Hearing Loss in Migrant Agricultural Workers

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ABSTRACT. *Background*: Farmers have high rates of hearing loss, yet little is known about the hearing status of migrant agricultural workers. We performed a cross-sectional survey to assess the prevalence and impact of hearing loss in this population.

Methods: One hundred fifty migrant and seasonal agricultural workers were surveyed at a series of health fairs held at migrant camps. A bilingual questionnaire included items related to hearing loss risk factors and subjective hearing difficulties. Pure tone audiometry and tympanometry were performed in a mobile testing van.

Results: More than half the subjects had some degree of hearing loss at audiometric frequencies between 500 and 6000 Hz, especially in the higher frequencies. Hispanic males in the sample had significantly greater prevalence of high-frequency hearing loss compared to adults in the national Hispanic Health and Nutrition Examination Survey (HHANES). More than 35% of respondents complained of subjective difficulty hearing or understanding speech, yet no workers reported use of hearing aids. Even after adjusting for measured hearing loss, Hispanic farm workers were more likely than their English-speaking counterparts to complain of difficulty hearing or understanding speech, suggesting that language barriers could worsen the impact of hearing loss. Risk factors for hearing loss included age and abnormal tympanometry. Occupational exposures to noise from tractors and other machinery as well as pesticides were frequently reported, while use of hearing protection was rare.

Conclusion: Hearing loss is a significant and under-recognized problem in the migrant worker population. Further preventive and treatment efforts are warranted.

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The authors thank Jacqueline Solimini for assistance with the survey administration and data entry, Edward Sapian and ConnectiCOSH for their organization of the health fairs, as well as Bruce Gould, MD, and Victoria Barreras, MPH, for coordination of clinical activities.

This project was made possible by support from the Northeast Center for Agricultural and Occupational Health, Grant # U01/CCU208030. The Hearing Center, Ansonia, CT, assisted with the audiometric screening.

Available online at http://www.haworthpress.com/web/JA

doi:10.1300/J096v10n04_04

KEYWORDS. Hearing loss, noise occupational, agricultural workers' diseases, migrant agricultural workers, Hispanics

BACKGROUND

Hearing loss is one of the most common sensory deficits. The prevalence increases with age, and the primary causes of acquired hearing loss are excessive noise exposure (noise-induced hearing loss, or NIHL) and age-related hearing loss (presbycusis).

Occupational noise exposure has been recognized as a risk factor for hearing loss since ancient times. More recently, farmers have been found to have an increased risk of high frequency, sensorineural hearing loss, presumably due to noise and possibly pesticide exposures.[1,2] Sources of noise exposure in agricultural settings include tractors[3,4] and other noisy farm machinery.[5] Since some pesticides have neurotoxic properties, their role in hearing loss has been investigated. A history of crop spraying in the previous year has been associated with increased risk of hearing loss.[1]

While the majority of studies of hearing loss in agriculture have focused on self-employed farmers, little or nothing is known about the hearing status of the approximately 2.5 million migrant agricultural workers in the United States. Migrant workers have disproportionate rates of a number of other health conditions related both to occupational exposures and socioeconomic factors. These include musculoskeletal disorders, pesticide-related conditions, traumatic injuries, respiratory conditions, dermatitis, infectious diseases, cancer, eye conditions, and mental illness.[6] Migrant workers are exposed to noise sources from tractors and other machinery, and are also at risk for pesticide exposures. Whether such exposures are causing elevated rates of hearing loss in migrant workers is currently unknown, however.

Hispanics, who make up a majority of the migrant farm worker population, have significant rates of hearing loss.[7] The reasons for high rates of hearing loss may be related to socioeconomic factors,[8] but it may also be related to occupational or non-occupational noise exposure. There is evidence that hearing loss may have a disproportionate impact in Hispanic populations, perhaps related to the difficulty of having both hearing impairment and limited English skills.[9] In a study of noise-exposed workers who were predominantly Hispanic, lower acculturation scores were associated with less effective use of hearing protection.[10]

We therefore conducted a cross-sectional survey of a largely Hispanic population of migrant agricultural workers. The aims of the survey were to determine whether rates of hearing loss appeared to be increased compared to comparison populations, whether measured hearing loss was associated with reported hearing difficulties, and whether significant associations could be found between hearing loss and occupational exposures to noise and pesticides.

