THE EFFECTS OF CHRONIC VIBRATION AND NOISE EXPOSURE ON THE HEALTH OF WOODCUTTERS - A PRELIMINARY REPORT

Henryk Rafalski, M.D., ScD.
Institute of Social Medicine, Medical Academy
Lodz, Poland

Ryszard Jakubowski, M.D.
Institute of Occupational Medicine and Rural Hygiene
Lublin, Poland

and

Czesław Popik, M.D.
Voivodeship Occupational Medicine Dispensary
Lublin, Poland

Our investigations cover longitudinal and cross-sectional observations on the health state of woodcutters working with motor-chain saws in order to determine the influence of chronic exposure to vibration and noise on the prevalence of pathological changes in these workers. These investigations are designed to give comprehensive information which will support or correct previous concepts on vibration disease and occupational hearing loss.

I. Theoretical and Methodological Assumptions of the Study

Our investigations are justified by the unsatisfactory state of knowledge of such an important problem of occupational medicine as changes in the health state of employees working with tools producing vibration shocks and noise. This concerns many hundreds of thousands of workers exposed in various branches of industry and other branches of the national economy. This exposure and its influence on the health of employees creates a concrete medico-social demand for our investigation. A demand for examining the motor-chain saw woodcutters constituting about a 15,000 person homogenous group of employees in our country is implied by the necessity for seeking methods and organization of working conditions to prevent the occurrence of vibration disease and occupational hearing loss.

Results published up to now in national and international literature concern single and partial observations based on a small number of characteristics studied. Those papers do not explain the prevalence of pathological changes in the whole working population or whether pathological changes found in the woodcutters are connected to and to what extent with working with the motor-chain-saw. Even if this relationship was observed, it has not been stated after what period of occupational work these changes occur and what is the relation between their extent and the period of occupational exposure. The relation between the exposure to various levels of vibration and noise, cooling ability of air and noted pathological changes is not clear either. Other than vibration and noise, pathogenic factors influencing the health state of the woodcutters were not taken into account. There was therefore a need for investigations comprising multi-variable observations, using various methods from a number of medical disciplines, among others, internal medicine, neurology, otolaryngology, ophthalmology, physiology, psychology, occupational medicine and medical statistics.

Performing such multi-disciplinary investigations on motor-chain saw woodcutters is possible in our country thanks to the existence of the social health service under which there are occupational scientific research institutes, industrial health services, and sanitary-epidemiologic stations, also thanks to the citizen's right to health care and to the work legislation allowing for carrying out mass preventive health examinations.

The aims of our investigation are the following:

1. Establishment of statistical relations between characteristics of working conditions with motor-chain saw and pathological changes in the woodcutter.

2. Evaluation of prevalence of vibration disease in motor-chain saw woodcutters.

3. Description of prevalence and intensity of metabolic, functional and morphologic symptoms accompanying vibration disease.

4. An attempt to determine the mechanism of the pathological changes during vibration disease.

5. Determination of the level of noise of the motor-chain saw causing occupational hearing loss.

In order to accomplish these aims a pilot study on 100 motor-chain saw woodcutters was performed before establishing a list of variables, selecting measurement methods and organizing the investigation. The woodcutters of the pilot group were submitted to a single general medical, laryngologic, X-ray, physiologic, and biochemical examinations in order to have an idea about the extent of exposure to vibration and noise and the type of pathological changes. Results of the pilot study also served for method verification, organization of the study and recording of the results.

II. Assumptions

The investigation comprises a group of longitudinal observations on 150-200 woodcutters and 40-50 forestry workers of similar age but not exposed to vibration and noise.

