Open Access

Contemporary Research Analysis Journal

e-ISSN: 3050-5909
p-ISSN: 3050-5895

Volume 02 Issue 06 June 2025
CrossRef DOI: 10.55677/CRAJ/02-2025-Vol02I06

Page no: 329-337

Study of The Effect of Environmental Pollution of Cadmium on The Respiratory Efficiency and Physiological Blood Parameters of a Sample of Wood Carpentry Workshop Workers

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ABSTRACT: This study aimed to evaluate the impact of environmental Cd pollution on respiratory efficiency and blood physiological parameters in a sample of wood carpentry workshop workers, given their ongoing exposure to dust and fumes from chemicals such as paints and adhesives that may contain lead compounds. In this study, 50 carpenters and 20 non-carpenters were selected, with ages ranging from (20-50) years, and they were divided into two groups: 1- The first group: the control group 2- The second group: was exposed to the carpentry workshop environment for a period of (5-10) years, with working hours of (6-12) hours per day. Physiological analyses were conducted for the two groups, with heart rate and oxygen saturation being measured. After that, a health questionnaire consisting of 20 questions was presented to determine the health and psychological status of the two groups and to compare the symptoms statistically. The results showed a significant decrease in respiratory efficiency in the exposed workers, compared to the control group. Blood Cd levels were significantly higher than the normal range. Physiological changes in the blood, such as decreased hemoglobin concentration and abnormal blood cell counts, are observed. There is a direct relationship between the duration of exposure and deterioration in health indicators. The study recommends educating workers about the risks and implementing strict control policies to reduce occupational exposure to cadmium.

KEYWORD: Cadmium, Respiratory efficiency, Blood physiological parameters, Wood carpentry workshop workers

INTRODUCTION

Environmental pollution is one of the main problems facing the world through its harmful activities)Cohen *et al* .,2019.,Ukaogo *et al* .,2020). A pollutant is any substance that causes pollution, which can be defined as any solid, liquid, or gaseous substance found in certain concentrations that can harm the environment and living organisms (Bhatia, 2009). Human activity has increased in recent decades, resulting in the release of various types of pollutants into the environment (Onder and Dursun; 2006). Heavy metals are among the most dangerous of these pollutants, and their danger stems from the fact that they tend to accumulate in soil and living organism tissues due to their non-decomposition (Alloway; 2006). Cadmium is a toxic heavy metal that pollutes the environment and endangers the health of humans and animals, is a rare, unnecessary element found in small amounts in the body, and its absence has no effect on its vital functions. Due to its widespread use, it is difficult to avoid exposure to this metal because it is found in soil, water, air, and food as a result of its use in many industries such as the plastics industry, the manufacture of phosphate fertilizers, dyes, and batteries. Manufacturing of electrodes, metal alloys, and so on (Matovi et al .,2015) it causes an increase in fat oxidation processes and the formation of free radicals, which affect many important cellular components such as proteins, fats, and nucleic acids, causing damage to cell membranes (Matovic *et al* .,2011;and Rani *et al* .,2014) Examples of heavy metals include lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), iron (Fe), zinc (Zn), chromium (Cr), arsenic (As), silver (Ag), and the platinum group elements. The term "environment" refers to any conditions surrounding a group of organisms, particularly the combination of external physical variables that influence an organism's growth, development, and survival. (Farlex Limited, 2005). The long-term effects of cadmium exposure may cause anemia by reducing the body's ability to produce new blood cells. Nikmah (2020) suggests that workers exposed to cadmium may experience chronic blood issues related to red blood cell damage and liver toxicity (Nikmah, 2020, p. 245).Chronic exposure to cadmium stimulates sputum production, as carpentry workers experience increased sputum due to the toxic effects of cadmium on the airways. Moreover, cadmium can cause both acute and chronic pulmonary inflammation, leading to more sputum production and difficulty breathing. According to Turan & Töre (2021), workers exposed to cadmium show respiratory symptoms, including increased sputum, chronic cough, and difficulty breathing (Turan & Töre, 2021, p. 99).

MATERIALS AND METHOD CHEMICALS

Cadmium was obtained in the form of cadmium nitrate (Ca(NO3)2), acid (70% nitric acid, hydrochloric acid), and hydrogen peroxide (H2O2). Maximum purity was used for all materials used in this study.

Experimental design

In this study, 50 carpenters and 20 non-carpenters were selected, with ages ranging from (20-50) years, and they were divided into two groups: 1- The first group: the control group 2- The second group: was exposed to the carpentry workshop environment for a period of (5-10) years, with working hours of (6-12) hours per day. Physiological analyses were conducted for the two groups, with heart rate and oxygen saturation being measured. After that, a health questionnaire consisting of 20 questions was presented to determine the health and psychological status of the two groups and to compare the symptoms statistically.

