ORIGINAL ARTICLES AAEM

Ann Agric Environ Med 2002, 9, 157–162

HEARING LOSS AMONG PRIVATE FARMERS IN THE LIGHT OF CURRENT CRITERIA FOR DIMINISHED SENSE OF HEARING

Leszek Solecki

Department of Physical Occupational Hazards, Institute of Agricultural Medicine, Lublin, Poland

Solecki L: Hearing loss among private farmers in the light of current criteria for diminished sense of hearing. *Ann Agric Environ Med* 2002, **9**, 157–162.

Abstract: The study covered a group of 128 private farmers aged 28–65 (mean age 47.2) who had a period of occupational activity of 11–40 years (23.9 years average). The evaluation of hearing capability was based on 2 calculated values: PTA (mean from frequency: 0.5; 1; 2 and 3 kHz) and HFA (mean from 3; 4; and 6 kHz). Statistically significant differences in mean hearing loss were observed between the 2 groups in the study: farmers - control group ($p < 0.001$). The value of 20 dB was adopted as a criterion of the deterioration of hearing. This criterion was exceeded in 78% of farmers examined – within the range of high frequencies (HFA), and in 45 % of farmers within the range of medium frequencies (PTA). In the control group, abnormal hearing loss was noted in 17% of people only for mean HFA value. In the group of farmers a significant correlation was noted between hearing loss (PTA and HFA) and age, as well as period of occupational activity. It was statistically confirmed that the most significant decrease in hearing occurred during the age interval up to the age of 50 and during the period of occupational activity of up to 30 years. The results of the study confirmed that noise present in the agricultural environment is the primary cause of the decrease in hearing among private farmers.

Address for correspondence: Doc. dr hab. Leszek Solecki, Department of Physical Occupational Hazards, Institute of Agricultural Medicine, Jaczewskiego 2, P.O. Box 185, 20-950 Lublin, Poland. E-mail: solecki@galen.imw.lublin.pl

Key words: hearing loss, PTA (Pure Tone Average), HFA (High Frequency Average), farmers, control group, age, period of occupational activity, diminished sense of hearing.

INTRODUCTION

Noise is one of the most important physical factors occurring in an agricultural working environment which is produced as the result of operating such machinery and mechanical equipment as: tractors operating with agricultural units, self-propelled agricultural machines, machines for fodder production, chain and electric saws, and various types of equipment used for repair [16].

In German agriculture [12], the manual handling of loads, noise and vibration create the main occupational health risks. Noise-related hearing impairment occupies the third position among occupational diseases recognized in agriculture. As early as 1937, bilateral hearing loss within the range of high frequencies observed among American farmers was reported by Bunch [3]. Studies of the state of hearing conducted by Glorig [6] confirmed a considerably greater hearing loss within the range of high frequencies (2–6 kHz) in older American farmers, compared to office workers of a similar age. Further investigations by Townsend *et al.* [21], Mönnich [13], Thelin *et al.* [20], Minczewa [11], Jindřichova *et al.* [8], Czerniuk [4], Karlovich *et al.* [9], Franzinelli *et al.* [5] and Beckett *et al.* [1], showed that occupational exposure to noise present on farms is the main cause of hearing loss among farmers. The age of farmers and the number of years spent on a farm are highly correlated with hearing loss.

In Poland, the problem of noise-related health risk among private farmers is poorly recognized and underestimated. This results from the fact that private farmers are not

Received: 20 May 2002
Accepted: 20 November 2002

covered by prophylactic medical examinations and are not subject to sanitary-hygienic control. The problem is especially important because over 1.3 million agricultural tractors are currently used in Poland, and it is estimated that over 1 million people are potentially exposed to noise on farms. At the present time, the Institute of Agricultural Medicine in Lublin is the only scientific centre dealing with this issue.

In order to recognize noise-related health risk among Polish private farmers the Institute conducted studies of the state of hearing in a selected group of farmers [17]. The objective of the present study was the analysis of health loss noted among private farmers with reference to the criteria concerning diminished sense of hearing (deteriorated comprehension of speech).