In this group, observations were performed on the occurrence and dynamics of metabolic, functional and morphological changes arising because of the chronic exposure to vibration, and noise of the motor-chain saw in woodcutters working during five years in the same conditions, and in the same forest area. Examinations are performed once a year during five years of work in selected occupational conditions. Therefore, every woodcutter and employee from the control group will be submitted to the same set of examinations done by the same methods. Woodcutters and the control group submitted to the longitudinal observation are subject to the internal, anthropometric, neurologic, ophthalmologic, otolaryngologic, radiologic, psychologic, physiologic, and biochemical examinations. These investigations are performed by a team of professional specialists who were trained in this field and work in the Voivodeship Occupational Dispensaries. Every motor-chain saw woodcutter and a control person comes once a year to the Voivodeship Dispensary and is examined according to the schedule during three subsequent days. Every person is conscious of the need for these investigations and comes voluntarily.

At the same time, the measurements of vibration and noise levels of motor-chain saws, the woodcutter's daily exposure to vibration and noise, cooling ability of air, and energy expenditure of the woodcutter at work will be performed twice in the five year period. These measurements are taken by a qualified team visiting certain work posts of motor saw woodcutters in the forest.

A group of cross-sectional observation comprises 2000-3000 motor-chain saw woodcutters with different length work histories in order to distinguish some subgroups of different years of experience with the motor-chain saw in different tree covers and different climate zones. A control group of about 200-300 persons was concluded. A cross-sectional (single) observation on this group is to give information on the prevalence and type of pathologic, functional and morphologic changes in woodcutters.

All woodcutters of the cross-sectional group will be subjected to clinical, anthropometric, neurologic, otolaryngologic, and radiologic examinations and some chosen psychologic, physiologic, and biochemical tests. These examinations will be carried out by the specialist teams instructed in this field. They will be organized in 3-4 units of Voivodeship Occupational Dispensaries and Occupational Medicine Institutes. The professional teams of chosen units will use the same organization and the same sets of characteristics and research methods in order to get comparable results. Every woodcutter will come to an examining unit for three days and will be subsequently submitted to particular examinations.

Among many possible variables those which seem to be important to the achievement of the study aims were chosen. A division into independent and dependent variables was made:

- Among independent variables, ten characteristics relating to exposure to vibration and noise, and to the characteristics of vibration and noise of the saw; ten characteristics relating to the socio-occupational status of the woodcutter;

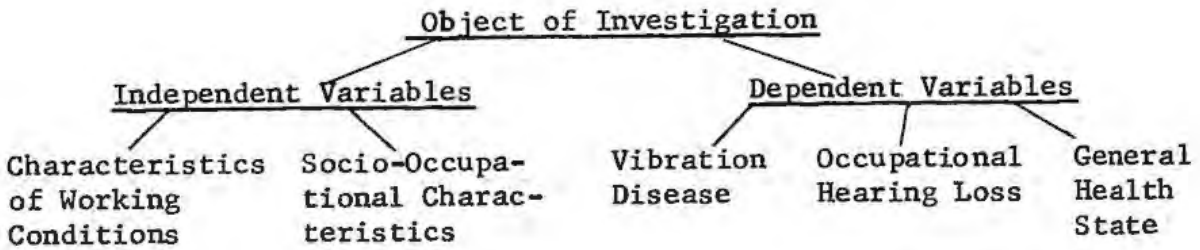
- Among 88 dependent variables there are such pathological changes which constitute vibration disease and occupational hearing loss, and those which characterize general health state of the persons examined. Within the independent and dependent variables a grouping was performed according to the method of gaining them and according to their direct and indirect importance in elucidating the relationship between the exposure to vibration and noise, and pathological changes.

Among 110 variables, because of their relevance in explaining the relationship between the exposure to vibration and noise and the symptoms of vibration disease and hearing loss, the following indices were designated as the direct ones:

among independent variables: age, period of work, working time and exposure to vibration and noise of motor-chain saw during the day and year, level of vibration (velocity, acceleration, amplitude), level of noise (frequency, intensity) at felling and cutting and exposure to cooling ability of air according to the season, energy expenditure at work, usage of personal protection, smoking, and alcohol; and

