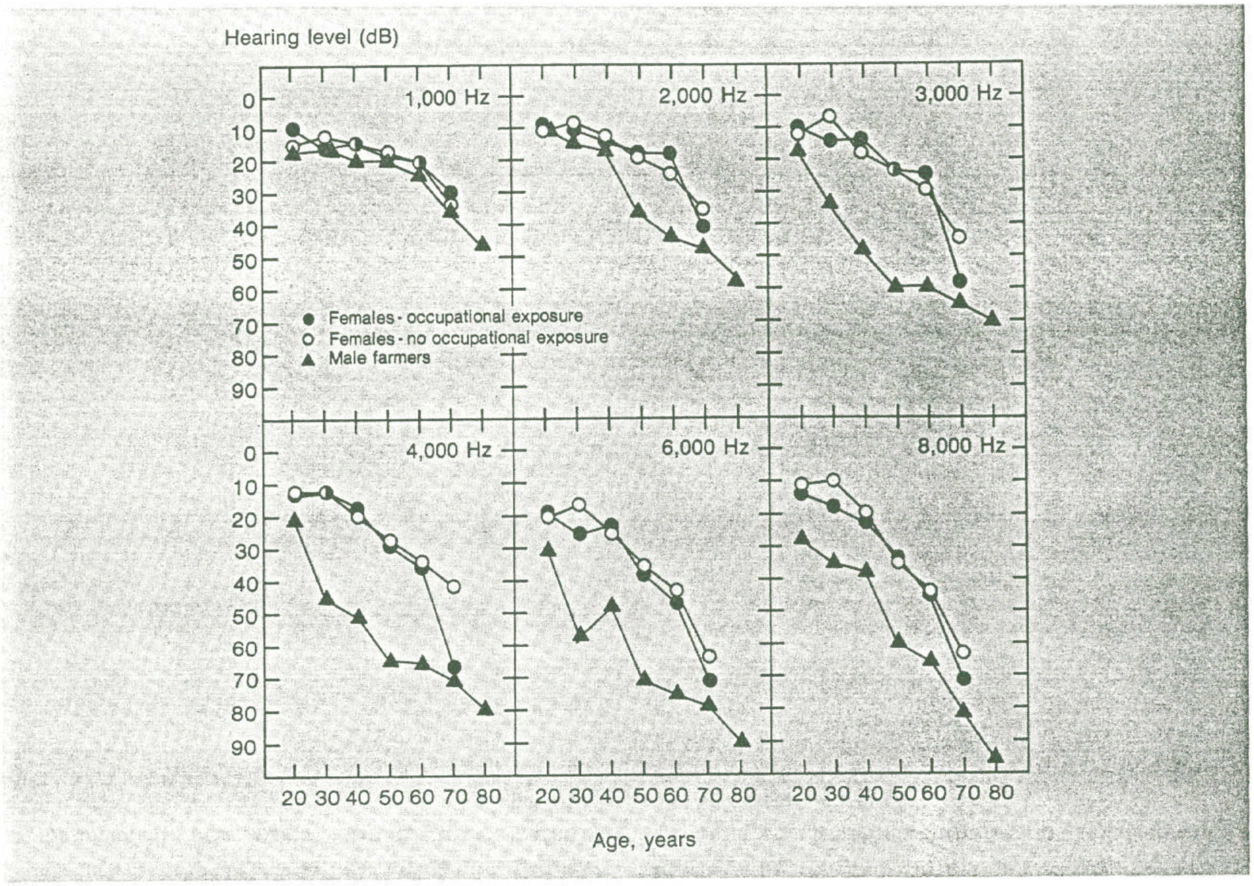
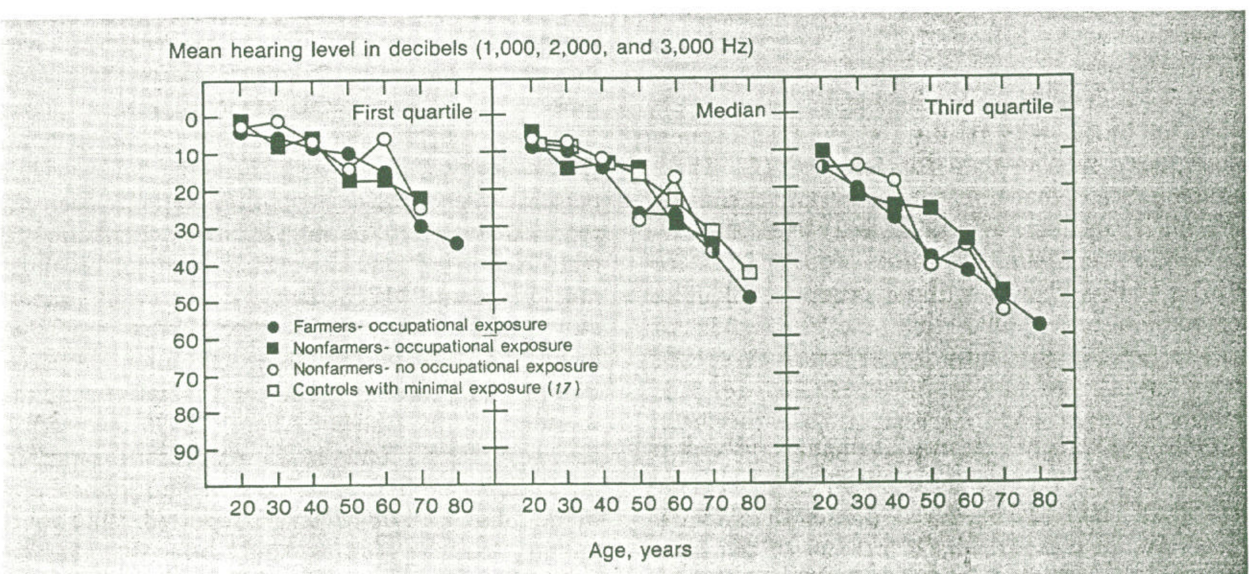