OBJECTIVES AND METHODS

The studies covered 128 private farmers aged 28–65 (mean age 47.2) who had a period of occupational activity on a farm 11–40 years (23.9 on average). These farmers ran family farms with a cultivated area of 10–100 ha (19.8 on average) and were exposed to noise which occurred exclusively on their own farms. In the course of further selection, farmers who had ever had ear diseases or suffered head injuries were excluded out of a larger cohort.

Preliminary environmental studies carried out previously [15] showed that during the period of the whole year private farmers are exposed to noise at the daily level of exposure of 89.1dB (mean value for the whole year; for farms: 5–40 ha).

The control group were 42 manual and office workers who during their occupational career to-date have not been exposed to noise which would result in a significant decrease in hearing (level <70dB) and with no hearing changes due to factors not related to noise. The ages of this group were similar to those of the farmers in the study (29–59; mean age 42.3).

Each farmer in the study was subject to physical laryngologic examination, taking a detailed otologic history and the proper audiometric test. The audiometric examination consisted of the determination of threshold curves for tonal air conductivity (8 pure tones of the frequencies: 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz) and bone conductivity (6 pure tones of the frequencies: 250, 500, 1000, 2000, 3000 and 4000 Hz) by means of ZALMED AAD-80 diagnostic audiometer possessing a valid certification. The examinations were performed in a specialist audiometric cabin. The results of hearing loss examinations were analysed primarily with the use of data concerning air conductivity. Bone conductivity supplemented basic medical examinations and was most often applied to exclude cases where hearing loss was due to non-occupational causes. Audiometric examination of each farmer was carried out in the morning, after 16 hours had elapsed since the last exposure (after completion of work on the day prior to the examination).

Hearing capability (deterioration of efficiency of the hearing organ) was based on 2 mean calculated values. The first value was calculated as a mean arithmetic value of hearing loss (in dB) for pure audiometric tones: 500, 1000, 2000 and 3000 Hz, denoted by the symbol PTA (Pure Tone Average), whereas the other value - as a mean arithmetic value of hearing loss (in dB) for 3 high frequency tones: 3000, 4000 and 6000 Hz - denoted by the symbol HFA (High Frequency Average). The mean PTA value (medium frequencies) contains pure tones within the range of sounds produced by human speech (300–3000 Hz), and therefore is the exponent of the quality of communication by speech. The mean value denoted as HFA (high frequencies) defines the susceptibility to hearing injury and is responsible for the reception of sounds which are harmonic components of human speech, decide about the timbre of the voice received, and to a certain extent, the possibility of recognizing individual features of the speech received. Hearing loss (mean PTA and HFA values) equal or higher than 20 dB, which were proposed as abnormal by Suter [19], were adopted as hearing capability criteria (deterioration of the efficiency of the hearing organ).

The results of the study were evaluated by use of SPSS/PC statistical programme [18]. The following statistical features were analysed: normality of data distribution (skewness, kurtosis, Kolmogorow-Smirnow test), mean values (arithmetic, median, mode), and degree of data scattering (dispersion, standard deviation). The strength of

Table 1. Statistical data for calculated mean hearing loss values (PTA and HFA) in the group of private farmers. [a] $p > 0.05$; [b] $p < 0.05$

Statistic parameter	Right ear		Left ear	
	PTA[a]	HFA[a]	PTA[b]	HFA[a]
Arithmetic mean	20.4	34.4	20.8	35.7
Standard deviation	12.2	19.4	13.7	19.7
Median	17.5	31.7	17.5	31.7
Mode	11.3	18.3	16.3	16.7
Skewness	1.80	0.84	2.25	0.83
Kurtosis	4.50	0.32	8.58	0.52
Min.–Max.	2.5–70.0	3.3–88.3	3.8–100.0	6.7–108.3

Table 2. Statistical data for calculated hearing loss values (PTA and HFA; dB) in the control group.

