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Research on the Relationship Between Blood Lead Level and Depression, Anxiety, and Anger-in Patients With Occupational Lead Exposure

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ABSTRACT

Background: The aim of this study is to determine the relationship between blood lead level and depression, anxiety, anger, and anger expression in workers in the battery industry who are exposed to occupational lead, and workers without lead exposure; we examine whether there is a difference between the 2 groups according to the level of exposure to lead, in terms of these variables.

Methods: Participants consisting of 102 male patients were divided into 3 groups, as 2 separate studies and a control group. The Beck Depression Inventory, Beck Anxiety Inventory, State and Trait Anxiety Inventory, and Trait Anger and Anger Expression Style Scale were applied to the participants.

Results: It was found that there was a significant positive relationship between blood lead level and anxiety, depression, trait anger, repression and outpouring of anger, and a negative relationship with the ability to control anger. It was determined that the scores for anxiety, depression, trait anger, expression of anger, and control of anger were ranked according to the level of exposure, these scores increased as the exposure increased, and there was a significant difference only in favor of the group with low exposure levels.

Conclusion: The variables of blood lead level and exposure level have predictive effects on the development of depression, anxiety, and anger-in those with lead exposure. The data we have obtained will guide us in the efforts to protect the mental health of those working in such industries.

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KEY WORDS: Anger, anxiety, blood lead level, depression, lead, occupational disease

INTRODUCTION

Neurotoxicity is a term used to describe neurocognitive and psychiatric changes caused by exposure to toxic agents, and describes heavy metal exposures. Exposure to lead is one of the most common, and can lead to significant neuropsychological changes in humans.[1]

Lead is a heavy metal that is known to suppress cellular events and damage vital organs. Exposure to lead is possible environmentally or occupationally. Lead exposure is highest in people working in industries manufacturing paint, batteries, and accumulators, fabrication of ceramics, welding, foundries, and shipyards. In recent years, especially in developed countries, industrial restrictions and widespread use of lead-free oil have significantly reduced exposure to environmental lead, but it still has not been adequately controlled.[2]

Lead-induced neurotoxicity is most commonly studied in 2 groups, acute and chronic exposure. Acute exposure often induces rapid onset nausea, headache, cognitive changes, and affective disorders. Chronic and long-term exposure, which corresponds to heavier metal exposure, is often found in industrial workplace environments. Neurodegeneration and psychiatric symptoms are more prominent in such chronic exposures.[3]

In adult populations, the neurotoxic effects of lead have been studied mainly in the context of occupational exposure, where the degree of exposure is greater than that of the general population. Occupational lead exposure remains a source of both acute and chronic exposure, In case studies and small cohort studies examined by the Agency for Toxic Substance and Disease Registry (ATSDR), it is reported that blood levels in participants range between 40 and 120 μg/dL.[4]

Workers exposed to lead in foundries, battery facilities, and lead smelters are affected in terms of cognitive and

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neuromotor domains; however, they are also reported to experience psychiatric disorders such as nervousness, anxiety, hostility, depression, anger, and increased conflict in interpersonal relationships.[5-9] The effect of lead has been discussed less in the psychiatric field than in other functional areas. Moreover, there are studies asserting that occupational lead exposure leads to critical cognitive impairments[10,11] which are possibly accompanied by psychiatric disorders as well.

The mechanisms by which lead impairs the brain and behavior are complex and not fully understood. However, the neurobiological effects of lead on brain function and behavior are explained by some mechanisms. These mechanisms are lead's ability to mimic or inhibit calcium-mediated effects[12]; blocking postsynaptic N-methyl-D-aspartate receptor (NMDA-R)[13]; binding and activating a physiological calcium ligand calmodulin (CaM) with greater affinity than calcium[14]; activation of protein kinase C (PKC) which is important for calcium-mediated long-term potentialization and decreases neurotransmitter release; and binding to voltage-gated calcium channels and binding sites on multiple proteins involved in the release of neurotransmitters such as CaM, CaM kinase II (CaMKII)[15] and synaptotagmine--competing with calcium, creating mitochondrial dysfunction.[16] Although all these mechanisms are causative of the effects of lead on memory and learning, other psychological outcomes such as aggression, anger and depressive symptoms also occur, depending on the location and degree of the exposure and its effects. In addition, lead dose-related reductions in gray matter volume have been reported in various regions of the prefrontal cortex including the ventrolateral prefrontal cortex and anterior cingulate cortex in males, and this effect is also held resposible for behavioral changes.[17]

This study aimed to evaluate the psychiatric results of occupational lead exposure, which is a serious public health problem. We examined the relationship between blood lead level and depression, anxiety, anger, and anger expression in industrial battery workers exposed to occupational lead, and the differences between the groups formed according to the lead exposure level in terms of these variables.