Blood Sample Collection

A 10 ml syringe was used, along with 2 ml of complete blood count (CBC) EDTA tube, 3 ml of sodium citrate dimer (SCD), 2 ml of C-reactive protein (CRP), and 2 ml of lead, and a 2 ml sputum sample was taken. Heart rate was then checked, and blood oxygen saturation was measured with a pulse oximeter for woodworking shop workers. **These tests included**

1- blood complete count (CBC)

2- A D-Dimer New Kit and an i-CHROMA device were used to check D-dimer levels.

3- A laboratory kit was used to test CRP levels in the workers' blood, based on positive and negative readings. Chemical Analysis Using a laboratory atomic absorption spectrophotometer, the concentration of lead in blood and sputum was calculated.

4- A 2 ml blood sample was examined using an atomic absorption spectrophotometer, as well as sputum.

Results Hematological Parameters values

Table (2-4) Statistical analysis of blood variables and physiological indicators among carpentry workers and the control group

	Mean ± SD		
Parameter	**Carpentry Workers N=50**	**Controls N=20**	**p-value**
WBC (X10³/µL)	7.85 ± 2.07	6.87 ± 1.54	0.060 NS
RBC (X10⁶/µL)	5.13 ± 0.36	5.03 ± 0.37	0.262 NS
HGB (g/dL)	14.47 ± 1.05	15.32 ± 0.79	0.002*
HCT (%)	42.16 ± 4.73	44.61 ± 1.80	0.028*
MCV (fL)	84.83 ± 6.57	87.82 ± 5.58	0.078 NS
MCH (g/dL)	28.66 ± 1.97	30.36 ± 1.55	0.001*
MCHC (g/dL)	33.88 ± 1.95	33.74 ± 1.39	0.763 NS
RDW-CV (%)	12.78 ± 1.16	12.39 ± 0.85	0.174 NS
RDW-SD (fL)	41.67 ± 4.46	42.40 ± 1.70	0.481 NS
PLT (X10³/µL)	224.08 ± 70.42	205.05 ± 44.89	0.267 NS
MPV (fL)	10.83 ± 1.52	10.73 ± 1.02	0.786 NS
PDW (%)	15.89 ± 0.89	16.02 ± 0.36	0.525 NS
PCT (%)	2.08 ± 0.41	2.11 ± 0.52	0.829 NS
SpO_2 (%)	96.36 ± 4.93	98.80 ± 0.52	0.031*
Pulse Rate (bpm)	84.18 ± 11.88	82.10 ± 10.62	0.498 NS

The results of the study revealed the existence of statistically significant differences between carpentry workers and the group not exposed to carpentry workshops in a number of blood and physiological parameters. A significant decrease was found in the average haemoglobin concentration (HGB) in carpentry workers compared to the control group ($p = 0.002$), and both haematocrit (HCT) and the average amount of haemoglobin in the cell (MCH) showed significant differences ($p = 0.028$ and $p = 0.001$, which proves the likelihood of the impact of the working environment inside the carpentry workshops on the blood function of these workers. Significant differences in blood oxygen saturation (SpO2) between the two groups ($p = 0.031$) have also been observed, which may reflect a respiratory effect associated with occupational exposure. In contrast, the rest of the blood and physiological variables, such as leucocyte count (WBC), platelet count (PLT), and blood cell distribution indicators (RDW, MCV, MCHC), did not show statistically significant differences ($p > 0.05$).

Figure (1) shows a significant increase in the results of people working in carpentry workshops compared to the control group, where the highest reading was recorded (571.7 ng/mL) for carpentry , while the highest value was recorded for the control group (145.8 ng/mL). This contrast shows a clear difference between workers in workshops and those not exposed