among dependent variables: muscle tension, muscle force, coordination of movements, state of peripheral vessels, state of upper extremities, disturbance of senses, disturbances of sensitivity to pain and vibration, otoscopy, bone and air conduction, state of hearing according to acuity and audiometric examinations, labyrinth excitability, state of eye fundus vessels, vision acuity, state of wrist joints, state of elbow joints, state of shoulder joints, state of lumbar vertebral column, single reaction time, vision-movement coordination, coordination of hand movements, ECG, oscillogram, plethysmogram, state of vessels after pressure, body weight, arm and forearm circumferences, shoulder breadth, skinfold thickness, levels of protein, sugar, alkaline phosphatase, phosphorus, calcium, aldolase, transaminase, hemoglobin, hematocrit, white blood cell smear, sedimentation rate, total fat level, cholesterol and esters levels in blood and urobilinogen and urobilin levels in urine.

The structure of variables can be presented as follows:



Information on the above characteristics is written on specially designed questionnaires and records using instructions prepared for a particular specialist's examinations. The whole set of information on variables comprises 17 questionnaires and records which have been prepared in such a way that the information on the variables can be analyzed using mechanographic computation technique. The necessary statistical and mathematical measures will be used in the analysis of variables.

In order to carry out these investigations four research groups were created:

- longitudinal observation of motor-chain saw woodcutters;
- cross-sectional observation of motor-chain saw woodcutter group;
- analysis, hypotheses, and publication group; and
- study control and verification group.

Work distribution of particular groups during the five year period of the contract from 1 August 1968 to 31 July 1973, is the following:

- longitudinal study group's work during the five years period:
- cross-sectional study group's work during two years, namely, the 3rd and 4th years of the contract; and
- analysis, hypotheses, and publication group, the control and verification group's work during the 2nd, 3rd, 4th, and 5th years of the contract.

Organizational links within the groups and between the groups are based on person-activity networks adjusted to particular organizational cycles of the study.

The report comprises a list of the most important methodological notes and results which were achieved during the first two years of the five-year study. According to the organizational cycle it was planned among others; examination of a pilot group, double examination of the motor-chain saw woodcutters, and control persons of the longitudinal observation group.

III. Preliminary Results of the Pilot Study

One hundred motor-chain saw woodcutters exposed to vibration and noise of motor-chain saws were examined. The age of examined persons ranged from 20 to 60 years and on the average it was 34 years. The working period with the motor-chain saw groups ranged from one month to nine years and was on the average 3.4 years.

The woodcutters worked with two types of saws which produced noise and vibration on similar levels.

The woodcutters reported pain in upper extremities, higher nervous irritability, headaches, and sleeping disturbances. It was found that the occurrence of these disturbances had statistically proved connection with the working period with motor-chain saw.

Internal medical examination showed existence of pathological changes in the cardiovascular system, bone and joint system, respiratory system, nervous system, vision system, and changes in the skin.

Otolaryngologic examination with audiometric tests found traumatic hearing loss caused by noise in 75 percent of woodcutters. A significant relation was found between hearing loss and the working period with motor-chain saws and between hearing loss and the age of the woodcutters.

X-ray examination showed that 69 percent of woodcutters had pathological changes in bones. These changes concerned bone structure and were determined as osteoporotic, atrophic, and cystic, particularly in wrist bones and forearm epiphyses and vertebral bones. A signficant relation was found between the working period with motor-chain saws and pathological changes in vertebral bones and upper extremities bones and the relation between the age of the woodcutter and changes in bones. Changes in wrist bones depended however only on the working period with motor-chain saw.

Electrocardiogram curves showed in 50 percent of woodcutters conduction disturbances and coronary ischaemia. A statistically significant relation was found between the working period with motor-chain saws, conductivity disturbances, and ischaemia.

These relationships between age, the working period, and pathological changes in woodcutters which were found and calculated were also reported in the professional literature.

IV. Preliminary Report of the First Examination of the Longitudinal Observation Group of Woodcutters and the Control Group

The age of 305 examined motor-chain saw woodcutters and 50 control persons (forest workers) ranged from 20 to 60 years and on the average it was 36 years. The working period with motor-chain saw groups ranged from 1 to 18 years. Sixty-five percent of all woodcutters worked with motor-chain saws less than 5 years, 25.6 percent from 6 to 10 years, and only 9.4 percent over 10 years.