Statistic parameter	Right ear		Left ear	
	PTA	HFA	PTA	HFA
Arithmetic mean	9.9	11.3	8.5	11.7
Standard deviation	3.9	6.5	4.3	7.0
Median	10.0	10.0	8.8	10.9
Mode	10.0	10.0	8.8	10.0
Skewness	0.07	0.65	0.14	0.77
Kurtosis	- 0.15	0.50	- 0.07	0.48
Min.–Max.	1.3–18.8	0–28.3	0–18.8	0–31.7

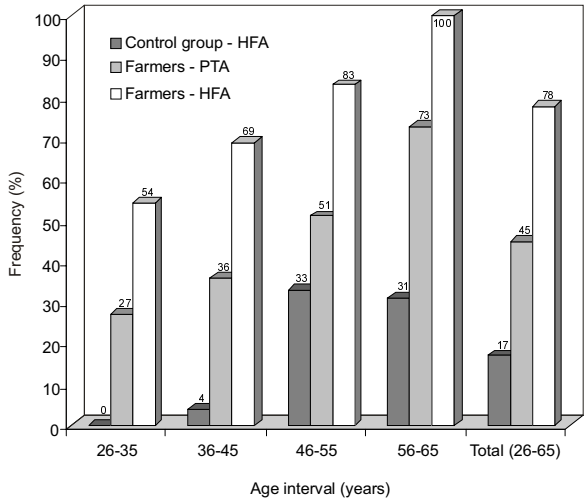

Figure 1. Frequency of occurrence of abnormal hearing loss (%).

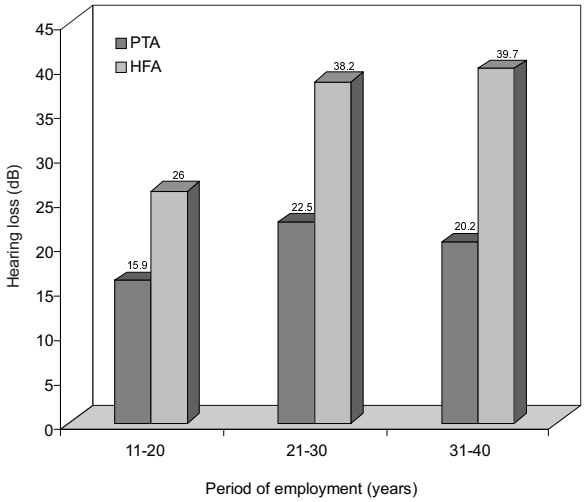

Figure 2. Mean hearing loss values (PTA and HFA) according to the period of occupational activity and ear of the person examined (dB).

rectilinear dependence between the values of hearing loss (mean PTA and HFA values) and age, as well as period of employment, was determined by means of r-Pearson correlation coefficient. In order to evaluate the significance of differences between mean values of hearing loss for the 2 different groups in the study: farmers and control group, t-Student group test for independent samples was applied (normal distributions). The significance of differences in mean values of hearing loss between the right and left ear was determined by means of t-Student test for paired samples (dependent variables, paired samples, normal distributions, and positive correlation). The character of the relationship between hearing loss and age, as well as the period of employment, was determined by means of linear regression analysis.

RESULTS

Table 1 presents the statistical data obtained for mean calculated values PTA and HFA and for both ears. The data distributions analysed for HFA (for both ears) are equivalent to normal distribution (Kolmogorow-Smirnow test; $p > 0.05$). For PTA mean value - left ear, this distribution considerably differs from normal ($p = 0.006$) due to high skewness (2.25) and considerable kurtosis (8.58). However, for PTA mean value - right ear, the distribution of data still remains within the range of normal distribution ($p = 0.056$; partial skewness and elevated kurtosis). The calculated mean arithmetic values (for PTA and HFA) are lower for PTA (20.4–20.8 dB; according to ear), however, these values are higher for HFA (34.4–35.7 dB), with standard deviation: 12.2 dB (PTA - right ear) - 19.7 dB (HFA - left ear). A similar distribution of values was obtained for median and mode. Scattering of values per unit is lower for PTA (2.5–88.3 dB) than for HFA (3.8–108.3 dB).

The calculations conducted by t-Student test for paired samples showed that mean hearing loss values for both ears were similar ($p = 0.16$ for HFA and $p = 0.75$ for PTA).