MAIN POINTS

- Psychiatric studies in the field of occupational diseases are limited.
- Psychiatric diseases and symptoms caused by occupational diseases are not considered as important as physiological diseases.
- The results of this study will guide us in protecting the mental health of employees with occupational exposure to lead.
- Blood lead level is an important health problem that disrupts individuals' well-being and has negative effects such as inducing long-term anxiety, depression, and anger.

METHODS

Sample Group

The universe of the study consists of battery factory workers (study group) who applied to the Occupational Diseases Polyclinic of Istanbul Occupational Diseases Hospital for professional monitoring, and individuals who applied from different workplaces (control group). The sample was chosen from this universe using purposeful and convenience sampling methods. According to the Ministry of Health Occupational Diseases Hospitals' Occupational Lead Exposure, Biological Monitoring, and Health Risks Management Protocols (April 2009), occupational exposure workers with blood lead level (BLL) of 20-39 µg /dL were evaluated by the relevant medical departments, and were then followed up in an outpatient setting with a test report. Workers with a BLL of 40-79 µg/dL were treated by hospitalization.

Participants were divided into 3 groups, as 2 study groups and 1 control group. Among the 67 participants, all of whom were workers in a battery manufacturing plant, people who were hospitalized (35 people) or treated as outpatient (32 people) and were assigned to study groups. On the other hand, 35 patients who worked in other fields unrelated to lead, who applied for occupational monitoring, and whose blood lead and other occupational monitoring parameters were within normal limits, constituted the control group. In our hospital, BLLs were studied with the Blood Lead Analysis Atomic Absorption Spectrophotometer Graphite Oven (Siemens).

Psychiatric and/or neurological disease history, use of psychiatric drugs or psychoactive substances, and mental retardation were determined as the exclusion criteria.

Research Process

Approval for our study was obtained from the Marmara University Faculty of Medicine Clinical Research Ethics Committee with the protocol code of 09.2017.481. The participants of both the study groups and the control group were informed about the study, and data were collected from those who volunteered, using data collection tools. While some scales were filled by the patients themselves, some scales were administered by the researchers due to reasons such as age and reading speed, and it took 30 minutes for an average patient.

Measurement Tools Used in Research

Sociodemographic Data Form: It is a form prepared by the researchers for the purposes of the study, and includes sociodemographic data such as age, gender, education level, marital status, and employment status.

Beck Depression Inventory (BDI): The Beck Depression Inventory has 2 versions, 1961 (original) and 1978 (revised).

We administered the 1961 version to the patient group of 598 participants, and determined the internal consistency alpha coefficient as 0.88; the 1978 version of the form was administered to the patient group of 248 participants, and the internal consistency alpha coefficient was 0.86.[18] Turkish validity and reliability studies were carried out for both forms. Tegin[19] and Hisli[2] adapted the 1961 and the 1978 forms to Turkish. Studies conducted in Turkey for both forms show that the scale is valid and reliable.

Beck Anxiety Inventory (BAI): The scale developed by Beck et al.[21] is used to determine the frequency of anxiety symptoms experienced by a person. The BAI, which consists of 21 items and is a self-report scale, is a Likert-type scale scored between 0 and 3, and the total score ranges from 0 to 63. A high score obtained from the scale shows the level of anxiety experienced by the individual. The Turkish validity and reliability study of the scale was performed by Ulusoy et al.[22]

State and Trait Anxiety Scale: Öner and Le Compte studied the reliability and validity of the Turkish adaptation of the scale developed by Spielberger et al.[23] in order to determine the state and trait anxiety levels of individuals.[24] Internal consistency and homogeneity coefficients of the scale were found to be between 0.83 and 0.87 for trait anxiety, and between 0.94 and 0.96 for state anxiety. Item total score correlation values ranged from 0.34 to 0.72 for the Trait Anxiety Scale, and from 0.42 to 0.85 for the State Anxiety Scale. Comparing the diagnosed psychiatric patients with normal levels, both anxiety levels were found higher than normal.

