Depressive Clinical Manifestations Associated with Professional Aluminum Exposure

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The aim of this study was to analyse the relation between professional aluminum exposure and depression. The study was performed on a number of 99 subjects exposed to aluminum, during a professional activity of 8 to 38 years in the aluminum production industry. The control group was represented by 36 subjects from the administrative sector. Chronically exposure to aluminum determined: headache, insomnia, apathy, asthenia, and a decrease in libido. Moreover, depression was more frequent in subjects chronically exposed to aluminum.

Keywords: aluminum, professional exposure, depression.

Aluminum is the most frequent metal seen on the surface of the Earth, with numerous uses, especially in the automotive, pharmaceutical and food industries, electronic devices manufacture industries and transportation. Simple aluminium salts, aluminium sulphate and polyaluminium chloride with an alkalinity of 80% [16] are also widely used in water treatment as coagulants in order to reduce organic matter and microorganism levels [1, 15].

Both obtaining and processing the aluminum, exposes workers to this metal, which is inhaled and absorbed in the organism.

The central nervous system represents one of the main target organs which the aluminum affects [1]. Due to the decreased permeability of the hematoencephalic barrier, the metal passes into the brain using a transferine dependent system, forming low weight molecular complexes [2]. That is why, aluminum interferes with the cellular homeostasis of iron, thus influencing cerebral iron dependent processes [2-3]. On the other hand, aluminum inhibits certain neurotransmitters (glutamate, gamma aminobutiric acid (GABA), choline, noradrenaline and serotonine). Aluminum also determines neural degeneration by decreasing the number of microchannels in the affected neurons, dendritic cells and other cells involved in memory [4]. Aside from the neurotoxic effects, this compound is imunotoxic as well. By releasing cytokines, aluminum induces inflammation and other immune reactions [5-6]. Usually, aluminum accumulates intracellularly, where it alteres the DNA and determines epigenetic modifications, thus having a mutagenic effect [6-7].

Aluminum is proved to be involved in the ethiopathogeny of encephalopathy and neurodegenerative diseases [8-9]. It also accelerates the nervous system aging [5]. Its neurotoxic effects are manifested as coordination problems, sedation, memory affliction, but it is also involved in depression and anxiety mechanisms [1]. Chronic exposure determines irritability, headaches, decrease in concentration ability, insomnia, vertigo, emotional lability, dysmnesia, anxiety and fear [10], fatigue, and mild motor function impairment [11]. Research performed on a number of subjects exposed to aluminum identified cognitive decline, memory problems, depression, anxiety, personality disorders [12].

Based on the data found in literature, this study aims to analyse the relation between professional exposure and depression.

Experimental part

Study protocol

The study was designed as an observational trial. The study included 135 patients age 20 to 65years old, who were hospitalized in the Work Medicine Clinic, Colentina Clinical Hospital, Bucharest, admitted for respiratory and musculoskeletal afflictions, between 01.06.2011-31.05.2012. The study group comprised of 99 subjects exposed to aluminum, all working in the aluminum industry, involved in the supervision of the technological process, repairing, maintainance, cleaning and manual manipulation of masses. The people exposed to aluminum pertain to different professional categories (electrometal workers, smelters and locksmiths). The study group was compared to a control group, containing 36 subjects as well, who were not exposed to aluminium (from the administrative sector, who performed desk work).

The inclusion criteria were: professonally active age of 20-65 years old, workplace in the aluminum industry, more than 1 year employment, female or male patients, admitted for respiratory and musculoskeletal afflictions, patients who graduated highschool or a professional school and patients who signed an informed consent.

The exclusion criteria were: age over 65, no formal education, people who were no longer working in the aluminum industry, psychiatric disorders, alcohol abuse, recent history of stressful personal events, patients with Alzheimer or Parkinsons disease, medical history of cerebrovascular disease, the refusal to participate in the study.

Our primary endpoint was to determine the relationship between aluminum exposure and depression. This was evaluated by the presence of certain central nervous system symptoms: headache, insomnia, apathy, asthenia, libido decrease. Speaking about the secondary outcomes of this study, we tried to determine whether the professional categories have a different distribution depending on age, sex, smoking status and alcohol consumption.