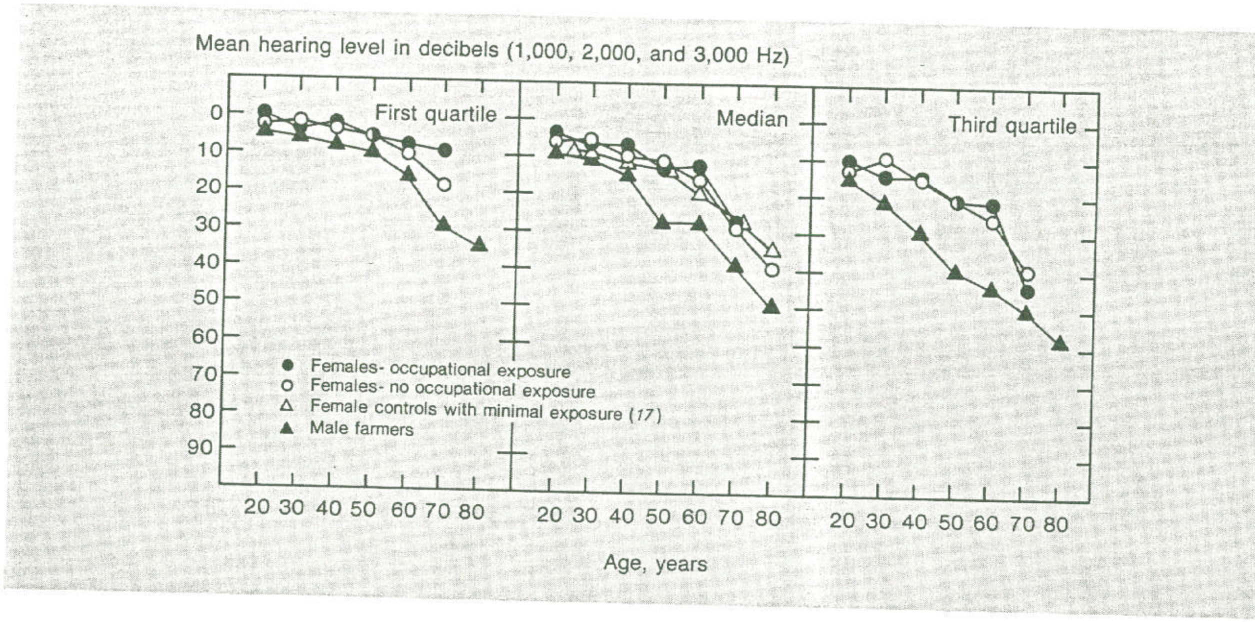