METHODS

The study protocol and questionnaire were reviewed and approved by the Human Investigation Committee for the Yale School of Medicine. During the agricultural season of 2001 and 2002, volunteers were recruited from health fairs held at different migrant camps and farms in the Connecticut River valley. After giving informed verbal consent, volunteers completed a short questionnaire regarding noise exposures, medical risk factors for hearing loss, and hearing loss symptoms. They subsequently had tympanometry using a Grason Stadler tympanometer, and then entered a mobile van audiometric booth for pure tone audiometry performed by certified audiometric technicians and a supervising audiologist. The sound levels in the testing booth were in compliance with OSHA standards. Due to equipment failures, tympanometry could not be completed on all subjects.

Study personnel administered the questionnaire, with bilingual personnel administering the instrument in Spanish to those volunteers who only spoke Spanish. Subjects received a copy of their hearing results and those with abnormal results were referred for medical follow-up. All participants received instruction in the use of hearing protectors, and were given samples of earplugs.

Altogether, 150 individuals completed the survey. Questionnaire responses were entered into a Microsoft Access database, and the data were exported into SAS 8.02 for analysis. Simple univariate and frequency analyses were performed on demographic variables.

Individuals were considered to have hearing loss if the hearing threshold (in either ear) at any frequency between 500 and 6000 Hz exceeded 25 dB.[11] For each individual, we determined whether such loss occurred either in the lower frequencies of 500, 1000, and 2000 or the higher frequencies of 3,000, 4000, and 6000 Hz (where noise-induced hearing loss typically is first detected[12]). We determined the presence of hearing impairment according to American Medical Association (AMA) and American Academy of Otolaryngology Head and Neck Surgery (AAOHNS) criteria[13,14] as a loss greater than 25 dB for the average hearing threshold level at the frequencies of 500, 1000, 2000, and 3000 Hz in either ear. For tympanometry, a pressure range of −100 to 100 DaPa and peak pressure of 0.3-1.9 cm^3 were considered normal.[15]

To determine correlates of subjective difficulty hearing and/or understanding speech, we performed simple and multiple logistic regressions between this self-reported condition and age, gender, and ethnicity as well as the presence of hearing loss.

In order to compare hearing loss among survey participants to a reference population, we used data from the 1982-84 Hispanic Health and Nutrition Examination Survey (HHANES).[16] HHANES was a large systematic sample of U.S. individuals of primarily Mexican, Puerto Rican, and Cuban descent.[17] The National Center for Health Statistics has recommended that in analyses of HHANES data, these groups should not be lumped into one "Hispanic" category.[18] For the purposes of the comparison to HHANES, six farm workers from Central America in the farm worker sample were grouped with those of Mexican origin, while one Hispanic male from Jamaica was analyzed together with the Puerto Ricans in the sample. The audiometric testing component of HHANES was limited to the frequencies of 500, 1000, 2000, and 4000 Hz. In order to focus on high frequency hearing loss possibly related to occupation, we compared the prevalence of hearing loss at the noise-sensitive frequency of 4000 Hz between male Hispanic farm workers in the survey and males in the HHANES sample. We confirmed that hearing loss at 4000 Hz in the farm worker survey was well-correlated with loss at 3000, 4000, and 6000 Hz: of the 78 individuals with loss at either 3000, 4000, or 6000 Hz, 50 (64%) had loss at 4000 Hz.

A logistic regression model was used to calculate bivariate and adjusted odds ratios for associations between demographic and occupational factors and hearing loss. In all the multivariate analyses, a backward elimination method was used, with a selection criterion of $p = 0.05$ in order to select the variables remaining in the final model.