The study group evaluation protocol included taking the medical history, enquiring possible personal medical

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history related to depression, the professional history, body mass index (BMI), lifestyle (smoking, alcohol consumption) and a medical questionnaire regarding the central nervous system symptoms, after obtaining an informed consent from each subject. The medical questionnaire included questions regarding certain symptoms: headache, insomnia, apathy, asthenia, libido decrease.

We characterised each group by determining: the distribution on professional category, mean age, gender distribution, smoker/non-smoker, alcohol consumption and employment years. The normality of the included subects' distribution was tested using the Kolmogorov-Smirnov test. The tested variables comparison between the subgroups was determined by parametric tests (t-student, ANOVA) and nonparametric tests (chi–square test - Pearson).

Results and discussions

38 electrometal workers (28%), 12 smelters (9%) and 49 locksmiths (36.3%) were included in the study group. Considering these people, the most exposed professional category is the smelter category, followed by electrometal workers and locksmiths. The control group, considered as the not exposed group, included 36 subjects (26.67%) from the administrative sector, who performed desk work.

Depending on the age of the subjects, the study group was divided in: 19 people with ages between 20-19 years old, 27 people with ages between 30-39 years old, 64 subjects with agest between 40-49 years old, 21 people with ages between 50-59 years old and 5 subjects with ages between 60-65 years old (fig. 1). The minimum age was 20 years old, while the maximum one was 65 years old. Regarding the age distribution, the study group was omogenous, as said by the statistical analysis of the data.

Age analysis depending on the professional category showed that electrometal workers had a mean age of 41.39 years old (± 6.37 SD), smelters 46.58 years old (±6.45 SD), locksmiths 45.90 years old (±5.76 SD) and administrative personnel 38.31 years old (±14.08 SD). Aside from the control group, represented by the administrative personnel, all the other professional categories had the means and centers relatively similar. We can consider them all as part of the same „risk group", not taking into consideration the risks associated with each profession (table 1).

After the analysis of the gender distribution, we observed a higher number of male subjects (81%) than female subjects (19%), which can be easily explained by the fact that the production phase of the aluminum industry is dominated by male workers (fig. 2).

The study group distribution depending on the employment years included 4 categories, 40% of the workers were employed between 8 and 17 years, followed by the 18 and 27 employment years (32%), the 28 and 38 years category (16%) and between 1 and 17 years (12%) (fig. 3).

The group distribution was performed depending on employment years and the professional categories (fig.4). By compairing the mean values of the employment years,

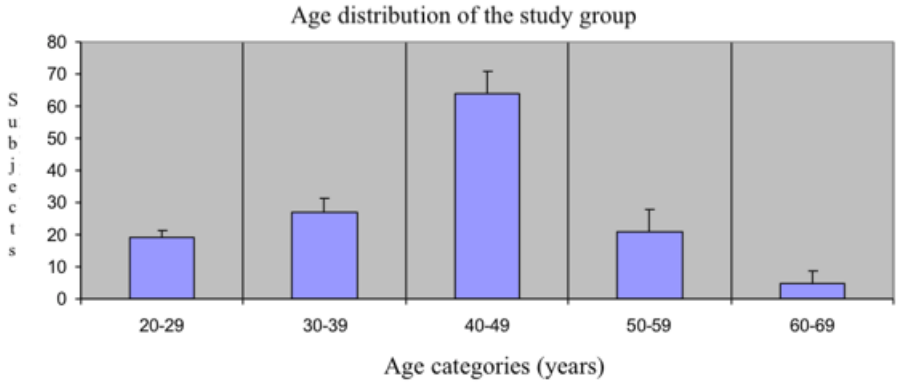

Fig. 1. Age distribution of the study group

Study group	Age Mean	Dev. Std	Er. Std	Center	Min	Max
Electrometal worker	41.39	6.37	1.033947	40.5	30	55
Smelter	46.58	6.45	0.911715	46	38	56
Locksmith	45.90	5.76	1.662685	44	31	59
Administrative	38.31428571	14.08957	2.381572	34	20	65