In the control group (Tab. 2) the distributions of data for 2 mean values PTA and HFA and for both ears were equivalent to normal distributions ($p = 0.36–0.71$). Mean calculated arithmetic values (for PTA and HFA) were the lowest for PTA (8.5–9.9 dB), whereas for HFA these values were higher (11.3–11.7 dB), with standard deviation: 3.9–7.0 dB and scattering of values per unit: 0–31.7 dB. Median and mode values remained within a small range (8.8–10.9 dB) and were close to mean arithmetic values, which is a feature of normal distributions. No differences were noted between the mean values for both ears.

Calculations performed by t-Student group test for independent samples indicated that in the case of private farmers the mean PTA and HFA values for both ears significantly differed statistically (were significantly higher), compared to the data obtained from the control group where the differences were very significant ($p < 0.001$).

In order to evaluate the deterioration of hearing capability in the organ of hearing in the 2 groups in the study (farmers and control group), the frequency of occurrence of abnormal hearing loss for one or both ears was determined for the values of this hearing loss ≥20dB (Fig. 1). Thus, in the whole group of private farmers (128 people), within the range of medium frequencies (PTA), 45% of such cases were noted (58 people in the study), while within the range of high frequencies (HFA) - 78% of cases (100 people). In the control group, abnormal hearing loss was observed only within the range of high frequencies (HFA) - 17% of cases (7 people).

To illustrate the frequency of occurrence of abnormal hearing loss the groups in the study were divided by age into 4 intervals: 26–35; 36–45, 46–55, and 56–65. Among private farmers the lowest incidence of hearing loss was observed in Decade I (26–35): PTA - 27%, HFA - 54%. In Decades II and III (36–45 and 46–55) the frequency of occurrence of hearing loss was higher (PTA: 36–51%; HFA: 69–83%), while the highest values were noted in Decade IV: PTA - 73%; HFA - 100%.

Table 3. r-Pearson correlation coefficients.

Study group	PTA		HFA	
	Right ear	Left ear	Right ear	Left ear
Variable: age				
Private farmers	0.38 [c]	0.37 [c]	0.48 [c]	0.49 [c]
Control group	0.40 [b]	0.56 [c]	0.57 [c]	0.73 [c]
Variable: period of employment				
Private farmers	0.21 [a]	0.15 [d]	0.30 [c]	0.23 [b]

[a] $p < 0.05$; [b] $p < 0.01$; [c] $p < 0.001$; [d] $p > 0.05$ (NS)

In the control group, however, no abnormal hearing loss was observed within the range of medium frequencies (PTA = 0%). The first abnormal hearing loss in this group and high frequencies (HFA) appeared as late as in Decade II (36–45): HFA = 4% of cases. An elevated incidence of this loss occurred in Decades III and IV and remained on an even level: 33–31%. The frequency of occurrence of abnormal hearing loss in individual age intervals was considerably higher in the group of farmers, compared to the control group.

The calculations of correlation coefficients (Tab. 3) showed that mean hearing loss values (PTA and HFA) are highly correlated statistically ($p < 0.001$) with age (farmers: r = 0.37–0.49; control group: r = 0.40–0.73); a stronger correlation being observed for high frequencies and the control group. The period of farmers' occupational activity in conditions of exposure to noise was also significantly correlated ($p < 0.01$ and $p < 0.001$) with mean values of hearing loss which covered high frequencies for both ears: HFA (r = 0.23–0.30) and with hearing loss PTA for the right ear ($r = 0.21$; $p < 0.05$).

Considering the effect of age on the values of hearing loss (so-called "old age loss"; *presbyacusis*) and various individual sensitivity to noise, linear regression was calculated for private farmers divided into 2 groups (Tab. 4). The first group covered those aged 28–50 (period of occupational activity 12–32 years; n = 87 people), and the second group - people aged 51-65 (period of occupational activity 11–40 years; n = 41). This division of farmers according to age resulted from the obtained data concerning abnormal hearing loss in the control group (Fig. 1), therefore, associated solely with the ageing of the hearing organ (old age loss). A significant deterioration in hearing was noted as late as in Decade III: 46–55 (mean age 50), and only within the range of high frequencies (HFA). Therefore, the age interval 28–50 years was selected as the first analytic group of farmers. The distribution of data in these groups, subordinated to PTA and HFA mean values, were equivalent to normal distributions ($p > 0.05$).