RESULTS

Demographics

As Table 1 shows, the study population was predominantly male. There was a wide age range, although the median age was less than 35 years. Most of the workers were from Spanish-speaking countries and territories, especially Puerto Rico and Mexico. The African Americans in the sample were all from Jamaica. The predominant crop currently worked was tobacco, although some participants worked other crops, including a commercial nursery and an apple orchard. The respondents reported a median of 4 years working in agriculture. During the rest of the year, participants reported a variety of other occupations, most commonly farm work in other parts of the United States or in their home countries, but also construction and service industry jobs.

Hearing Status

Table 2 shows the prevalence of measured and reported hearing loss for study subjects, grouped according to tympanometry testing status. Overall, 12% of individuals had hearing impairment by AMA/AAOHNS criteria, and more than 35% of respondents complained of subjective difficulty hearing or understanding speech due to hearing problems. Despite this, no respondents reported use of hearing aids

TABLE 1. Demographics of Study Population (N = 150)

Age (median, range)	34 (18-75)
Male–No. (%)	140 (93.3)
Race/Ethnicity–No. (%)	
Hispanic	112 (74.7)
African American	31 (20.7)
White, non Hispanic	2 (1.3)
Unknown	5 (3.3)
Country of Origin (%)	
Mexico	61 (40.7)
Jamaica	32 (21.3)
Puerto Rico	26 (17.3)
Guatemala	17 (11.3)
U.S.A.	7 (4.7)
Dominican Republic	3 (2.0)
Honduras	2 (1.3)
Unknown	2 (1.3)
Type of Agriculture (%)	
Tobacco	97 (64.7)
Commercial nursery	33 (22.0)
Apple orchard	20 (13.3)
Years in agriculture (median, range)	4.0 (0-35)
Other Jobs During Year (%)	
Construction/Manufacturing	31 (20.7)
Agriculture	66 (44.0)
Services/Other	13 (8.7)
None or unknown	40 (26.7)

(data not shown). Hearing loss was more common in the higher frequencies of 3000, 4000, and 6000 Hz compared to the lower frequencies of 500, 1000, and 2000 Hz (52% vs. 16%, respectively). The 23 individuals with abnormal tympanometry (indicating middle ear dysfunction) were more likely to have hearing impairment as well as hearing loss at higher frequencies. Subjective complaints of hearing difficulty, however, did not differ significantly by tympanometry status.

Factors Associated with Hearing Difficulty

Table 3a shows the bivariate and adjusted associations between reported difficulty hearing or understanding speech and both demographic factors and measured low and high frequency hearing loss. In this table, hearing loss is defined as a categorical variable (hearing threshold level in at least one frequency greater than 25 dB). In both the bivariate and multivariate logistic regression models, hearing loss at the higher frequencies of 3000, 4000, and 6000 Hz was significantly associated with difficulty hearing or understanding speech (OR = 2.30, $p = 0.02$). Hispanic ethnicity also showed a strong association with reported hearing difficulty, even after adjusting for age, gender, tympanometry status and measured hearing loss (OR = 4.43, $p < 0.01$).

Table 3b shows the same bivariate and multivariate analysis of perceived hearing difficulty, using low and high frequency hearing threshold averages in the worse ear to define hearing status as a possible contributing variable. In this analysis, Hispanic ethnicity remained an important explanatory variable (OR = 3.56, $p = 0.02$). Measured hearing status, as determined by high frequency hearing threshold average, was also significantly associated with reported hearing difficulty (OR = 1.04 per 1 dB increment in threshold average, $p < 0.01$).

Prevalence of Risk Factors for Hearing Loss

Table 4 shows the prevalence of reported risk factors for hearing loss in the study population, including occupational and recreational noise exposures, self-reported pesticide exposures, and medical conditions. Although exposures to noise sources were commonly reported, only 14% of subjects responded "yes" to the question "do you use hearing protection?" The reported use of hearing protection varied by type of agriculture, with 36% of commercial nursery workers versus 10% of apple workers and 7% of tobacco workers reporting use of hearing protection in the past ($p < 0.001$).