Table 1
MEAN, CENTRE AND STANDARD DEVIATION FOR THE STUDY GROUPS DEPENDING ON THE PROFESSIONAL CATEGORY

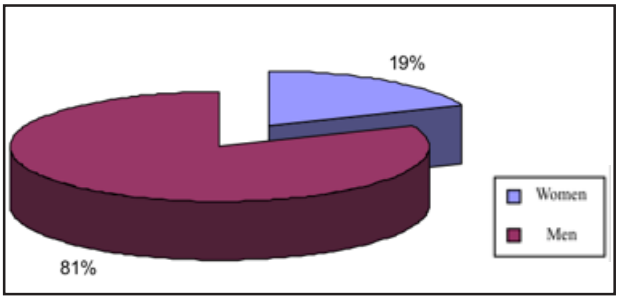

Fig.2. Gender distribution of the study group

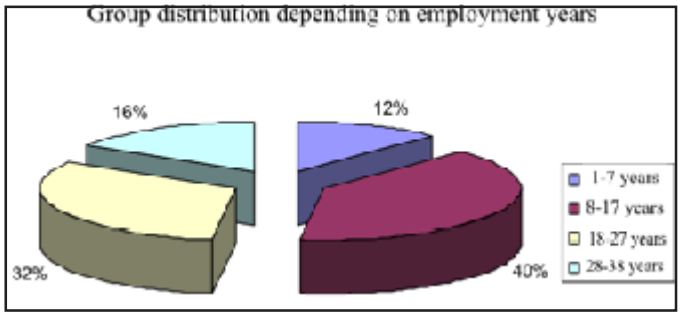

Fig. 3. Study group distribution depending on employment years

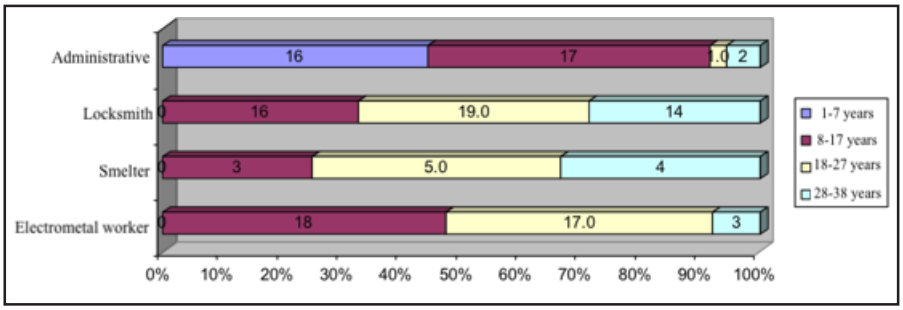

Fig. 4. Distribution on professional categories depending on employment years

Table 2
ANOVA TEST FOR COMPARISON OF THE EMPLOYMENT YEARS

			Mean Difference (I-J)	Std. Error	Sig.
Tukey HSD	Electrometal worker	Locksmith	-4.50526	1.94082	.098
		Smelter	-5.18860	2.98624	.309
		Administrative	3.08045	2.11279	.466
	Locksmith	Electrometal worker	4.50526	1.94082	.098
		Smelter	-.68333	2.89896	.995
		Administrative	7.58571*	1.98752	.001
	Smelter	Electrometal worker	5.18860	2.98624	.309
		Locksmith	.68333	2.89896	.995
		Administrative	8.26905*	3.01679	.035
	Administrative	Electrometal worker	-3.08045	2.11279	.466
		Locksmith	-7.58571*	1.98752	.001
		Smelter	-8.26905*	3.01679	.035
Dunnett t (2-sided)[b]	Electrometal worker	Administrative	3.08045	2.11279	.341
	Locksmith	Administrative	7.58571*	1.98752	.001
	Smelter	Administrative	8.26905*	3.01679	.019

we showed that the exposure to aluminum was in relation to the employment years ($p<0.01$).

The analysis using the parametric ANOVA tests for compairing the employment years between the study groups showed that there are statistically semnificative difference between the professional categories, the minimum mean employment years being found in the administrative personnel, and the maximum in the locksmith group (table 2).