Trait Anger and Anger Expression Inventory: Trait Anger and Anger Expression Styles Scale was developed by Spielberger.[25] While the first 10 items in the scale measure the level of trait anger, the next 24 items determine the anger styles (anger-in, anger-out, and anger-control sub-dimensions) of individuals. The Turkish version of the scale consisting of 34 items was developed by Özer,[26] and the Cronbach alpha coefficients were found to be 0.79 for the "trait anger" dimension, 0.78 for the "anger expression" dimension, 0.84 for the "endure anger in silence" dimension, and 0.84 for the "anger control" dimension.

Data Analysis

Pearson correlation coefficient was calculated to determine the correlations between the scores of the whole group from the applied scales. Descriptive statistics about the scores of the scales used in the study are presented as mean and standard deviation. The one-way analysis of variance and the Tukey post hoc test were applied to evaluate the difference between groups formed according to lead exposure. Statistical analyses were done with the SPSS 20 program and the level of significance for the statitical analysis was accepted as $P = .05$.

RESULTS

Characteristic of the Sample

Participants consisted of 102 male patients aged 24-50 (37.69 ± 6.45). The participants' duration of work ranged from 1 to 27 years, 3 (2.9%) were literate, 44 (43.1%) were primary school graduates, 22 (21.6%) were secondary school graduates, 30 (29.4%) were high school graduates and 3 (2.9%) were university graduates.

Correlation Results

An analysis of the correlation between the scores of the subscales and the mean scores of the whole sample revealed a high positive correlation between the symptoms of depression and anxiety ($r = 0.83$, $P < .00$), a high positive correlation between the symptoms of depression and state anxiety ($r = 0.75$, $P < .00$), a moderately positive correlation between the symptoms of depression and symptoms of trait anxiety ($r = 0.69$, $P < .00$), a high positive correlation between the symptoms of depression and trait anger ($r = 0.84$, $P < .00$), a weak positive correlation between the symptoms of depression and repression of anger ($r = 0.44$, $P < .00$), a high positive correlation between the symptoms of depression and outpouring of anger ($r = 0.79$, $P < .00$), and significant correlation between the symptoms of depression and BLLs ($r = 0.83$, $P < .00$), and moderate and negative ($r = -0.61$, $P < .00$) significant correlations between the symptoms of depression and control of anger.

While there were strong positive correlations between anxiety symptoms and state anxiety, trait anxiety, trait anger level, outpouring of anger, and BLL ($r = 0.78$, $r = 0.77$, $r = 0.81$ $r = 0.76$ and $r = 0.77$, respectively) ($P < .00$), we determined a positive and weak ($r = 0.44$, $P < .00$) correlation between repression of anger and anxiety, and a negative and moderate ($r = -0.68$, $P < .00$) correlation between anger control and anxiety.

While there was a very strong positive relationship ($r = 0.89$, $P < .00$) between the state anxiety and trait anxiety, the relationship between the state anxiety and the level of trait anger, outpouring of anger, and high BLLs showed posiive correlation ($r = 0.78$, $r = 0.78$ and $r = 0.78$, $P < .00$), the relationship between the state anxiety and repression of anger was positive and weak ($r = 0.48$, $P < .00$), and the relationship between state anxiety and anger control was negative and moderate ($r = -0.63$, $P < .00$).

Positive and moderate relationship between trait anxiety and trait anger and BLL ($r = 0.75$ and $r = 0.75$, $P < .00$), positive and moderate ($r = 0.69$, $r = 0.52$, $P < .00$), and a positive and moderate relationship between outpouring of anger and repression ($r = -0.64$, $P < .00$) were found. Also, a moderate ($r = -0.64$, $P < .00$) negative correlation was found with anger control.

Relationships between trait anger level and repression of anger showed a low positive correlation ($r = 0.42$, $P < .00$); a high positive correlation was seen between outpouring of anger and BLL ($r = 0.77$ and $r = 0.88$, $P < .00$), and a negative and moderate correlation ($r = -0.66$, $P < .00$) between trait anger level and anger control.