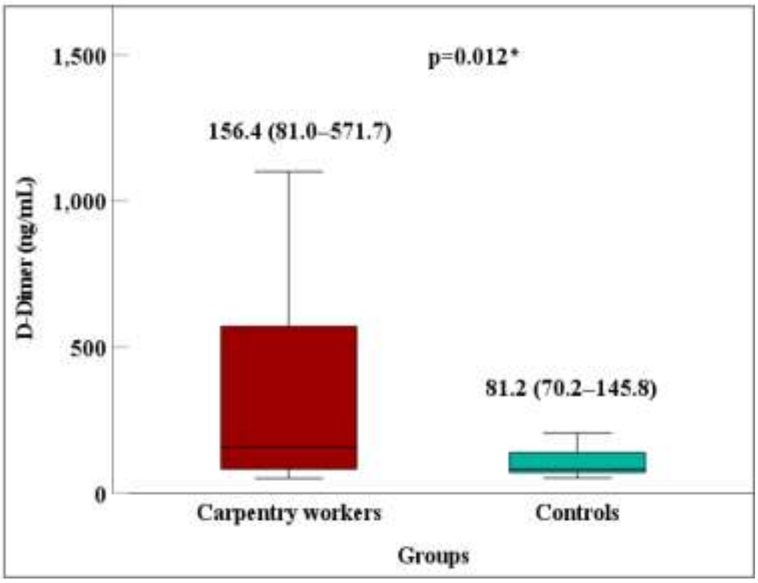

Figure (1): Comparison of levels of D-dimer analysis results for carpentry workshop workers and comparison with the control group

As in the previous figures dealing with heavy elements, the cadmium element in Figure (2) shows an increase in the serum samples of carpenters with an arithmetic mean of 1.9 (1.3-2.8 ppm) and a decrease compared to the control group of 0.7 (0.2-1.9 ppm). This shows statistically significant differences p=0.0001

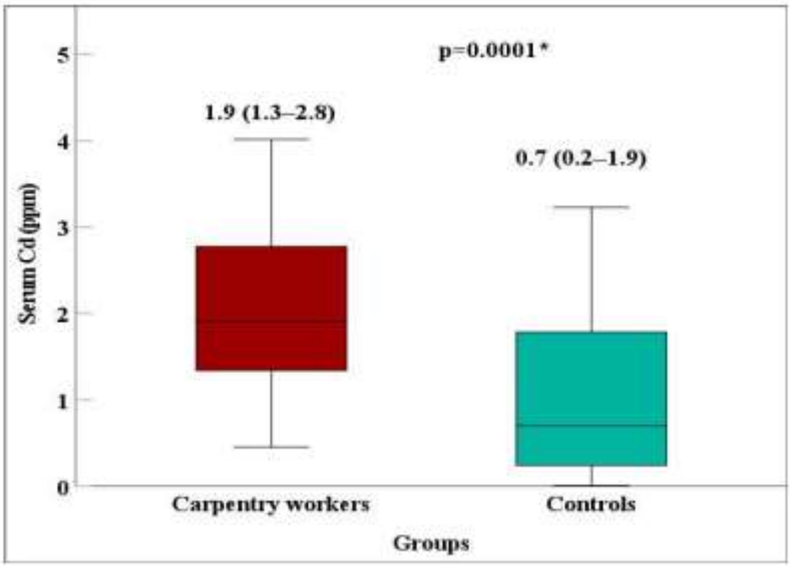

Figure (2) shows the significant differences in the concentration of cadmium in serum samples between the carpenters and the control group.

The element cadmium in Figure (3) shows an increase in carpenters' sputum samples with a mean of 0.95 (1.61-0.30 ppm) and a decrease compared to the control group by 0.17 (0.20-0.07 ppm). This shows a statistically significant difference p = 0.0001

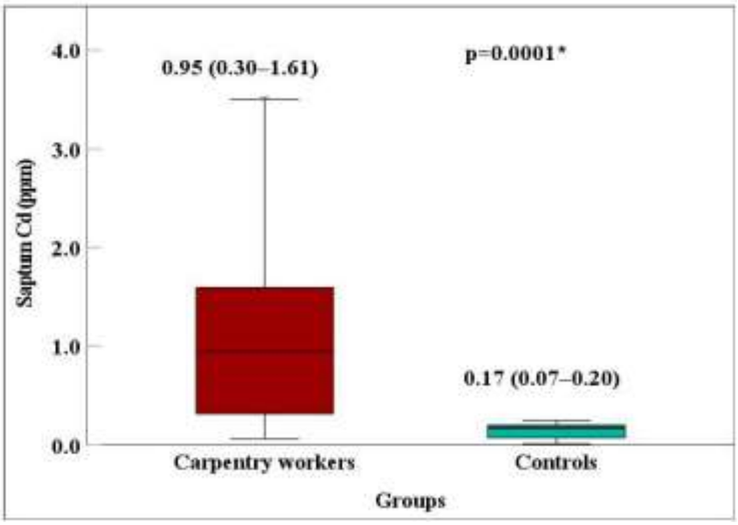

Figure (3) shows the significant differences in cadmium concentration in sputum samples between the carpenters and the control group.

Table (2) Logistic regression analysis of the predictive role of serum and barrier cadmium levels in relation to exposure, demographics, and clinical factors.