Among control groups, 62.8 percent worked in the forest over 10 years, 16.3 percent from 6 to 10 years, and 20.9 percent less than 5 years.

Eighty-five percent of motor-chain saw woodcutters and control persons apart from their regular job activities worked on their own farms too. The examined persons have primary general education, moreover, the woodcutters have professional training to work with the saw.

Sixty-five percent of employed woodcutters are stabilized in their occupation. The remaining 35 percent leave their work after different working periods.

Smokers constituted 76 percent of woodcutters and 78 percent of control persons.

Certain characteristics of working conditions of motor-chain saw woodcutters and control persons are the same. They work in the forest in lowland areas where among the prevailing trees are pine, oak, birch, and hornbeam; spruce, larch, and poplar are less frequent. The climate has a continental character, average yearly temperature ranging from 6 to 9 degrees centigrade. The lowest temperature at which work is allowed is of minus 20 degrees centigrade.

Woodcutters and control persons work about 300 days in a year, however, felling and cutting of wood take place mainly in the autumn-winter season. Daily working time ranges from 8 to 10 hours. Effective daily working time of the woodcutter ranges from 55 percent to 91 percent, on the average 70 percent.

Effective daily working time with motor-chain saw ranges from 43 to 50 percent, on the average 31 percent of total daily working time.

Energy expenditure of the woodcutter assessed in 20 examined persons is on the average 4.8 Kcal/min net while felling, 3.9 Kcal/min net while cutting, and 6.2 Kcal/min net while felling and moving to the next tree.

Exposure time of the woodcutter to vibration and noise of motor-chain saws checked in 30 examined persons amounts to an average of 149 minutes daily, and 334 hours in a year. Exposure to these factors has an unsteady character because on the average, the woodcutter is exposed every 33 minutes to vibration and noise for about 17 minutes. This cycle is repeated irregularily regarding different interval times between sawing spells. On the average, the woodcutter is exposed to a 17 minute vibration and noise period about 8 times during the 8 hour working day. General values of parameters of vibration of the saws examined are the following:

Parameters	BK-3	Partner R-11
Velocity cm/sec	5.0 - 12.5	4.5 - 14.0
Acceleration cm/sec^2	5,600 - 18,000	10,000 - 28,000
Amplitude mm	0.06 - 0.48	0.22 - 0.27

Analysis of vibration of both motor-chain saws shows that oscillations of frequencies 63, 125, and 31.5 Hz prevail. It was found that vibration velocity of the saw is high in frequency bands ranging from 63 to 2000 Hz, particularly in the band 125 Hz.

Noise levels of the examined saws are the following:

Saws	Noise Intensity In dB According Hearing Correction Curves		
	A	B	C
BK-3	106 - 108	106- 109	107 - 110
Partner R-11	107 - 108	105 - 106	107 - 108

Spectral analysis shows that the highest noise intensity exists in frequencies 500, 1000, 2000, and 4000 Hz.

Analysis of the health state of 247 examined motor-chain saw woodcutters exposed to vibration and noise of the saw and 43 forestry workers not working with the saw shows that 141 (57 percent) of woodcutters and 22 (51 percent) control persons have various pathological changes.

Forty-seven (33 percent) out of these 141 woodcutters showed symptoms of the vibration syndrome in the form of vascular, osseous, and nervous changes. Statistically significant relationship was found between the symptoms of vibration syndrome and the working period. However, this relationship was not found between the symptoms of vibration syndrome and the age of woodcutters. Furthermore, 40 examined (28 percent) out of 141 woodcutters have changes in wrist, forearm, and vertebral column bones. These is a significant relationship between osseous changes and the working period, but no relationship was found between these changes and the age of the woodcutters. Other pathological changes found in the examined woodcutters show significant relationship with age and no significant relationship with the working period.