Depressive manifestations were present in 18.18% of the smelters, followed by electrometal workers (13.16%

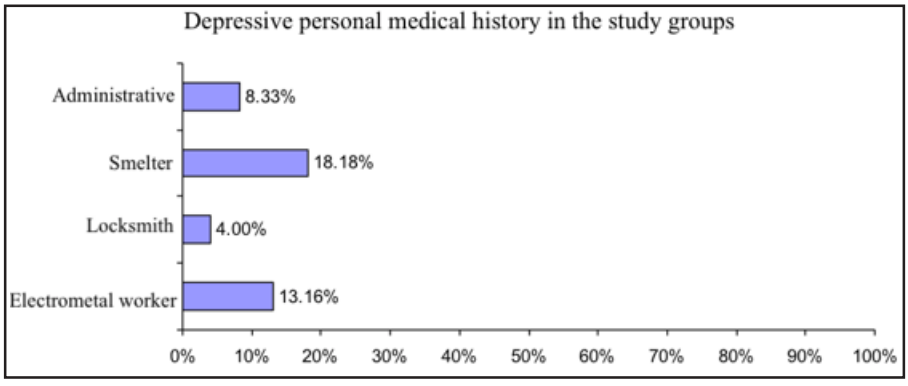

Fig. 5. Personal history of depression of the subjects

of them). 8.33% of the administrative personnel and 4% of the locksmiths had depression symptoms (fig. 5).

After the statistical analysis, no statistically significant differences regarding the depressive history were seen in the study groups.

In the study group, we evaluated the BMI in order to establish whether depressive manifestations and the results represented in figure 6 are related. We observed that in 58 cases, the BMI was normal (BMI between 18-25), in 68 of the cases the subjects were overweight (BMI between 25.1-30), while only 9 people were obese (BMI>30).

32 subjects from the overweight group were locksmiths, while 5 obese subjects were electrometal workers, the mean BMI differences depending on the professional categories were statistically semnificant ($p<0.01$), correlated with aluminum exposure.

The exogenous risk factors related to the study participants' lifestyle, such as smoking and alcohol consumption, can intervene in the development or evolution of depression.

Smoking was seen the most frequent in electrometal workers (52.63%), followed by locksmiths (48%), smelters (36.36%) and the control group (22.22%) (fig.7).

After the statistical analysis of the data we can safely say that there is no difference between the exposed group and the not exposed group.

80% of the locksmiths, 57.89% of the electrometal workers, 54.55% of the smelters and only 16.13% of the administrative personnel chronically consumed alcohol (table 3).

Statistical analysis showed that the difference in alcohol consumption in the exposed and not exposed groups was statistically significant ($p<0.05$). The decreased incidence of alcohol consumption in administrative personnel can be explained by the small age of the subjects and better work environment.

The headache incidence depending on the professional category was present in similar percentages in the aluminum exposed group (47.37% electrometal workers, 45.45% smelters and 44.90% locksmiths), while in the administrative sector it was lower (11.11%) (table 4), the difference being statistically semnificant ($p<0.05$).

Another symptom present in the medical questionnaire, insomnia was present in 73.47% of the locksmiths, 50% of the smelters, 47.37% of the electrometal workers and 8.33% of the control group (fig. 8).

After statistical analysis (table 5), we saw that the differences between professional categories and the