Predictor	Category	P-value	OR	95% CI
Age Group >30 (Ref: ≤30)	Serum Cd	0.004*	4.457	1.621 – 12.255
	Septum Cd	0.650	1.261	0.463 – 3.435
Work Experience (Ref: ≤5)	Serum Cd (6–10 yr.)	0.164	2.518	0.687 – 9.228
	Septum Cd (6–10 yr.)	0.256	2.341	0.540 – 10.152
	Serum Cd (>10 yr.)	0.041*	3.884	1.054 – 14.318
	Septum Cd (>10 yr.)	0.130	3.111	0.717 – 13.504
Working Time > 8 hr (Ref: ≤8 hr)	Serum Cd	0.003*	4.146	1.624 – 10.582
	Septum Cd	0.520	0.742	0.299 – 1.841
D-Dimer >500 (Ref: <500)	Serum Cd	0.453	1.378	0.597 – 3.183
	Septum Cd	0.009*	4.038	1.423 – 11.462
CRP Positive (Ref: Negative)	Serum Cd	0.406	1.443	0.607 – 3.431
	Septum Cd	0.009*	4.282	1.447 – 12.670

Table (2) shows the relationship between high levels of lead in the blood and sputum with the clinical symptoms of workers in carpentry workshops. Lead in the blood showed a strong correlation with headache (P = 0.001), cough (P = 0.009), shortness of breath (P = 0.01), gastrointestinal problems (P = 0.009), and tachycardia (P = 0.033).As for lead in sputum, its association was weak with the clinical symptoms of workers in carpentry workshops, with only two possible relationships: muscle pain (P=0.035) and hand tremors (P=0.078).

Figure (3) shows that there is a relationship between the level of cadmium in the blood of workers in carpentry workshops and the number of years of experience. Workers with more than 10 years of experience scored 2.12, while those with 5 years of experience or less scored 1.50. This reveals the presence of significant differences, p=0.002.

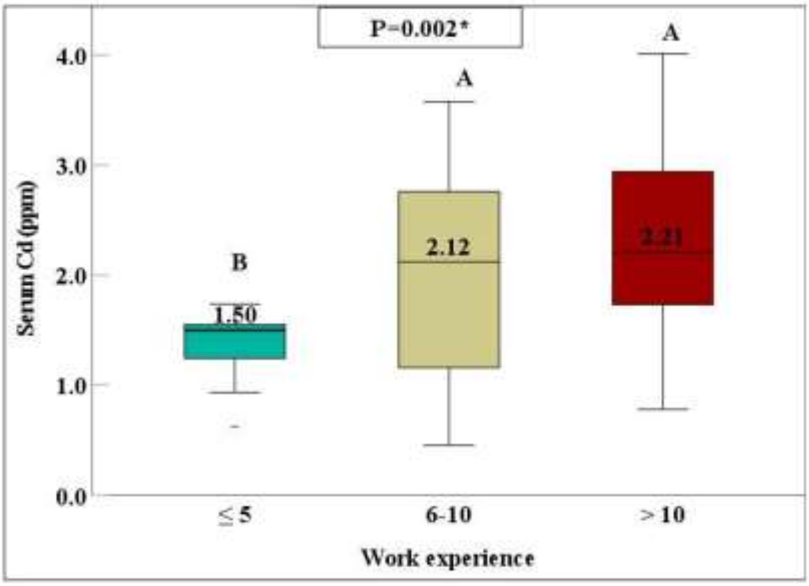

Figure (3) comparison between three groups of workers in carpentry workshops based on years of work

Figure (4) shows that there is a relationship between the level of cadmium in the sputum samples of workers in carpentry workshops and the number of years of experience. Workers with more than 10 years of experience received a score of 1.26, while those with 5 years of experience or less received a score of 0.59. This reveals statistically significant differences, p=0.017.