Among 43 control persons seven (16 percent) showed symptoms similar to vibration syndrome and five (12 percent) pathological symptoms in bones similar to changes in woodcutters. These two types of changes do not, however, show any relationship with age and the working period of the control person. Findings of similar changes in control persons required further details in investigations in order to find their cause.

Evaluation of pathological changes diagnosed by internist, neurologic, otolaryngologic, ophthalmologic, radiologic, psychologic, physiologic, and biochemical examinations showed that in woodcutters pathological changes of cardiovascular system, nervous system, hearing and vision systems, and in bones are significantly more frequent than in control persons. These changes simultaneously aggravate the working period of the woodcutter in the range of one to 15 years and more working with the motor-chain saws.

More important findings of the examinations of woodcutters from the pilot group, the first examination of woodcutters, and control persons of the longitudinal observation group are the following:

> changes in upper extremity bones, vertebral bones and hearing losses depend on the working period with the motor-chain saws.

pathological changes in cardiovascular and nervous systems, hearing and vision systems, and bones are significantly more frequent in woodcutters than in control persons and depend on the working period with the motor-chain saws.

On the basis of the two year period of investigation a confrontation could be made between the methodological assumptions and experiences and preliminary results achieved. Methodological and organizational experience acquired enable us to state that the study aim can be achieved within the five year observation.

Discussion After Dr. Rafalski's Paper:

Dr. Lainhart:

I was interested that you were including in your investigation the educational-social differences. We examined some workers in the community where there are coal miners and other workers and the small differences between education-social backgrounds were apparently important. We don't know why, but they have the same role to play in the differences, for example, symptoms and signs of disease. Completely aside from such obvious things as pneumoconiosis and coal miners. So I was glad that you included those factors in your analysis.

Dr. Henschel:

First a comment. In some animal work in Poland with high frequency and intensity vibrations in the rats, very short exposures produce changes in the production of acetylcholine and acetylcholinesterase in the nervous tissue. I was told the frequency level is similar to the frequency of vibration that the woodcutters are exposed to. Did you find any differences between the men who are using the lower frequency vibration saws and the higher vibration saws? Were you able to break your group down to see whether there are any differences in the responses of these two groups?

Dr. Rafalski:

According to Dr. Lainhart's comment we think that there is the influence of social-economical condition on the increase of pathological symptoms. The education plays a role in using protections. Maybe the more educated workers used them properly. They protect themselves every day. We always include in our epidemiological study the social-economical condition.

Dr. Lainhart:

Is there any attempt at getting at the type of nutrition in the two groups? Are there social differences, with regard to the kind and amount of food eaten? You said that they lived in the same general environments in the woods or, I suppose, small villages, but do they in essence have the same kind of nutrition background?

Dr. Rafalski:

The answer is yes. As I said about 85-90 percent of the woodcutters are not pure workers. We call them peasant workers. They have small farms and usually men become a forestry worker or do other work, for instance, in the industrial plants. In that area we are talking about, there is the similar pattern of diets and nutritional status of the persons. We are considering to include diet surveys but it is easier to state the nutritional status than to examine the diets. As you know, it consumes a lot of time to investigate diets. We need one week observations at different seasons in a year. So it is a time consuming examination in addition for each family an investigator must be there to see what they eat, how they eat, what quantity they eat, etc. So this problem is very complicated to study. At present we include the observation of nutritional status of woodcutters and control persons, so we can get some idea of food intake.

Dr. Lainhart:

But would the financial or the percapita income or family income be the same in the two groups between the woodcutters and the controls? In terms of the amount of Zlotys that they have to buy the things they need: household, furniture, food. In the whole social aspects, are they the same?

Dr. Rafalski:

Yes, but woodcutters earn more than the control group, because their work is more dangerous and specialized. Simultaneously they have smaller land. So, maybe the income percapita is quite similar.