Figure 5. First-quartile, median, and third-quartile pure-tone averages (1,000, 2,000, and 3,000 Hz) for rural males by age and occupational noise exposure



NOTE: The first-quartile panel indicates that 25 percent of the subjects in each group had thresholds better than those shown by the functions. The third-quartile panel data show that 25 percent of the subjects had thresholds poorer than those described by the functions.

Figure 6. First-quartile, median, and third-quartile pure-tone averages (1,000, 2,000, and 3,000 Hz) for rural females by age and occupational noise exposure



frequency average. Referring to fig. 1, note that our data begin to deviate from Spoor's results at 3,000 Hz. Considering a 25-dB hearing level as a low-fence estimate of a beginning handicap in communication, our findings suggest that a large number of males from rural communities, including farmers, have hearing losses that impair everyday communication. According to the third-quartile data in fig. 5, for example, 25 percent of the male farmers had thresholds poorer than a 25-dB hearing level by age 35, and 25 percent had thresholds poorer than a 40-dB hearing level by age 60.

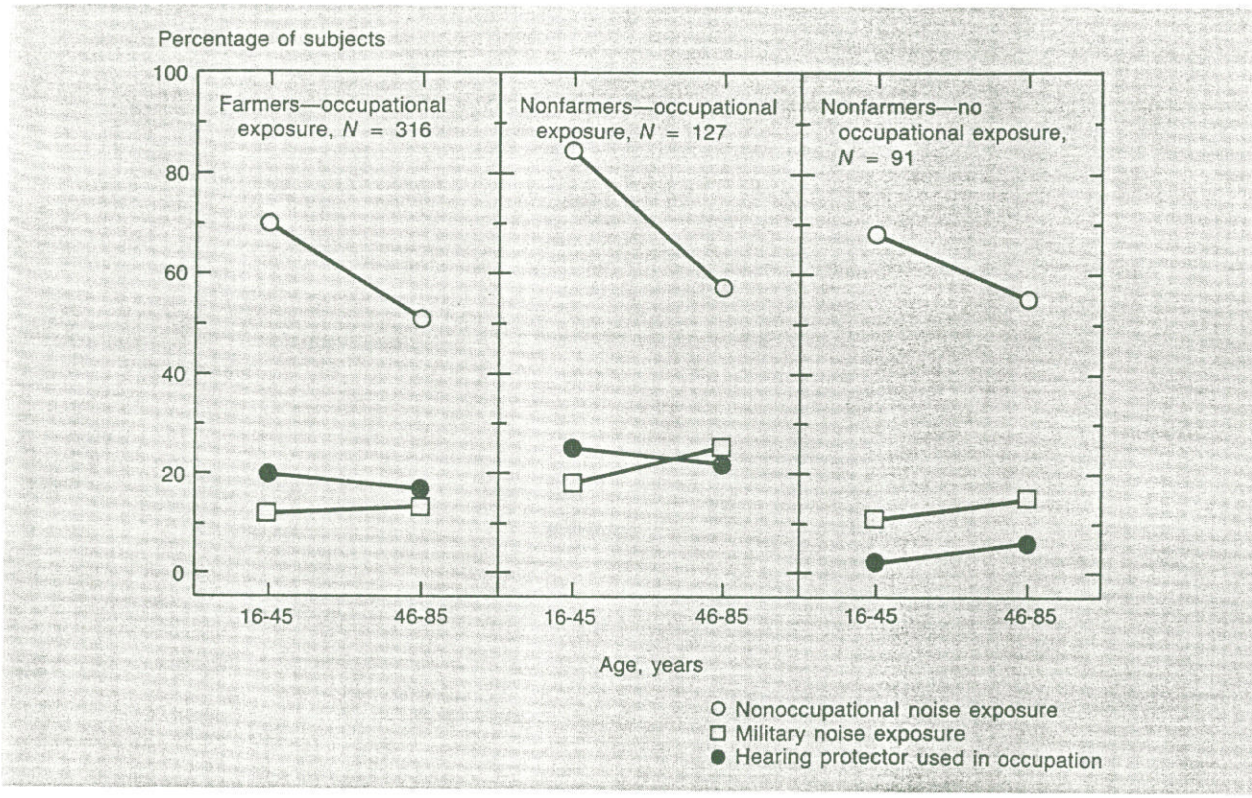
Three-frequency average hearing levels (1,000, 2,000, and 3,000 Hz) for the female subjects are shown in fig. 6, with results for the male farmers and Spoor's median data for females (*17*). These results indicate that for each descriptive statistic (quartile 1, median, and quartile 3) average hearing levels were similiar across age groups for females both with and without occupational noise exposure histories, and that the thresholds of females were consistently better than those for male farmers at all ages. Thresholds for the females were in good agreement (± 5 dB) with Spoor's data at all ages. Inspection of the third-quartile data in fig. 6 indicates that 25 percent of the females had hearing levels poorer than 25 dB by age 60. In comparison, 25 percent of the male farmers had hearing levels poorer than 25 dB by age 35.