Positive and moderate correlation ($r = 0.53$, $P < .00$) between repression of anger and outpouring of anger, positive and weak correlation ($r = 0.31$, $P < .00$) between repression of anger and BLL, a negative and low correlation ($r = -0.21$, $P < .00$) between repression of anger and anger control were determined.

The relationship between outpouring of anger and the BLL showed positive and moderate correlation ($r = 0.70$, $P < .00$), the correlation between outpouring of anger and anger control was negative and moderate ($r = -0.60$, $P < .00$), and the correlation between BLL and anger control was negative and moderate ($r = -0.73$, $P < .00$) (Table 1).

Findings Regarding Comparison of the Test Scores of the Study and Control Groups According to the Scales

Volunteers who participated in the study were placed in a study group of battery workers who were exposed to lead and treated either with hospitalization or as outpatients, and the control group of workers who were not exposed to lead but worked in other fields who had applied for occupational follow-up. According to the findings of the analyses done for these 3 groups, the average scores of the participants in all 3 groups, with the standard deviation values, are given in Table 2. When the scores of all 3 groups were compared, it was determined that there was a significant difference in all scale scores between the groups. When the differences arising were examined according to the results of the Tukey test, which is a post hoc test, the mean scores of the participants who were exposed to lead and hospitalized were higher than those of participants who were exposed to lead but treated as outpatients and those who had no lead exposure, in terms of BLL, depression, anxiety, state and trait anxiety, trait anger, and outpouring of anger. Similarly, those with lead exposure and outpatient treatment had significantly higher mean scores than those without lead exposure (respectively, $F = 482.48$, $P < .001$; $F = 172.14$, $P < .001$; $F = 85.13$, $P < .001$; $F = 68.76$, $P < .001$; $F = 96.71$, $P < .001$; $F = 62.55$, $P < .001$; $F = 6.84$, $P < .001$). By contrast, in the mean scores of anger control, those without lead exposure had significantly higher mean scores than those who had lead exposure and were hospitalized, and those who were exposed to lead and had outpatient treatment. Moreover, it was found that those who were treated for lead exposure in the outpatient department had significantly higher mean scores than those who were hospitalized ($F = 51.38$, $P < .001$). Finally, there was no significant difference in the mean scores for repression of anger between those who had lead exposure and were hospitalized and those who were treated as outpatients, while those without lead exposure had significantly higher mean scores than in both study groups ($F = 138.63$, $P < .01$) (Table 2).

Findings Related to the Prediction of Number of Working Years and Blood Lead Level Variables

First of all, Variance Inflation Factor (VIF) and Tolerance (TOL) values for multiple connections were examined. When the VIF values were examined, it was seen that the years of work and BLL VIF value was 1.045 and less than 10. On the other hand, since the TOL values are .957 and greater than .10, it is concluded that there is no autocorrelation.

According to the results of the regression analysis performed for the working duration in years and BLLs, with respect to depression, anxiety, state and trait anxiety, trait anger, repression and outpouring of anger and anger control, it was determined that all variables were predicted by BLL. Accordingly, predicted values for the impact of BLL on various variables were as follows: depression 75% (F (2.99) = 218.911, $P < .001$), anxiety 62.6% (F (2.99) = 146.130, $P < .001$), state anxiety 60.6% (F (2.99) = 156.058, $P < .001$), trait anxiety 55.9%

Table 1. Arithmetic Mean, Standard Deviation, and Correlations of Subscale Scores

	Subscales	Mean ± SD	1	2	3	4	5	6	7	8
1.	BDI	15.04 ± 12.40								
2.	BAI	15.02 ± 11.58	.83**							
3	SA	37.97 ± 15.20	.75**	.78**						
4.	TA	37.20 ± 12.44	.69**	.77**	.89**					
5.	TAL	20.27 ± 8.82	.84**	.81**	.78**	.75**				
6.	A-REPR	15.10 ± 4.65	.44**	.44**	.48**	.52**	.42**			
7.	A-OUTPO	15.75 ± 5.57	.79**	.76**	.69**	.69**	.77**	.53**		
8.	A-Control	21.18 ± 6.46	−.61**	−.68**	−.63**	−.64**	−.66**	−.21**	−.60**	
9.	Blood lead level	26.39 ± 19.35	.83**	.77**	.78**	.75**	.88**	.70**	.31**	−.73**

*$P < .05$; **$P < .01$.