For the 99 study subjects with normal tympanometry (see Table 2), these risk factors were tested for possible association with high-frequency hearing loss. In a multivariate logistic regression model that also included age and ethnicity, only age (OR = 1.06, $p < 0.01$)

TABLE 2. Hearing Problems and Tympanometry Results (N = 150)

Outcome	Total (N = 150)	Tympanometry Status: Normal (N = 99)	Abnormal (N = 23)	Not performed (N = 28)	p *
Hearing Loss–No. (%)					
Low frequency †	24 (16.0)	13 (13.1)	7 (30.4)	4 (14.3)	0.12
High frequency ‡	78 (52.0)	51 (51.5)	17 (73.9)	10 (35.7)	0.02
Hearing Impairment ††–No. (%)	18 (12.0)	7 (7.1)	6 (26.1)	5 (17.9)	0.02
Difficulty hearing or understanding speech–No. (%)	53 (35.3)	37 (37.4)	9 (39.1)	7 (25.0)	0.44

† loss greater than 25 dB in any of the frequencies 500, 1 K, or 2 KHz in either ear
‡ loss greater than 25 dB in any of the frequencies 3 K, 4 K, or 6 KHz in either ear
†† loss greater than 25 dB in the average of frequencies 500, 1 K, 2 K, and 3 KHz in either ear
* Differences between the 3 groups evaluated using chi-square test

TABLE 3a. Factors Associated with Difficulty Hearing or Understanding Speech: Hearing Loss as a Categorical Variable (N = 150)

	Bivariate Model		Multivariate Model*	
	OR (95% CI)	p	OR (95% CI)	p
Demographic Factors				
Age	0.99 (0.97,1.02)	0.67	–	–
Male	1.30 (0.32,5.24)	0.72	–	–
Hispanic ethnicity	3.70 (1.33,10.29)	0.01	4.43 (1.55,12.64)	< 0.01
Tympanometry				
Normal (reference)	1.00	–	–	–
Abnormal	1.08 (0.43,2.73)	0.88	–	–
Unknown	0.56 (0.22,1.44)	0.23	–	–
Hearing Loss				
Low frequency †	1.69 (0.70,4.10)	0.24	–	–
High frequency ‡	1.91 (0.96,3.78)	0.06	2.30 (1.12,4.69)	0.02

† loss greater than 25 dB in any of the frequencies 500, 1 K, or 2 KHz in either ear
‡ loss greater than 25 dB in any of the frequencies 3 K, 4 K, or 6 KHz in either ear
* – variables removed from the model after backward selection procedure

and ear infections (OR = 3.76, p = 0.03) showed a significant association with hearing loss at the noise-sensitive frequencies of 3000, 4000, and 6000 Hz. In particular, no significant associations were found for reported exposure to tractor or machinery noise, guns, loud music, or a noisy job during the rest of the year.

Comparison with the Hispanic HANES Population

Figure 1 shows, by age category, the prevalence of hearing loss at 4000 Hz in Mexican and Puerto Rican male agricultural workers compared to that of Mexican and Puerto Rican males in the HHANES survey. In all age

TABLE 3b. Factors Associated with Difficulty Hearing or Understanding Speech: Hearing Threshold Averages as Continuous Variables (N = 150)

	Bivariate Model		Multivariate Model*	
	OR (95% CI)	p	OR (95% CI)	p
Demographic Factors				
Age	0.99 (0.97,1.02)	0.67	–	–
Male	1.30 (0.32,5.24)	0.72	–	–
Hispanic ethnicity	3.70 (1.33,10.29)	0.01	3.56 (1.26,10.03)	0.02
Tympanometry				
Normal (reference)	1.00	–	–	–
Abnormal	1.08 (0.43,2.73)	0.88	–	–
Unknown	0.56 (0.22,1.44)	0.23	–	–
Hearing Threshold Average				
Low frequency †	1.03 (0.99,1.07)	0.12	–	–
High frequency ‡	1.91 (1.02,1.08)	0.003	1.04 (1.01,1.08)	<0.01

† Average hearing threshold at 0.5,1, and 2 KHz (worse ear)
‡ Average hearing threshold at 3, 4, and 6 KHz (worse ear)
* – variables removed from the model after performing a backward selection procedure