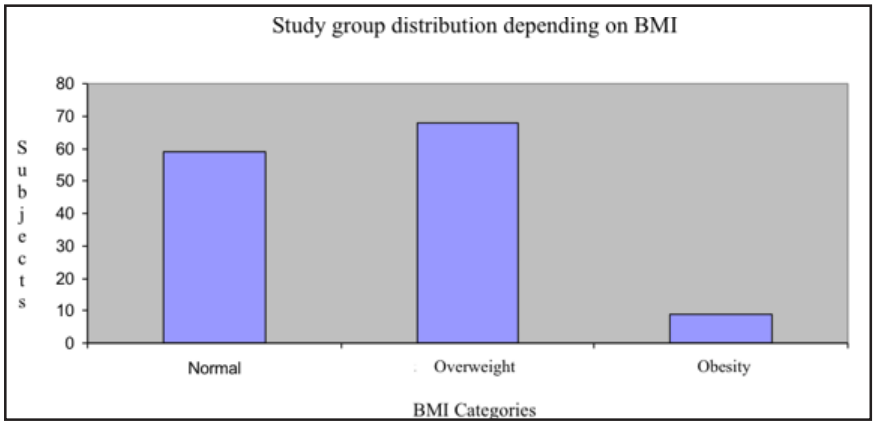

Fig. 6. Body mass index (BMI) of the subjects

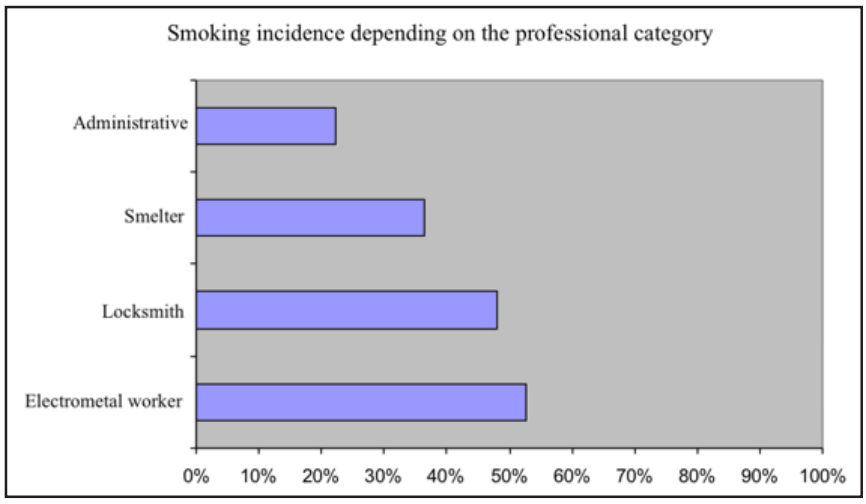

Fig. 7. Smoking prevalence on the professional categories

Alcohol	Present	Percentage	Absent
Electrometal worker	22	57.89%	16
Locksmith	40	80.00%	10
Smelter	6	54.55%	5
Administrative	5	16.13%	31
	72		

Table 3
ALCOHOL CONSUMPTION PREVALENCE ON PROFESSIONAL CATEGORIES

	Electrometal worker	Locksmith	Smelter	Administrative
Present	18	22	5	4
Absent	20	27	6	32
Total	38	50	11	36
Chi square(χ2)	13.809			
p		0.003		

Table 4
ESTIMATED PARAMETERS IN HEADACHE ASSOCIATION ON STUDY GROUPS

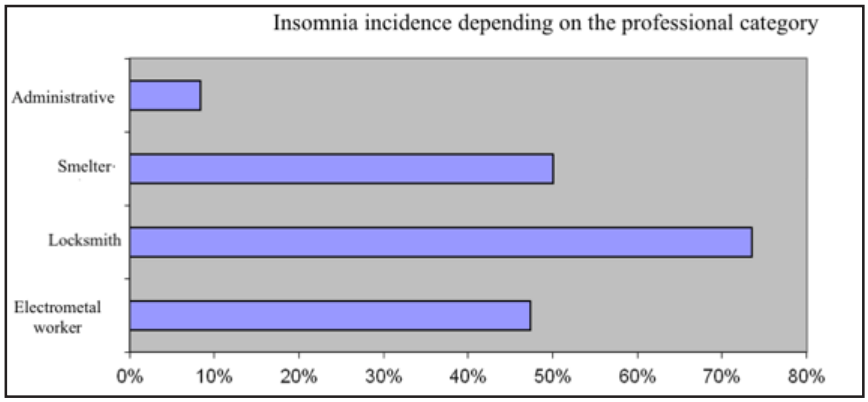

Fig. 8.Insomnia incidence on professional categories

Insomnia				
	Electrometal worker	Locksmith	Smelter	Administrative
Present	18	36	6	3
Absent	20	13	6	33
Total	38	49	12	36
Chi square (χ2)	35.459			
p		0.000		

Table 5
ESTIMATED PARAMETERS IN INSOMNIA ASSOCIATION ON PROFESSIONAL CATEGORIES

control group were statistically semnificant ($p<0.0001$). The presence of insomnia in locksmiths can be explained by the chronic exposure to high noises, another professional risk factor.