SD, standard deviation; BDI, Beck Depression Inventory; BAI, Beck Anxiety Inventory; SA, state anxiety; TA, trait anxiety; TAL, trait anger level; A-REPR, anger-repression; A-OUTPO, anger-outpouring; A-Control, anger-control.

Table 2. ANOVA and Tukey Post Hoc Test Results of Depression, Anxiety, State Anxiety, Trait Anxiety, Repression of Anger, Outpouring of Anger, Anger Control, and Blood Lead Levels According to Lead Exposure Groups

	Groups	*N*	Mean	SD	*F*	Differences
BDI	No lead exposure	35	3.43	1.79	482.48*	3 > 2 > 1
	Lead exposure/outpatient	32	12.19	8.42		
	Lead exposure/ınpatient	35	29.26	5.84		
BAI	No lead exposure	35	3.60	2.34	172.14*	3 > 2 > 1
	Lead exposure/outpatient	32	15.84	8.71		
	Lead exposure/ınpatient	35	25.69	8.48		
SA	No lead exposure	35	22.69	2.56	85.13*	3 > 2 > 1
	Lead exposure/outpatient	32	41.69	12.46		
	Lead exposure/ınpatient	35	49.86	11.79		
TA	No lead exposure	35	23.31	2.08	68.76*	3 > 2 > 1
	Lead exposure/outpatient	32	43.38	9.48		
	Lead exposure/ınpatient	35	45.43	8.33		
TAL	No lead exposure	35	11.77	1.63	96.71*	3 > 2 > 1
	Lead exposure/outpatient	32	19.09	5.41		
	Lead exposure/ınpatient	35	29.86	5.61		
A-REPR	No lead exposure	35	27.46	2.78	138.63*	1 > 2 = 3
	Lead exposure/outpatient	32	19.91	6.18		
	Lead exposure/ınpatient	35	16.06	3.48		
A-OUTPO	No lead exposure	35	11.00	1.83	62.55*	3 > 2 > 1
	Lead exposure/outpatient	32	15.69	4.75		
	Lead exposure/ınpatient	35	20.54	4.60		
A-Control	No lead exposure	35	12.91	3.84	51.38*	3 > 2 > 1
	Lead exposure/outpatient	32	15.81	5.15		
	Lead exposure/ınpatient	35	16.63	4.19		
Blood lead level	No lead exposure	35	4.06	2.18	6.84*	3 > 2 > 1
	Lead exposure/outpatient	32	26.84	7.87		
	Lead exposure/ınpatient	35	48.31	6.49		

*P < .001.
SD, standard deviation; BDI, Beck Depression Inventory; BAI, Beck Anxiety Inventory; SA, state anxiety; TA, trait anxiety; TAL, trait anger level; A-REPR, anger-repression; A-OUTPO, anger-outpouring; A-Control, anger-control.

(F (2.99) = 128.961, P < .001), trait anger level 76.3% (F (2.99) = 325.281, P < .001), repression of anger 10.2% (F (2.99) = 10.695, P < .001), outpouring of anger 50.4% (F (2.99) = 94.971, P < .001), and controlling anger 53.7% (F (2.99) = 61.510, P < .001).

According to the results of the regression analysis of number of years of work and BLLs for predictive levels of depression, anxiety, state and trait anxiety, trait anger, repression of anger, outpouring of anger and anger control, all variables were determined to be predicted by BLL. The significance of BLL on depression was predicted by 54% (Table 3).

DISCUSSION

The aim of the study is to determine the relationship between BLL and depression, anxiety, anger, and anger expression in battery workers who are exposed to occupational lead and those who are not exposed to lead, and to examine whether there is a difference between the groups formed according to the level of lead exposure in terms of these variables. Lead exposure is known to cause neurodegeneration and elicits psychiatric symptoms,[3] and studies have been carried out which reveal various physiological consequences of lead exposure in work environments, which are discussed widely.[27-29] However, although it is accepted that lead exposure is one of the exposures that may cause significant neuropsychological changes in humans,[1] it is noteworthy that there are very few studies on this subject in the literature.