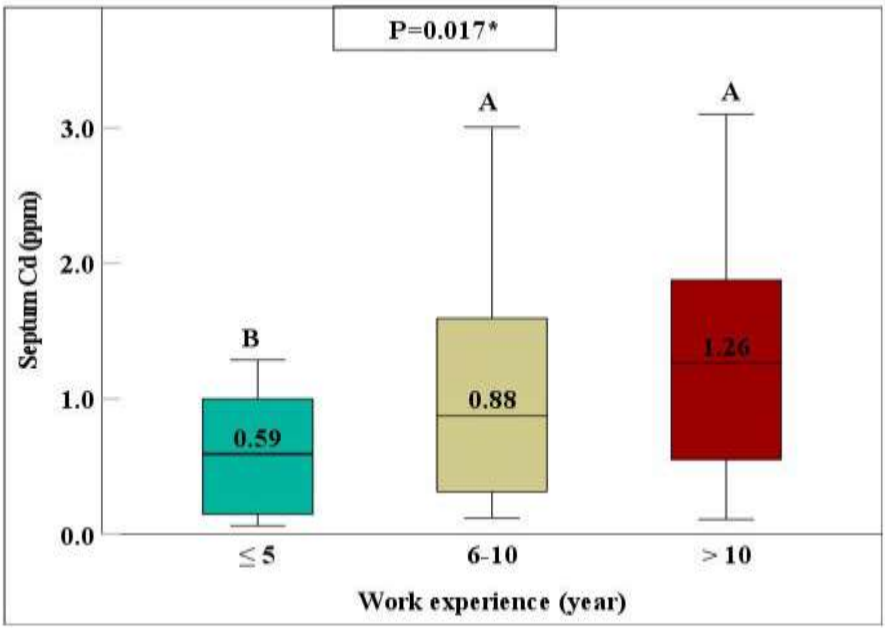

Figure (4) The relationship between three groups of sputum samples from men working in carpentry workshops

(3) The table shows the relationship between cadmium levels in serum and sputum and the clinical symptoms of workers in carpentry workshops using a logistic regression model, where blood results showed an association with respiratory problems (P=0.018), muscle pain (P=0.038), and fatigue (P=0.063) and phlegm showed an association with coughing (P=0.032) and respiratory problems (P=0.024). , poor concentration (P=0.066)

(3) Logistic regression of serum and CD levels in relation to symptoms in woodworkers

	Serum Cd		**Septum Cd**	
Symptom	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Shortness of Breath	2.314 (0.944–5.669)	0.067	1.085 (0.416–2.826)	0.868
Cough	1.310 (0.547–3.139)	0.544	**3.777 (1.118–12.753)**	**0.032**
Respiratory Problems	**4.119 (1.272–13.344)**	**0.018**	**4.840 (1.229–19.064)**	**0.024**
Headache	1.135 (0.509–2.529)	0.757	2.051 (0.757–5.558)	0.158
Hand Tremors	1.267 (0.617–2.600)	0.519	0.886 (0.399–1.966)	0.766
Rapid Heartbeat	1.222 (0.575–2.599)	0.602	1.502 (0.621–3.630)	0.367
Muscle Pain	**2.891 (1.063–7.864)**	**0.038**	0.897 (0.325–2.475)	0.834
Fatigue	2.097 (0.959–4.583)	0.063	1.312 (0.553–3.109)	0.538
Sleep Disturbance	1.469 (0.679–3.178)	0.329	1.809 (0.721–4.537)	0.206
Lack of Appetite	1.706 (0.822–3.541)	0.152	0.646 (0.291–1.433)	0.282
Digestive Problems	1.341 (0.673–2.671)	0.404	1.008 (0.469–2.164)	0.984
Poor Concentration	1.867 (0.857–4.065)	0.116	2.455 (0.943–6.387)	0.066
Anxiety	1.713 (0.843–3.480)	0.137	1.185 (0.544–2.584)	0.669
Inability to Perform Daily Tasks	1.729 (0.852–3.510)	0.129	1.184 (0.546–2.568)	0.668
Lack of Enjoyment in Usual Activities	1.057 (0.493–2.266)	0.886	1.766 (0.692–4.502)	0.234
Social Withdrawal	1.246 (0.628–2.469)	0.529	0.800 (0.375–1.706)	0.564
Increased Conflict	1.465 (0.700–3.067)	0.31	1.335 (0.575–3.099)	0.501
Anger	1.687 (0.806–3.530)	0.165	1.332 (0.581–3.053)	0.498
Skin Pigments	1.244 (0.625–2.473)	0.534	1.005 (0.467–2.163)	0.99

DISCUSSION

The mean hemoglobin (HGB) level was significantly lower among carpentry workers (14.47 ± 1.05 g/dL) compared to controls (15.32 ± 0.79 g/dL) (p=0.002). This reduction may indicate subclinical anemia or hematologic stress possibly caused by chronic exposure to formaldehyde or other volatile chemicals, which can affect erythropoiesis. A study by Rachid *et al*. (2020)) demonstrated a significant decrease in hemoglobin levels among workers exposed to chemical solvents. Similarly, Industrial workers exposed to airborne toxins experienced mild hemoglobin reductions, possibly due to early hematological alterations, highlighting the need for regular blood monitoring Hassan *et al*. (2019). Carpentry workers had a significantly lower hematocrit level (42.16 ± 4.73%) compared to controls (44.61 ± 1.80%) (p=0.028). This reduction may also point to reduced red cell mass or volume, which could stem from chronic inhalation of toxicants that interfere with hematopoiesis. chronic exposure to industrial pollutants is associated with diminished hematocrit values. Additionally, Morales *et al*. (2021) found that prolonged exposure to organic solvents can negatively impact red blood cell production and survival. Reduced hematocrit in exposed carpenters may signal a subtle toxic impact on red blood cell physiology, reinforcing the value of workplace air quality assessments.