Questionnaire results. Questionnaire information is presented in fig. 7 for males and in fig. 8 for females. The subjects were categorized into younger (16–45 years) and older (46–85 years) groups. Both figures show the percentage of younger and older subjects classified according to frequent occupational noise exposure history, frequent nonoccupational noise exposure history, military noise exposure, and consistent use of hearing protectors in their occupations.

More than 50 percent of all males, regardless of age or occupational noise exposure history, reported a history of frequent exposure to excessive nonoccupational noise (fig. 7). Firearm use was the most frequently reported nonoccupational noise. More of the younger males (70–85 percent) reported such a history than the older males (50–55 percent). A smaller proportion (10–25 percent) reported a history of military noise exposure. Of males reporting a positive history of occupational noise exposure (both farmers and nonfarmers), only about 18–25 percent reported that they used hearing protectors in their occupation.

Noise exposure information for the females is summarized in fig. 8. About 28–38 percent of younger females and 11–15 percent of older females reported frequent exposure to nonoccupational noise. Only one female reported a history of military noise exposure, and only 9–15 percent indicated consistent use of hearing protectors in their occupation.

Figure 7. Percentage of younger and older rural males classified by occupational noise exposure who also reported evidence of nonoccupational noise exposure, military noise exposure, and use of hearing protectors in occupations



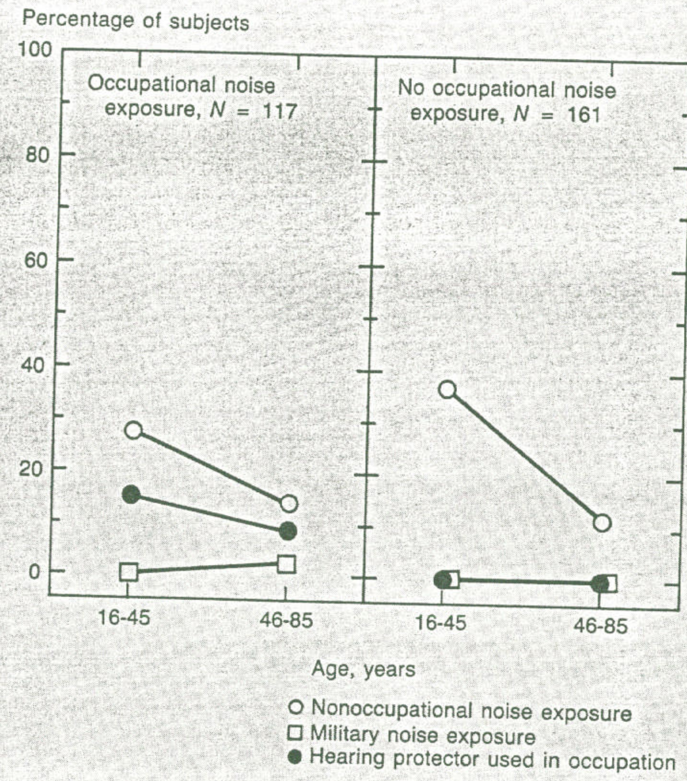
One way in which the subjects were categorized into groups was by their self-reported history of occupational noise exposure. The data in fig. 1, however, suggest that the male nonfarmers who reported that they had not been exposed to occupational noise probably had experienced significant noise exposure, because their thresholds were poorer over the frequency range of 3,000–6,000 Hz compared with thresholds for lower and higher test frequencies. Either the nonfarmers with no history of occupational noise exposure had experienced significant occupational noise exposure or they experienced sufficient military or nonoccupational noise exposure to affect their hearing sensitivity in the 3,000–6,000-Hz region. A high percentage (55–70 percent) of males in the nonfarmer group with no occupational noise exposure history reported frequent nonoccupational noise exposure, the most common being use of firearms.