In the first age interval (28–50) a highly significant relationship was obtained ($p < 0.001$) between the mean HFA and age (r = 0.35–0.37) and between HFA and period of occupational activity (r = 0.29–0.38). Also, the determination coefficients (R^2) and regression coefficients (B) were relatively high. This may be evidence of a significant linear relationship between hearing loss and age, as well as period of occupational activity. A weaker relationship was noted between mean PTA values and age (r = 0.23–0.28; $p < 0.05$ and $p < 0.01$). Between PTA and period of occupational activity, however, a significant relationship was observed only for the right ear ($r = 0.23$; $p < 0.05$).

In the second age interval (51–65) a significant relationship was observed only between mean HFA value and age; this

Table 4. Results of regression analysis for private farmers.

Age interval	Mean	Ear	Variable	r	R^2	B (SE)	Sig.
28-50	PTA	Right	Age	0.23	0.05	0.45 (0.21)	0.036
			Period of employment	0.23	0.05	0.51 (0.23)	0.031
		Left	Age	0.28	0.08	0.58 (0.22)	0.009
			Period of employment	0.18	0.03	0.42 (0.24)	0.088
	HFA	Right	Age	0.37	0.13	1.15 (0.32)	0.0005
			Period of employment	0.38	0.14	1.32 (0.32)	0.0003
		Left	Age	0.35	0.12	1.10 (0.32)	0.001
			Period of employment	0.29	0.08	1.01 (0.36)	0.007
51-65	PTA	Right	Age	0.23	0.05	0.77 (0.52)	0.15
			Period of employment	0.04	0.002	0.09 (0.34)	0.78
		Left	Age	0.25	0.06	1.06 (0.66)	0.12
			Period of employment	0.01	0.0002	- 0.04 (0.44)	0.93
	HFA	Right	Age	0.32	0.10	1.65 (0.79)	0.042
			Period of employment	0.05	0.002	0.16 (0.54)	0.76
		Left	Age	0.32	0.10	1.63 (0.78)	0.043
			Period of employment	0.02	0.0006	- 0.08 (0.53)	0.88

r - correlation coefficient; R^2 - determination coefficient; B - regression coefficient; Sig. – significant.

relationship, however, was weaker ($r = 0.32$; $p < 0.05$). No significant correlation was noted between health loss and period of occupational activity. The data obtained clearly shows that up to the age of 50, apart from the physiological process of ageing of hearing organ, the hazardous effect of noise results in significant deterioration of the state of hearing. The effect of this factor decreases after the age of 50.

In order to establish the effect of period of occupational activity on conditions of exposure to noise on health loss, mean arithmetic values were calculated for 2 analysed parameters: PTA and HFA, in 3 employment period intervals: 11–20, 21–30, and 31–40 (Fig. 2). In the first interval (11–20), mean arithmetic values reached the lowest values (PTA - 15.9 dB; HFA - 26.0 dB). In the second interval (21–30) the mean values increased; especially for HFA (up to 38.2 dB), while in the third interval (31–40) the calculated mean values remained on a similar level. This confirms that the most intense decrease in hearing takes place during the period of exposure to noise, with a period of occupational activity of up to 30 years, after which the process slows down.

DISCUSSION

The results of the studies indicated that hearing loss among farmers exposed to noise are considerably higher than those observed in the control group ($p < 0.001$). Similar data were obtained by Thelin *et al.* [20], Jankowski and Piotrowski [7], Marvel *et al.* [10] and Plakke and Dare [14]. A statistically significant difference in hearing loss (mean PTA and HFA values) between the groups in the study (farmers, control), as well as the lack of differences in hearing loss noted between right and left ear, indicate that the decrease in hearing among farmers is the result of an excessive exposure to occupational noise. Marvel *et al.* and Plakke and Dare arrived at the same conclusions.