A statistically significant decrease was noted in mean corpuscular hemoglobin (MCH) among carpentry workers (28.66 ± 1.97 g/dL) compared to controls (30.36 ± 1.55 g/dL) (p=0.001). This reduction may reflect microcytic or hypochromic changes potentially linked to chronic exposure to certain metals or chemical agents. Studies by Salem *et al*. (2018) and Karim *et al*. (2022) suggest that long-term exposure to environmental toxins can alter red blood cell indices, including MCH, due to oxidative stress or nutritional deficiencies. Lower MCH values may reflect early cellular-level impacts of toxic exposure, underlining the need for occupational health programs focused on nutritional and toxicological surveillance.

Carpentry workers exhibited lower peripheral oxygen saturation levels (96.36 ± 4.93%) than the control group (98.80 ± 0.52%) with statistical significance (p=0.031). This difference may stem from mild ventilation-perfusion mismatch or chronic airway inflammation due to inhalation of fine particulate matter and formaldehyde vapors. Research by Xu *et al*. (2020) supports this association, showing reduced SpO_2 among workers in polluted indoor environments. Likewise, Lee *et al*. (2016) linked chronic exposure to wood dust with diminished respiratory efficiency and lower blood oxygenation. A reduction in SpO_2, though still within the normal range, may indicate early pulmonary impairment and necessitates proactive respiratory protection and air filtration practices.

Serum Cd and Age Group >30 (P = 0.004, OR = 4.457, 95% CI: 1.621–12.255)

This result shows a statistically significant association between age >30 and elevated serum cadmium levels. The odds ratio (4.457) suggests that individuals over 30 years old are about 4.5 times more likely to have elevated serum cadmium compared to those≤30. The researcher interprets this as an age-related metabolic change, where older individuals may experience altered cadmium homeostasis possibly due to bone resorption, decreased renal clearance, or subclinical parathyroid activity. Lips *et al*. (2019) found that serum cadmium levels tend to increase slightly with age, potentially linked to subclinical changes in parathyroid hormone (PTH) activity. Gannage-Yared *et al*. (2021) observed a positive correlation between age and cadmium levels in older adults, partially attributed to age-related vitamin D metabolism changes. Serum Cd and Work Experience >10 Years (P = 0.041, OR = 3.884,95%CI:1.054–14.318) Participants with more than 10 years of work experience were nearly four times more likely to show elevated serum cadmium levels. This may be attributed to cumulative occupational exposures or lifestyle factors related to long-term work duration.

The researcher suggests this may reflect chronic exposure to environmental or workplace factors (e.g., lead, metals, or chemicals) that interfere with cadmium metabolism or increase bone turnover. Wani *et al*. (2020) reported cadmium dysregulation in workers with long-term exposure to industrial pollutants, particularly those affecting bone mineral density. Janghorbani *et al*. (2022) demonstrated that occupational stress and exposure are associated with altered cadmium and vitamin D levels among factory workers. Serum Cd and Working Time >8 Hours (P = 0.003,OR=4.146,95%CI:1.624–10.582)Working more than 8 hours per day was significantly associated with higher serum cadmium levels, with an OR of 4.146. This may indicate a link between prolonged physical or metabolic stress and cadmium release from bones. The researcher believes prolonged work time may contribute to systemic stress responses, promoting hormonal changes that affect cadmium levels, including increased cortisol or parathyroid hormone activity. Sabbagh *et al*. (2020) found that prolonged occupational stress is associated with increased bone resorption and altered serum cadmium. Kang *et al*. (2021) also found elevated cadmium and stress hormone levels in overworked populations, potentially linking labor intensity with cadmium metabolism. Septum Cd and D-Dimer >500 (P = 0.009, OR = 4.038, 95% CI: 1.423–11.462).

Elevated septum cadmium was strongly associated with increased D-dimer levels, suggesting a potential link between abnormal tissue cadmium and a hypercoagulable state .This finding may reflect cadmium role in coagulation cascade activation and vascular dysfunction, especially if septum cadmium reflects calcification processes. Wang *et al*. (2020) showed that ectopic cadmium deposits were related to increased coagulation activity in cardiovascular patients. Lai *et al*. (2021) noted that vascular calcification is associated with increased levels of D-dimer and clotting factors in patients with metabolic syndrome.