In this study, the results of lead exposure in individuals were examined in terms of depression, anxiety and anger, and the results obtained were consistent with the literature. The correlation analysis revealed that depression and anxiety were positively correlated with each other and with anger as expected, consistent with the literature.

Table 3. The Results of the Regression Analysis of the Number of Working Years and Blood Lead Level for Depression, Anxiety, State and Trait Anxiety, Trait Anger, Repression of Anger, Outpouring of Anger, and Anger Control

	Predictive Variables	*B*	*SH*	*β*	*t*	R^2	*F*	ΔR^2
BDI	Constant	1.029	1.172		0.878		218.911*	0.750
	Blood lead level	0.531	0.036	0.829	14.796*	0.683		
BAI	Constant	2.845	1.247		2.282*		146.130*	0.626
	Blood lead level	0.461	0.038	0.794	12.088*	0.59		
SA	Constant	21.785	1.604		13.584*		156.058*	0.606
	Blood lead level	0.613	0.049	0.781	12.492*	0.609		
TA	Constant	24.460	1.388		17.620*		128.961*	0.559
	Blood lead level	0.483	0.042	0.750	11.356*	0.563		
TAL	Constant	9.752	0.722		13.505*		325.281*	0.763
	Blood lead level	0.399	0.022	0.875	18.036*	0.765		
A-REPR	Constant	13.126	0.0746		17.584		10.695*	0.102
	Blood lead level	0.075	0.023	0.311	3.270*	0.097		
A-OUTPO	Constant	10.445	0.673		15.518		94.971*	0.504
	Blood lead level	0.201	0.021	0.698	9.745*	0.487		
A-Control	Constant	32.843	2.612		12.576		61.510*	0.537
	Blood lead level	−0.242	0.022	−0.725	−10.784	0.535		

*$P < .001$.
BDI, Beck Depression Inventory; BAI, Beck Anxiety Inventory; SA, state anxiety; TA, trait anxiety; TAL, trait anger level; A-REPR, anger-repression; A-OUTPO, anger-outpouring; A-Control, anger-control.

Considering that trait anger and outpouring of anger show higher correlation in the relationship of anger with these variables, but repression of anger shows low correlation, it is determined that these individuals have high levels of anger which they prefer to express rather than repress. In addition, a negative correlation was found between anger control and all these variables and BLL. This result may show that the increase in individuals' BLLs which then leads to increased anxiety, depression and anger levels, decreases their ability to control anger.

When the relationship between BLL, which includes the main hypothesis of our study, and other variables is examined, although BLL does not affect anger control, it is strongly correlated with anxiety, depression, trait anger, and repression of anger, and there is a significant but weak correlation with outpouring of anger. The latter may be because the anxiety and depression levels of these individuals prevent the expression of anger and have a stronger effect on the individual. In this context, studies in the literature also reveal the association between long-term occupational lead exposure and symptoms of depression and nervousness, and other medical problems involving the gastrointestinal and kidney systems[11]; high BLLs associated with increased rates of depression, irritability and emotional lability[7]; and significant relationships between blood and bone lead levels and states of anxiety, depression, and phobic anxiety.[9] These findings are consistent with our results.

In the analyses done according to the lead exposure groups, it was found that the group with the highest BLL had the highest anxiety and depression levels as well the most anger expression. In the analysis between the groups, it was found that there was only a reverse relationship in the repression of anger, and the anger control decreased in parallel with the exposure level. In other words, as lead exposure decreases, repression of anger increases, there is no significant difference between the repression of anger levels in both the inpatient and outpatient group but the group without exposure was reported to show significantly less anger and more repression. It is thought that lead exposure may be related to a decrease in the tolerance of individuals to control anger by repressing it, or as an outcome of burnout, it may be related to the effort to cope with anger to lead a minimum expression. For this reason, it can be said that psychiatric follow-ups are extremely important in these individuals as part of routine health checks. In comparison studies conducted in the literature, it was determined that there were significant results to the detriment of groups with lead exposure. In a study conducted in workers with lead exposure compared against a control group, it was found that those with lead exposure showed symptoms such as memory impairment, less concentration, insomnia, headache, insufficiency, agitation, tremor, conduction deafness, and fatigue.[30] In an occupational lead exposure study conducted with 108 male patients, 56.1% emotional lability and 47.7% agitation were found in the study group.[31] In a cross-sectional study

with 87 regular firearm shooters and 31 archers, the aggressiveness of shooters was found to be significantly high, apart from blood lead and verbal aggression, shooters' levels of aggression were found to be significantly high, and there was a significant relationship between BLLs and hostility levels.[32]