Abnormal hearing loss concerning one or both ears and exceeding 20 dB (an accepted criterion) were observed in 78% of private farmers within the range of high frequencies (HFA), and in 45% of farmers within the range of mean frequencies (PTA). In the case of the control group abnormal hearing loss occurred only for HFA - 17% of people in the study. Marvel *et al.* [10] obtained 65% of hearing loss for HFA and 37% - for PTA in a selected group of American dairy farmers. These values are slightly lower than data obtained in our study, which may be explained by the fact that the American farmers were loaded with a lower noise level (most of their time was spent in animal houses where the level of noise is lower than while operating agricultural tractors and machinery).

Considering the division of farmers into 4 age Decades, impermissible hearing loss was 54% and 27% (Decade I), 69% and 36% (Decade II), 83% and 51% (Decade III) and 100% and 73% (Decade IV), respectively. Plakke and Dare [14] reported the frequency of occurrence of medium hearing loss (frequency 1, 2 and 3 kHz) exceeding 19 dB in 3 age decades (I, II and III) as being 10%, 30% and 50%. These data are close to the values obtained in the present study for PTA, except for Decade I (in our study - 27%). This may be justified by the fact that our study group was characterised by a longer period of occupational activity (11–40) than the group of farmers examined by Plakke and Dare.

In our study, the age of farmers was significantly correlated with mean hearing loss ($r = 0.37–0.49$), this correlation being very high ($p < 0.001$). A significant correlation was also noted between the period of occupational activity ($p < 0.001–0.05$) with hearing loss ($r = 0.21\ 030$), except for the mean PTA value for the left ear. Slightly higher values of correlation coefficients were obtained by Marvel *et al.* ($r = 0.42–0.59$ for the relationship age - hearing loss, and $r = 0.33–0.42$ for the relationship period of occupational activity - hearing loss). This may be explained by the fact that the group of farmers examined by Marvel were specially selected from the aspect of age and period of occupational activity. For the control group in the present study the correlation between age and hearing loss were similar to those obtained by other researchers (e.g. Marvel: $r = 0.53–0.71$).

A series of correlation and regression analyses conducted among private farmers divided into 2 age intervals: 28–50 and 51–65 showed that in the first group of younger farmers a very highly significant correlation was observed between mean HFA values and age ($p < 0.001$; $r = 0.35–0.37$), and a slightly weaker correlation between HFA and period of occupational activity ($p < 0.01$ and $p < 0.05$; $r = 0.29–0.38$). In the second age interval (51–65, older farmers) significant relationships concerned only the correlation between HFA and age ($p < 0.05$; $r = 0.32$). These results confirm that the hazardous effect of noise on the organ of hearing takes place mainly up to the age of 50, and that younger people are more susceptible to the effect of noise (showing a greater sensitivity). Considerable health loss among young people was also described by Karlovich *et al.* [9], Broste *et al.* [2] and Marvel *et al.* [10].

An analysis of the relationship between hearing loss and period of employment indicated that the most significant decrease in hearing is observed during a period of no longer then 30 years of agricultural occupational activity. This may also be associated with the previous statement that considerable hearing loss occurs in the group of young people, during the age interval not exceeding 50 years.

CONCLUSIONS

The results of own studies and data from literature confirm the thesis that exposure to noise in an agricultural environment is the primary cause of hearing loss among private farmers.

A significant correlation was observed between hearing loss (PTA, HFA) and age, as well as period of occupational activity.

The most significant decrease in hearing due to noise occurred in the age interval up to the age of 50, and during the period of up to 30 years of occupational activity.

Private farmers should be covered by free specialist medical care (audiometric examinations) within organized prophylactic examinations.

Acknowledgements

The author would like to express his thanks to Dr Andrzej Horoch for conducting otolaryngologic examinations and technician Maria Bychawska for audiometric examinations of the state of hearing of private farmers.

REFERENCES

1. Beckett WS, Chamberlain D, Hallman E, May J, Hwang SA, Gomez M, Eberly S, Cox C, Stark A: Hearing conservation for farmers: source apportionment of occupational and environmental factors contributing to hearing loss. *J Occup Environ Med* 2000, **42**, 806-813.