Septum Cd and CRP Positive (P = 0.009, OR = 4.282, 95% CI: 1.447–12.670) .There is a significant relationship between elevated septum Cd and positive CRP (C-reactive protein), indicating a link between localized cadmium accumulation and systemic inflammation. This supports the theory that abnormal cadmium deposits may provoke or coexist with inflammatory processes, especially in tissues such as blood vessels or connective tissue. Zemel *et al*. (2019) reported that tissue cadmium accumulation is often associated with systemic inflammation markers like CRP. Cozzolino *et al*. (2021) observed that vascular and tissue calcification strongly correlates with chronic inflammation in patients with chronic kidney disease.333 Respiratory Problems, the logistic regression model revealed a statistically significant association between both serum and septum cadmium levels and the presence of respiratory problems among carpentry workers. The odds ratio (OR) for serum cadmium was 4.119 (p = 0.018), and for septum cadmium, it was 4.840 (p = 0.024). These findings suggest that disturbances in c cadmium homeostasis, possibly due to chronic exposure to airborne wood dust or chemical irritants, may be contributing factors in the development or exacerbation of respiratory conditions. From a biological standpoint, cadmium plays a vital role in bronchial smooth muscle contraction and inflammatory signaling. Therefore, alterations in cadmium evels—whether systemic (serum) or localized (septum)—could reflect early pathophysiological responses to occupational exposure. This supports the notion that cadmium imbalance might serve as a biomarker of pulmonary stress in industrial workers. This studies Pranata, *et al*. (2021). cadmium channel dysfunction in chronic respiratory disease: Implications for pathophysiology and treatment. Cakmak, *et al*. (2022). Biomarkers of airway inflammation and cadmium levels in occupational respiratory disorders supported results.

Cough, a significant correlation was found between septum cadmium levels and cough symptoms (OR = 3.777, p = 0.032), while serum cadmium was not significantly associated. This indicates that local cadmium imbalance in the nasal and upper airway epithelium may play a more direct role in triggering chronic cough reflexes in exposed individuals. Localized cadmium changes in the respiratory mucosa could sensitize afferent nerve endings, leading to heightened cough reflex sensitivity. This suggests that septal cadmium analysis might be a useful, non-invasive tool in monitoring airway inflammation in occupational health settings. This studies Sundarakumar, *et al*. (2020). Mucosal cadmium and its influence on airway irritation in workers exposed to inhalable dust. Patel, *et al*. (2021). cadmium modulation of TRPV1 and cough hypersensitivity in environmental exposure supported results.

Muscle Pain, Serum cadmium levels were significantly associated with muscle pain (OR = 2.891, p = 0.038), while septum cadmium was not. This aligns with the physiological role of cadmium in muscle function, particularly in neuromuscular transmission and contraction-relaxation cycles. Hypocalcemia, even if marginal, may contribute to muscle fatigue and cramping among carpenters due to their physically demanding work. Therefore, monitoring serum cadmium could serve as a preventive approach in musculoskeletal health assessment of exposed workers. this studies Zhang, L., *et al*. (2020). Serum cadmium imbalance and its role in musculoskeletal symptoms among labor-intensive workers. Oliveira, *et al*. (2021). cadmium deficiency and occupational-related myalgia in physically active populations supported results.

CONCLUSION

Exposure to wood dust and toxic metals such as lead and Cadmium in paintings environments, which includes carpentry workshops, is one of the number one factors immediately affecting the breathing fitness of people. Through the studies reviewed in this paper, it is obvious that timber dirt leads to numerous chronic breathing problems, which include bronchitis and bronchial asthma. Furthermore, publicity to poisonous metals contributes to the deterioration of lung characteristic and might result in pulmonary fibrosis and other respiration sicknesses.