TABLE 4. Prevalence of Risk Factors for Hearing Loss (N = 150)

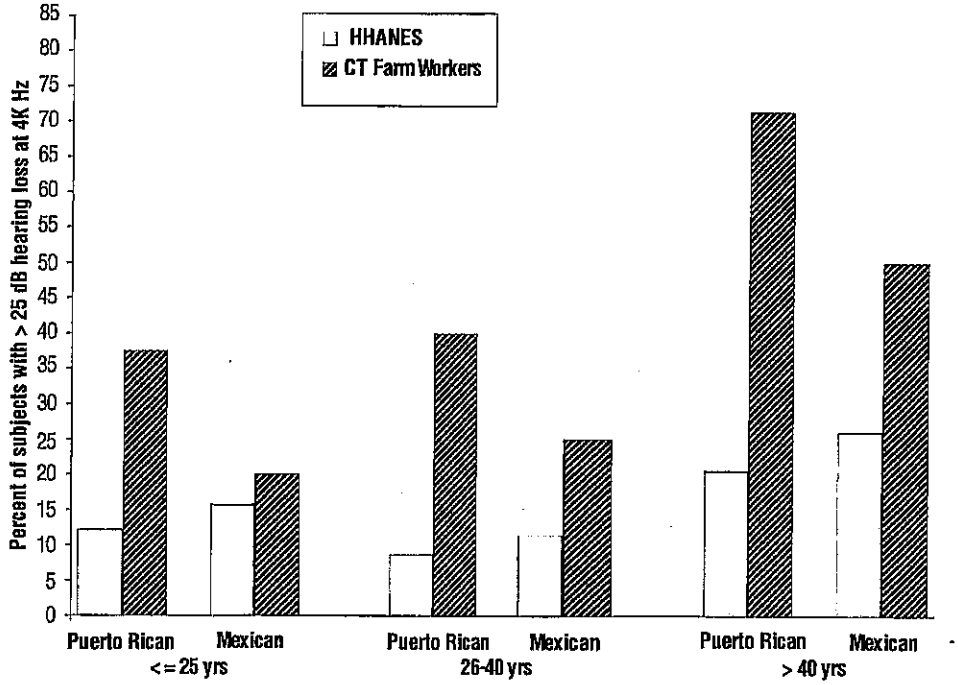
Reported Exposures–No. (%)	
Machinery	53 (35.3)
Tractors	54 (36.0)
Pesticides	78 (52.0)
Use of hearing protection	21 (14.0)
Fired a rifle or pistol	32 (21.3)
Noisy job rest of the year	53 (35.3)
Loud music	87 (58.0)
Medical Risk Factors–No. (%)	
Allergy	28 (18.7)
Head Injury	29 (19.3)
Ear Infection	27 (18.0)
Family history	19 (12.7)

groups, the farm workers had substantially higher rates of high-frequency hearing loss than the comparison HHANES population.

DISCUSSION

The findings of this study indicate that migrant agricultural workers may have disproportionately high rates of hearing loss. Hearing loss was present even in workers in the younger age categories, while overall, 12% of the subjects had hearing loss that met AMA criteria for hearing impairment, and more than 50% of the individuals in the sample had hearing loss ≥ 25 dB at one or more audiometric frequencies. Testing for middle ear dysfunction was abnormal in 19% of those tested, and this dysfunction was associated with greater risk of hearing loss and subjective hearing difficulty. Overall, more than 35% of the farm workers reported subjective difficulty with hearing or understanding speech. These complaints were increased among Hispanics, even after adjusting for age and presence of hearing loss, suggesting an effect of language barriers on the impact of hearing loss. Mexican and Puerto Rican male farm workers had greater hearing loss at the noise sensitive frequency of 4000 Hz compared to the HHANES comparison population. While reported exposures to noise and pesticides were common, use of hearing protection was rare. These findings have relevance for clinicians providing medical care for migrant worker populations, as well as occupational health professionals interested in reducing health risks for agricultural workers.