2. Broste SK, Hansen DA, Strant RL, Stueland DT: Hearing loss among high school farm students. *Am J Public Health* 1989, **79**, 619-622.

3. Bunch CC: The diagnosis of occupational or traumatic deafness: A historical and audiometric study. *Laryngoscope* 1937, **47**, 615-691.

4. Czerniuk WI: Occupational hearing loss in workers engaged in work mechanisation on farms. *Wraczebnoje Dieło* 1987, **7**, 91 (in Russian).

5. Franzinelli A, Maiorano M, De Capua B, Masini M, Vieri M, Cipolla G: Annual dose of noise absorbed by machine drivers in wine and cereal growing. *G Ital Med Lav* 1988, **10**, 131-134.

6. Glorig A: Some medical implications of the 1954 Wisconsin state fair hearing survey. *Trans Am Acad Ophtalmol Otolaryngol* 1957, **61**, 160-171.

7. Jankowski J, Piotrowski W: Tractor-drivers syndrome. *Med Wiejska* 1987, **1**, 55-67 (in Polish).

8. Jndřichova J, Vesely G, Štěpanek O: Hearing loss from noise in tractor-drivers. *Pracovni Lekarstvi* 1985, **5**, 150-152 (in Czech).

9. Karlovich RS, Wiley TL, Tweed T, Jensen DV: Hearing sensitivity in farmers. *Public Health Rep* 1988, **103**, 61-71.

10. Marvel ML, Pratt DS, Marvel LH, Regan M, May JJ: Occupational hearing loss in New York dairy farmers. *Ann J of Industrial Medicine* 1991, **20**, 517-531.

11. Minczewa L: Hearing impairment in tractor-drivers. *Gig Truda i Prof Zabol* 1982, **5**, 50-51 (in Russian).

12. Mohr D: Evaluation of physical hazards at workplaces in agriculture. **In:** Solecki L (Eds): *Zagrożenia fizyczne w rolnictwie,* 80-87. Institute of Agricultural Medicine, Lublin, 1999 (in Polish).

13. Mönnich HT: General report on aspects of occupational medicine concerning noise. Inter. Conf. „Ergonomic Standards in Agriculture – Self-propelled Agricultural Machines and Tractors". 6-10 May. Potsdam 1974.

14. Plakke BL, Dare E: Occupational hearing loss in farmers. *Public Health Rep* 1992, **107**, 2, 188-192.

15. Solecki L, Zagórski J, Horoch A, Wasilkowki J, Krawczyk M, Skrzek W, Bychawska M: Recognition of exposure to noise and occupational hearing loss among private farmers on selected family farms. Study report 2.17/96 (1996-1998). Institute of Agricultural Medicine . Lublin 1998 (in Polish).

16. Solecki L: Noise-related risk among agricultural workers. **In:** Solecki L (Eds): *Zagrożenia fizyczne w rolnictwie,* 43-51. Institute of Agricultural Medicine, Lublin 1999 (in Polish).

17. Solecki L, Horoch A, Wasilkowski J, Bychawska M: Evaluation of occupational hearing loss risk in private farmers on selected family farms. Study report 2.17/99 (1999-2001) Institute of Agricultural Medicine. Lublin 2001 (in Polish).

18. SPSS/PC: Statistical data analysis. SPSS/PC + 4,0 Base Manual for the IBM-PC/XT/AT and PS/2. SPSS Inc. 444 N. Michigan. Avenue. Chicago. Ilinois. 60611, 1988 .

19. Suter AH: The ability of mildly hearing-impaired individuals to discriminate speech in noise. EPA. Hearing Report No. 550/9-78-100 U.S. Environmental Protection Agency. Washington. DC, 1978.

20. Thelin JW, Joseph DI, David WE, Baker DE, Hosokawa MC: High frequency loss in male farmers of Missouri. *Public Health Rep* 1983, **98**, 268-273.

21. Townsend T, Bess F, Fishbeck W: Hearing sensitivity in rural Michigan. *Am Ind Hyg Assoc J* 1975, **36**, 63-68.