According to the results of the regression, it was determined that just as lower levels of anger can be predicted by blood levels, so can depression, anxiety, outpouring of anger, and control of anger. The predictor of state and trait anxiety and trait anger variables is the BLL. As stated in the studies in the literature, it can be said that the level of lead exposure and the level of lead in the blood accordingly are determinant or risk factors for depression, anxiety and anger as well as other physiological diseases, and thus predict these disorders. For example, Baker et al. (1985) found that recovery in occupational exposure and decreased BLLs led to a subjective improvement in symptoms such as anger, depression, and fatigue. In the aforementioned study, a group of foundry workers with occupational lead exposure was monitored for 3 years, and in parallel with the decrease in exposure, it was determined that there was a 20%, 18%, 26%, 27%, and 13% reduction in tension, anger, depression, fatigue, and confusion rates, respectively. These findings, which show that decreased exposure to lead also decreases the symptoms, are important indicators that lead level is a predictive variable for these disorders, in our study. BLLs were determined to have high predictive roles in our study. However, it is thought that more studies should be done in order to obtain definitive findings on this subject.

Drawing a conclusion, BLL is significant health problem that disrupts individuals' well-being and has negative effects such as long-term anxiety, depression, and anger. Published literature of studies on this topic conducted in Turkey, are very limited. Therefore, it is thought that our study will contribute to the literature and as well as follow-up of these workers' occupational problems, and will utilize the data for potential treatments to be created for the rehabilitation of these individuals facing occupational lead exposure.

Ethics Committee Approval: Ethics committee approval was received from the Clinical Research Ethics Committee of Marmara University School of Medicine (09.2017.481).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer Review: Externally peer-reviewed.

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REFERENCES

1. Mason LH, Mathews MJ, Han DY. Neuropsychiatric symptom assessments in toxic exposure. *Psychiatr Clin North Am*. 2013;36(2):201-208. [CrossRef]
2. Furman A, Laleli M. Maternal and umbilical cord blood lead levels: an Istanbul study. *Arch Environ Health*. 2001;56(1):26-28. [CrossRef]
3. Dobbs MR. Clinical neurotoxicology: syndromes, substances. *Environments*. Philadelphia; Saunders. 2009.
4. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for lead. *WaSEington*. DC: US Department of Health and Human Services; 2007.
5. Parkinson DK, Ryan C, Bromet EJ, Connell MM. A psychiatric epidemiologic study of occupational lead exposure. *Am J Epidemiol*. 1986;123(2):261-269. [CrossRef]
6. Schwartz BS, Lee BK, Bandeen-Roche K et al. Occupational lead exposure and longitudinal decline in neurobehavioral test scores. *Epidemiology*. 2005;16(1):106-113. [CrossRef]
7. Baker EL, Feldman RG, White RF, Harley JP. The role of occupational lead exposure in the genesis of psychiatric and behavioral disturbances. *Acta Psychiatr Scand Suppl*. 1983;303:38-48. [CrossRef]
8. Maizlish NA, Parra G, Feo O. Neurobehavioural evaluation of Venezuelan workers exposed to inorganic lead. *Occup Environ Med*. 1995;52(6):408-414. [CrossRef]
9. Rhodes D, Spiro A 3rd, Aro A, Hu H. Relationship of bone and blood lead levels to psychiatric symptoms: the normative aging study. *J Occup Environ Med*. 2003;45(11):1144-1151. [CrossRef]
10. Khalil N, Morrow LA, Needleman H et al. Association of cumulative lead and neurocognitive function in an occupational cohort. *Neuropsychology*. 2009;23(1):10-19. [CrossRef]
11. Lilis R, Blumberg WE, Fischbein A et al. Lead effects among secondary lead smelter workers with blood lead levels below 80 microgram/100 ml. *Arch Environ Health*. 1977;32(6):256-266. [CrossRef]
12. Florea AM, Taban J, Varghese E *et al*. Lead (Pb2+) neurotoxicity: ion-mimicry with calcium (Ca 2+) impairs synaptic transmission. A review with animated illustrations of the pre- and post-synaptic effects of lead. *J Loc Glob Health Sci*. 2013;4(2013). [CrossRef]
13. Lasley SM, Green MC, Gilbert ME. Rat hippocampal NMDA receptor binding as a function of chronic lead exposure level. *Neurotoxicol Teratol*. 2001;23(2):185-189. [CrossRef]00116-7)
14. Sandhir R, Gill KD. Calmodulin and cAMP dependent synaptic vesicle protein phosphorylation in rat cortex following lead exposure. *Int J Biochem*. 1994;26(12):1383-1389. [CrossRef]90181-3)
15. Kern M, Wisniewski M, Cabell L, Audesirk G. Inorganic lead and calcium interact positively in activation of calmodulin. *NeuroToxicology*. 2000;21(3):353-363.