FIGURE 1. Prevalence of hearing loss at 4000 Hz by age catagory: Male Hispanic farm workers vs. males in the HHANES survey.



The study design was limited by the convenience nature of the sample. Screenings took place at migrant health fairs where other activities were also taking place over a period of several hours, and the screening effort was limited by time and space constraints. While we do not have definite figures about the total number of persons who attended the fairs, an estimate that 10-20% of attendees received hearing screening appears reasonable. Since we were not able to test the entire population at the fair, much less all workers, it is possible that some degree of selection bias occurred, and that the results of the survey are not representative of all migrant workers as a group. For example, individuals with existing hearing loss or perceived hearing difficulties may have been more motivated to participate in the study, leading to an overestimate of hearing loss in the population. On the other hand, it is possible that individuals with significant hearing problems would have declined to participate in the survey out of reluctance to be identified, despite the anonymous survey design. Such a phenomenon would lead to an underestimate of hearing loss prevalence in the population.

The prevalent finding of hearing loss was often accompanied by subjective difficulty with hearing and understanding speech. This association was confirmed in a multivariate model that adjusted for age, gender, ethnicity, and tympanometry status. At the same time, while 12% of the sample had hearing loss that met criteria for "hearing impairment," none of the subjects reported current use of hearing aids. A study of Hispanic adults in the HHANES sample found hearing aid usage rates between 2 and 12% among hearing impaired individuals.[8] That this is a lower rate than the 14-55% hearing aid usage prevalence reported for a largely Caucasian population may reflect access to care difficulties as well as cultural perceptions about the treatment of hearing loss, although in the general U.S. population, rates may be almost as low.[19] Similarly, the high rate of middle ear dysfunction in this sample of adults may be a reflection of dietary factors, allergy, or infection related to socioeconomic status.

The association between Hispanic ethnicity and speech perception difficulties, even adjusting for actual hearing loss or measured hearing threshold averages, suggests an effect of lan-

guage barriers on perception of hearing difficulty. In human speech, consonant sounds are higher frequency than vowels, and individuals with high-frequency hearing loss consequently may experience difficulties with speech discrimination, especially in situations of background noise. This problem may be exacerbated when one is trying to understand a second language. Virtually all of the Hispanics were from Spanish-speaking countries or territories where Spanish would be the first language spoken in the home. It is possible that these workers, living in a country where they encountered English as a second language, would be more aware of hearing difficulties for a given degree of actual hearing loss than their English-speaking counterparts. Such difficulty could interfere with their acculturation into U.S. society. An alternative explanation would be that the Hispanics in the sample were less reluctant to admit hearing difficulty than the non-Hispanic workers.

While the rate of high-frequency hearing loss was greater in the Hispanic male migrant agricultural workers compared to a reference population (HHANES), we were not able to identify occupational sources of noise or pesticides that correlated well with measured hearing loss. One possible explanation was that the brevity of the questionnaire that was designed to rapidly screen participants for significant factors related to hearing loss could have led to exposure misclassification. One important limitation of our exposure assessment was the lack of information regarding dose and frequency of exposure. Another possibility for the lack of correlation is that noise exposures in other jobs could be playing a greater role. Many of the farm workers reported spending time in construction and other activities during the rest of the year. Age was significantly associated with hearing loss, while this could represent purely the effect of presbycusis, it is also possible that the association reflected in part the cumulative impact of noise and chemical exposures, which are also associated with age. Future studies of hearing loss in migrant workers should explore such exposure issues in greater detail.

Despite a high prevalence of reported exposures to noise sources, only 14% of the subjects reported using hearing protection. Other studies of Hispanic workers have shown that perceived self-efficacy and barriers to hearing protection use are important predictors of actual use.[20] It was encouraging that workers in the commercial nursery, with higher prevalence of reported noise exposures, were more likely to wear hearing protection. There appears, however, to be room for further improvements in training and enforcement of hearing protector use in migrant agricultural worker populations.

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RECEIVED: 10/11/2004
REVISED: 03/08/2005
ACCEPTED: 06/21/2005