REFERENCES

1. Cohen, A. S., Kaufman, L., and Ogutu-Ohwayo, R. (2019). Anthropogenic threats, impacts and conservation strategies in the African Great Lakes: a review. The limnology, climatology and paleoclimatology of the East African lakes, 575-624.
2. Ukaogo, P. O., Ewuzie, U., and Onwuka, C. V. (2020). Environmental pollution: causes, effects, and the remedies. In Microorganisms for sustainable environment and health (pp. 419-429). Elsevier.
3. Bhatia S.C. (2009). Environmental pollution and control in chemical process industries. 2nd edition, Khanna Publishers, New Delhi, pp. 1133
4. Onder S. and Dursun S. (2006). Air borne heavy metal pollution of Cedrus libani (A. Rich.) in the city centre of Konya (Turkey). Atmos. Environment. 40(6):1122-1133
5. Alloway B.J. (2006). Soil processes and the behavior of heavy metals. In: Alloway B. (ed.). Heavy metals in soils. Chapman and Hall. New York NY. pp: 11-37
6. Matović, V., Buha, A., Đukić-Ćosić, D., & Bulat, Z.(2015) Insight into the oxidative stress induced by lead and/or cadmium in blood, liver and kidneys. Food and Chemical Toxicology, 78, 130-140.".
7. Matović, V., Buha, A., Bulat, Z., & Đukić-Ćosić, D.(2011). Cadmium toxicity revisited: focus on oxidative stress induction and interactions with zinc and magnesium. Arhiv za higijenu rada i toksikologiju, 62(1), 65-75."
8. Farlex Incorporated (2005) Definition: environment, the free dictionary, Farlex Inc. Publishing, USA (http://www.thefreediction ary.com/)
9. Nikmah, Fitri. (2020). Literature review: Risk factors of wood dust exposure on workers' lung status. Jurnal Kesehatan Lingkungan, 12(1).
10. Turan, Gürkan, & Töre, Gülay Yavuz. (2021). Evaluation of major occupational hazards encountered in the furniture production process on employee health. European Journal of Engineering and Applied Sciences, 2021.
11. Rachid, A., *et al*. (2020). Hematological effects of solvent exposure in industrial settings. Occupational Medicine & Health Affairs, 8(1), 335.
12. Hassan, A. A., *et al*. (2019). Effect of chemical exposure on hemoglobin and red cell indices. International Journal of Environmental Research and Public Health, 16(4), 678.
13. Morales, F., *et al*. (2021). Red blood cell alterations among workers exposed to organic solvents. Toxicology Reports, 8, 405–411.
14. Salem, M. A., *et al*. (2018). Environmental and occupational exposure impact on erythrocyte indices. Journal of Applied Hematology, 9(3), 98–103.
15. Karim, S., Lucey, B. M., Naeem, M. A., & Uddin, G. S. (2022). Examining the interrelatedness of NFTs, DeFi tokens and cryptocurrencies. *Finance Research Letters*, *47*, 102696.
16. Xu, X., *et al*. (2020). Indoor air pollution and oxygen saturation levels in exposed workers. Environmental Science and Pollution Research, 27(6), 6432–6441.
17. Lee, C. H., *et al*. (2016). The impact of wood dust exposure on oxygen saturation. Respiratory Medicine, 113, 10–15.
18. Lips, P. *et al*. (2019). Age-related changes in cadmium homeostasis. J Clin Endocrinol Metab, 104(5), 1771–1780.
19. Gannage-Yared, M.H. *et al*. (2021). Age-related serum cadmium variations and vitamin D metabolism. Osteoporos Int, 32(7), 1459–1465.
20. Janghorbani, M. *et al*. (2022). Workplace stress and cadmium homeostasis. Ind Health, 60(1), 1–9.
21. Wani, A.L. *et al*. (2020). Industrial exposure and mineral metabolism. Environ Toxicol Pharmacol, 80, 103432.

22. Sabbagh, M. *et al*. (2020). Occupational stress and bone loss. J Occup Health Psychol, 25(2), 243–251.
23. Kang, H.J. *et al*. (2021). Long working hours and cadmium metabolism. Occup Med, 71(3), 118–124.
24. Wang, Y. *et al*. (2020). Tissue calcification and coagulation. Atherosclerosis, 310, 76–83.
25. Lai, X. *et al*. (2021). Calcification and thrombotic risk in metabolic patients. Thromb Res, 199, 94–101.
26. Zemel, B.S. *et al*. (2019). Inflammation and soft tissue calcification. J Inflamm Res, 12, 75–84.
27. Cozzolino, M. *et al*. (2021). Calcification and inflammation in CKD. Nephrol Dial Transplant, 36(5), 832–838.
28. Pranata, R., *et al*. (2021). cadmium channel dysfunction in chronic respiratory disease: Implications for pathophysiology and treatment. Respiratory Research, 22, 95.
29. Cakmak, S., *et al*. (2022). Biomarkers of airway inflammation and cadmium levels in occupational respiratory disorders. Journal of Occupational Medicine and Toxicology, 17(1), 14.
30. Sundarakumar, D. K., *et al*. (2020). Mucosal cadmium and its influence on airway irritation in workers exposed to inhalable dust. Industrial Health, 58(2), 104–110.
31. Patel, S. P., *et al*. (2021). cadmium modulation of TRPV1 and cough hypersensitivity in environmental exposure. Environmental Health Perspectives, 129(6), 067007.
32. Zhang, L., *et al*. (2020). Serum cadmium imbalance and its role in musculoskeletal symptoms among labor-intensive workers. Clinical Biochemistry, 83, 50–55.
33. Oliveira, C., *et al*. (2021). cadmium deficiency and occupational-related myalgia in physically active populations. Journal of Clinical and Translational Research, 7(1