Dr. Rafalski: (answer to Dr. Henschel's question)

They use two saws, but both saws are similar in producing the level vibration and the level of noise. One is Swedish and another is Polish, and the Polish one was constructed according to the pattern of Swedish. Well, let us say the Polish one is a little bit better, maybe less dangerous, but it should be proved. According to the detailed answer to Dr. Henschel's question we shall look for exposure to two saws. Talking of the usage of the saws I should like to say that about 70 to 80 percent of the woodcutters use Polish saws and 20-30 percent use the Swedish one.

Dr. Potkonjak:

I understand your study is just in progress and it seems to me far from the end; therefore I understand you are in the same situation as is with my project, and it is not possible to give any definitive conclusion, but anyway, I would like to ask you the question not about a conclusion but about your impression. It is stated that low blood pressure is background for the development of the effects of the chronic vibration. In our examination we did not prove this statement, what is your impression?

Dr. Rafalski:

I am not sure that I can give you the right answer because I have no data with me about the blood pressure in woodcutters. We measure among the physiological test the blood pressure before the effort and after the effort.

Dr. Potkonjak:

May I ask you a question: Did you include finger plethysmography as a method of examination?

Dr. Rafalski:

The answer is yes. We included it.

Dr. Potkonjak:

I am asking that because I had the opportunity to follow-up a group of woodcutters and we noticed that in a number of workers, who in the first year of the examination had no complaints, had abnormal plethysmography curves, only one year later these workers showed the other signs of the vibration syndrome. Therefore, we are inclined to conclude that plethysmography method is the best one for discovering very early changes.

Dr. Rafalski:

Yes, you are right. We have similar experiences which we got from our pilot study.

Dr. Giec:

You have told us that some of your investigated subjects have the sign of coronary disease. How do you explain these changes, because as I know this kind of work does not give predisposition to the coronary vessel changes.

Dr. Rafalski:

We have some data on rats. We examined rats exposed to the different kind of vibration (low and high frequency vibration) and we found some biochemical and morphological changes in vessel collagen. The impression is that the vibration might have an influence on vessels. In that observation we are talking about, we examine the electrocardiogram of woodcutters. We found some disturbances in conductivity and non-specific ST-T changes. We think the prevalence of those disturbances is too high. We shall look into our results whether the disturbances have been involved by the vibration or by the age.

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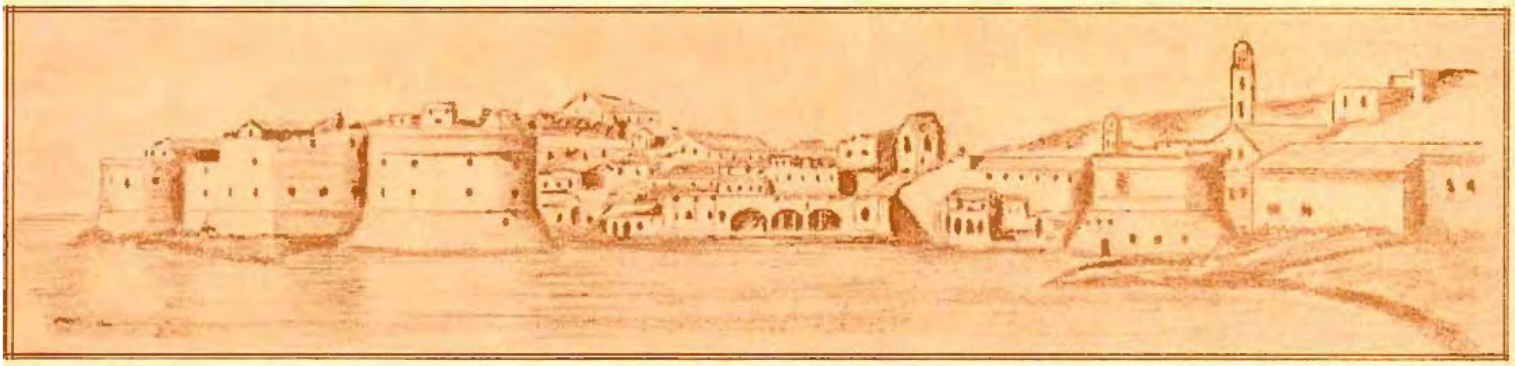

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