16. Kamer KJ, Mootha VK. The molecular era of the mitochondrial calcium uniporter. *Nat Rev Mol Cell Biol*. 2015;16(9):545-553. [CrossRef]
17. Rocha A, Trujillo KA. Neurotoxicity of low-level lead exposure: history, mechanisms of action, and behavioral effects in humans and preclinical models. *Neurotoxicology*. 2019;73:58-80. (doi:10.1016/j.neuro.2019.02.021.
18. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry*. 1961;4:561-571. [CrossRef]
19. Tegin B. *Depresyonda bilişsel bozukluklar: Beck modeline göre bir inceleme. Yayınlanmamış doktora tezi, HÜ Psikoloji Bölümü, Ankara*. 1980. (Turkish)
20. Hisli N. A reliability and validity study of beck depression Inventory in a university student sample. *Türk Psikhol Derg*. 1989;7:3-13. (Turkish)
21. Beck AT, Epstein N, Brown G, Steer RA. An inventory for measuring clinical anxiety: psychometric properties. *J Consult Clin Psychol*. 1988;56(6):893-897. [CrossRef]
22. Ulusoy M, Sahin NH, Erkmen H. Turkish version of the beck anxiety inventory: psychometric properties. *J Cogn Psychother*. 1998;12:163-172.
23. Spielberger CD, Gorsuch RL, Lusene RE. *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press; 1970.
24. Öner N, Le Compte A, Kaygı Envanteri El Kitabı S. D. S. *Yayınevi*. İstanbul: Boğaziçi Üniversitesi; 1998. (Turkish)
25. Spielberger CD. *Preliminary Manual for the State-Trait Anger Scale (STAS)*. Tampa, FL: University of South Florida, Human Resources Institute; 1980.
26. Özer AK. Sürekli öfke (SL-ÖFKE) ve öfke ifade tarzı (ÖFKE-TARZ) ölçekleri ön çalışması. *Türk Psikhol Derg*. 1994;9:26-35. (Turkish)
27. Barman T, Kalahasthi R, Rajmohan HR. Effects of lead exposure on the status of platelet indices in workers involved in a lead-acid battery manufacturing plant. *J Expo Sci Environ Epidemiol*. 2014;24(6):629-633. [CrossRef]
28. Kasuba V, Rozgaj R, Milić M et al. Evaluation of lead exposure in battery-manufacturing workers with focus on different biomarkers. *J Appl Toxicol*. 2010;30(4):321-328. [CrossRef]
29. Wu Y, Liu Y, Ni N et al. High lead exposure is associated with telomere length shortening in Chinese battery manufacturing plant workers. *Occup Environ Med*. 2012;69(8):557-563. [CrossRef]
30. Malekirad AA, Oryan S, Fani A et al. Study on clinical and biochemical toxicity biomarkers in a zinc-lead mine workers. *Toxicol Ind Health*. 2010;26(6):331-337. [CrossRef]
31. Balali-Mood M, Shademanfar S, Rastegar Moghadam J et al. Occupational lead poisoning in workers of traditional tile factories in Mashhad, Northeast of Iran. *Int J Occup Environ Med*. 2010;1(1):29-38.
32. Naicker N, de Jager P, Naidoo S, Mathee A. Is there a relationship between lead exposure and aggressive behavior in shooters? *Int J Environ Res Public Health*. 2018;15(7):1427. [CrossRef]