Apathy is an important symptom present in depression. It was encountered in 66.67% smelters, 55.26% electrometal workers, 42.86% locksmiths and 8.33% administrative personnel. That is to say the control group registered the lowest incidence of apathy, the highest being present in the smelters group.

The frequence of apathy observed in the aluminum exposed group is statistically significant higher than in the control group ($p<0.0001$) (table 6).

Another symptom enquired in the medical questionnaire was asthenia. Depending on the professional category, asthenia was observed in 58.33% smelters, in 57.14% locksmiths, in 50% electrometal workers and in 8.33% of the administrative sector.

The statistical analysis showed a statistically significant difference between the study group and the control group ($p<0.0001$), which allows us to assume that aluminum

Apathy				
	Electrometal worker	Locksmith	Smelter	Administrative
Present	19	28	7	3
Absent	19	21	5	33
Total	38	49	12	36
Chi square (χ2)	22.566			
p		0.000		

Table 6
ESTIMATED PARAMETERS IN APATHY ASSOCIATION ON PROFESSIONAL CATEGORIES

Asthenia				
	Electrometal worker	Locksmith	Smelter	Administrative
Present	19	28	7	3
Absent	19	21	5	33
Total	38	49	12	36
Chi square ($\chi 2$)	23.639			
p		0,000		

Table 7
ESTIMATED PARAMETERS IN ASTHENIA ASSOCIATION DEPENDING ON THE PROFESSIONAL CATEGORY

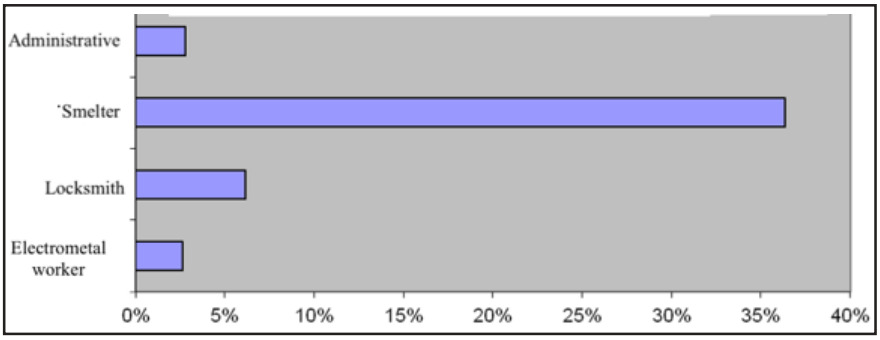

Fig. 9. Libido decrease incidence depending on the professional category

might be directly involved in determining this symptom (table 7).

The questionnaire tried to highlight possible libido decreases (considered important manifestations of depression). This symptom was observed in 36.36% smelters, 6.12% of locksmiths, in 2.63% electrometal workers and in 2.78% of administrative personnel (fig. 9).

The statistical analysis of the data showed a statistical significant difference between the study and control group ($p<0.0001$).

Conclusions

Headache, insomnia, apathy, asthenia were the main symptoms investigated in the medical questionnaire, symptoms we considered crucial in depression. The results of our study showed the positive medical hystory for these manifestations were more frequently seen than a medical history of diagnosed depression. We also enquired about the lifestyle of the subjects, people exposed to aluminum having a chronic use of nicotine and alcohol as well. In conclusion, the symptoms mentioned above were seen more frequently seen in patients exposed to aluminum than in the control group.

The symptoms characterizing depression caused by chronic professional exposure to aluminum can be correlated to the results seen in an experimental study regarding the aluminum influence on the thymus in mice, which showed that aluminum has a depressive effect in acute administration and antidepressive effect in chronic administration [13]. The following symptoms: coordination problems, sedation [14], memory affliction, are all the expression of the neurotoxic effects of aluminum.

There are other factors that can be involved in the pathogeny of these manifestations. Some of these are: professional stress, unfavourable environment, physical exertion, static electromagnetic fields, noise and others. However, the results of the study can generate other study protocols for the medical and psychological evaluation of aluminum exposed workers, in order to diagnose depression in its early stages.

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