Median thresholds at all test frequencies for females who reported a positive history of occupational noise exposure were virtually identical to the thresholds of those who reported a negative history (fig. 3). Contrary to the data for men, these relations suggest that the females who reported occupational noise exposure may not have received sufficient exposures to noise over time to shift their thresholds.

'The results of our study strongly suggest that there is a need to reemphasize and intensify educational hearing conservation efforts among farmers and others living in rural areas.'

These examples underscore the difficulty in obtaining valid information about a person's exposure to noise by using abbreviated questionnaire approaches and suggest that, if a noise exposure history is of interest, a more detailed questionnaire will have to be used. In spite of the problems associated with asking people to assess their own noise exposure histories, those difficulties do not alter the validity of the pure-tone hearing threshold results.

Figure 8. Percentage of younger and older rural females classified by occupational noise exposure who also reported evidence of nonoccupational noise exposure, military noise exposure, and the use of hearing protectors in their occupations



Implications

There is ample evidence that exposure to excessive noise affects hearing sensitivity in industrial workers (*21,23–25*) and in farm workers (*12–14,26*). Unfortunately, the overall trends in the data from our study are similar to those reported by Glorig and his associates in 1957 (*12*) and suggest that males continue to acquire noise-induced hearing losses that affect their ability to communicate. It is discouraging that, based on our findings, noise-induced hearing loss continues to occur in many young males, including farmers. As early as 20 years of age (fig. 1), thresholds for the males in this study were poorer over the frequency range of 3,000–6,000 Hz than those reported by Spoor (*17*) for males with little or no exposure to noise; the thresholds were considerably poorer than presbyacusis and socioacusis estimates reported by Kryter (*21*). Our results are supported by a recent audiometric screening study by Thelin and associates (*14*) in which farmers and nonfarmers were tested with a 4,000-Hz tone. The investigators reported high-frequency hearing loss for younger as well as older farmers.

It is distressing to consider the obvious possibility that noise-induced hearing loss will progressively increase in many of the young males in this study with advancing age in trends similar to those shown in the data presented. Should this be the case, a significant number of these young males will experience increasing communication problems over time due to hearing loss.

Although 25 dB is often used as the low fence in many worker's compensation formulas for noise-induced hearing loss, Suter proposed that the dividing line between being handicapped and not handicapped for everyday communication should begin at 19 dB for the frequencies of 1,000–3,000 Hz (*9*). Note from fig. 5 that, when averaged across the noise exposure groups tested, a 19-dB cutoff would occur at about age 50 for the median data and at about age 30 for the third-quartile data. In other words, 50 percent of the males had some degree of communication handicap by age 50, and 25 percent had at least the beginning of a handicap by age 30. It is unfortunate that less than 25 percent of males who reported a history of noise exposure also reported consistent use of hearing protectors (fig. 7).

When the 19-dB hearing-level criterion for the data of females is used (fig. 6), 50 percent (median) had the beginning of a communication handicap by about age 63, and 25 percent (third quartile) had a handicap by about age 50, but this is normal for females and is somewhat expected due to age. The impact of noise exposure is obviously more dramatic for males.

In conclusion, we have been promoting hearing conservation for many years at the annual Wisconsin Farm Progress Days Expositions, but that limited involvement clearly is insufficient in view of the continuing magnitude of the noise-induced hearing loss problem in male farmers as well as other males living in rural areas. The results of our study strongly suggest that there is a need to reemphasize and intensify educational hearing conservation efforts among farmers and others living in rural areas. In addition, the similarity between our present findings and those reported more than 25 years ago supports the need for periodic studies of the efficacy of hearing conservation programs.

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