Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2021 Aug 08; 9(B):831-835.
https://doi.org/10.3889/oamjms.2021.6430
eISSN: 1857-9655
Category: *B - Clinical Sciences*
Section: *Hematology*

Evaluation of Anemia in the Residents of Tambaklorok Exposed to Plumbum

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Edited by: Sinisa Stojanoski
Citation: Santosa B. Macedonian Evaluation of Anemia in the Residents of Tambaklorok Exposed to Plumbum. Open Access Maced J Med Sci. 2021 Aug 08; 9(B):831-835. https://doi.org/10.3889/oamjms.2021.6430
Keywords: Anemia; Hemoglobin levels; Hematocrit levels; Erythrocytes levels; Plumbum
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Received: 11-May-2021
Revised: 26-Jul-2021
Accepted: 29-Jul-2021

Funding: This study was supported by Universitas Muhammadiyah Semarang
Competing Interests: The authors have declared that no competing interests exist

Abstract

BACKGROUND: Anemia is a health condition characterized by a decreased in the levels of hemoglobin (Hb), hematocrit (Ht), and the number of erythrocytes. It is usually caused through exposure to plumbum (Pb) common in most industrial areas. Based on several studies, Tambaklorok is located in the Northern part of the city of Semarang in Indonesia with Pb levels higher than the normal threshold.

AIM: Therefore, the purpose of this study was to determine the level of anemia among the residents of Tambaklorok based on the characteristics of the respondents.

METHODS: Characteristics assessed include length of stay in the area, the use of personal protective equipment (PPE), smoking habits, and consumption of shellfish. The methods are the cross-sectional research method was used with analytic study approach. The study sample was made up of 104 respondents with the characteristics evaluated through questionnaires. The levels of Hb, Ht, and erythrocytes were analyzed using Hematology Analyzer.

RESULTS: The results showed that 38.6% of residents with over 30 years of stay, 42.2% with other jobs, 45.3% not wearing PPE, 26.7% smokers, and 38.7% of respondents had anemia. In addition, the Gamma statistical test results showed a significant relationship between the use of PPE with the levels of Hb ($p = 0.001$) and Ht ($p = 0.012$).

CONCLUSION: The conclusion is generally, 41% of Tambaklorok residents in Semarang had mild anemia based on the industrial activities in the region.

Introduction

Anemia is a health condition that involves reduced oxygen supply to body tissues [1] and it is a major problem in most developing countries. Globally, its prevalence was estimated to be 9% in developed and 43% in developing countries. Also, the condition is common among children and women in the childbearing age and according to a study, 47% of under-fives and 42% of pregnant women come up with it [2]. The target of the World Health Organization is to reduce anemia by 50% by 2025 [3]. Then, based on the results of the 2013 Basic Health Research (Riskesdas), the prevalence of anemia among women in childbearing age was 35.3% [4]. The condition could lead to maternal mortality, low birth weight in newborns, infection in the fetus and mother, premature birth, and miscarriage5. It could also lead to cognitive impairment, reduced levels of productivity, and susceptibility to infection, and even death [5]. Patients who are treated for more than a few hours and show the presence of pain [6].

Malnutrition and infection are the main causes of anemia, especially among children whose prevalence exceeds the national standard of 20% [7]. The presence of malignancies such as cancer and tumor, radiation, chronic diseases, drugs, toxic substances capable of damaging the kidney and liver, could also cause anemia, characterized by decreased hemoglobin (Hb) levels and the number of red blood cells also known as erythrocytes [8]. An example of toxic substances causing anemia is plumbum (Pb). Exposure to this substance causes the type of anemia known as microcytic hypochromic anemia. In this condition, there is a synthesis of heme, but the age of erythrocyte is usually short <120 days. The mechanism of Pb toxicity occurs due to the suppression of enzyme activity at the beginning, middle, and end of heme biosynthesis. The δ ALAD enzyme is the first to be inhibited by the presence of Pb, which results in the cessation of δ ALA from turning into porphobilinogen. This consequently increases the levels of δ ALA in the blood and urine. The intermediate enzyme inhibited by being exposed to Pb is coproporphyrinogen oxidase which leads to an increase in coproporphyrinogen levels. The ferrochelatase is the last enzyme inhibited by Pb and this leads to the increased levels of protoporphyrin in red blood cells/free erythrocyte protoporphirin, decreased heme and Hb levels, short life of red blood cells, and increased reticulocytes [9], [10].

Exposure to Pb is common in areas with fossil fuel combustion, industry, mining, production of battery, ammunition, solder, pipes, gasoline, paint, ceramic coating, children's toys, and contact of green

shells and seaweed with water contaminated with Pb, etc. [11], [12]. There are various industrial activities in Tambaklorok, located in the Northern part of Semarang, Indonesia, with a huge potential of polluting the environment. Schwartz *et al*. [12] reported that children living near primary lead smelters in the US of Idaho, had blood lead levels (BLLs) near 25 μg/dl and were associated with anemia in a dose-related manner. In addition, Drossos *et al*. [13] reported that children with BLL >30 μg/dl had a linear decline in Hb level. Whereas on the contrary, Froom *et al*. [14] suggested that Hb level did not correlate well with BLL and suggested that anemia is not related to lead at low BLL.

Based on research conducted [13], the waters in Tambaklorok contained about 0.06 ppm of Pb, but the maximum standard quality was set at 0.008 ppm [14]. Furthermore, the research conducted [14], showed that the levels of Pb in the air around Tambaklorok were 8.41 $\mu g/m^3$ more than the quality threshold value of 2 $\mu g/m^3$ per 24 h and the highest compared with other areas in Semarang [15]. In addition, the level of pollution is increasing continuously due to the direct disposing of industrial wastes into the surrounding waters. This is a common phenomenon in the area because most of these industries are not equipped with waste water treatment plants IPAL, which makes the river and sea waters contain high levels of Pb. Consequently, these Pb are accumulated in shellfish and other fish consumed by Tambaklorok residents. Prior to this period, there was no clear data of anemia condition among these residents being constantly exposed to Pb. Therefore, the aim of this study was to determine the level of anemia among the residents of Tambaklorok, based on the characteristics of the respondents.

Materials and Methods

The cross-sectional research method was used with an analytic study approach testing the relationship of anemia based on the characteristics of respondents. It was conducted between January and March 2020. The study population was the residents of Tambaklorok divided into 5 hamlets, namely 12, 13, 14, 15, and 16. The study samples were 104 residents selected based on the Lameshow formula [16].

This study uses a purposive sampling technique used to select respondents from 104 populations from the area without age group restrictions, consisting of children, adolescents, adults, the elderly, and people aged over 65 years who have lived in the area for at least 1 year. The age group includes adolescents (17–25 years), adults (26–45 years), the elderly (46–65 years), and over 65 years. Then the picture of anemia was obtained from the measurement of Hb, erythrocyte, and hematocrit (Ht) levels using the impedance principle on the BZ 2600 hematology analyzer. Furthermore, the sample used was the venous blood without any special preparation such as fasting, limiting physical activity, etc. from the respondents. Questionnaires were used to collect data involving age, gender, length of stay, profession, personal protective equipment (PPE), smoking, consumption of shellfish, etc. A respondent is assumed to consume shellfish if taken at least once a week and smokers, if at least 1–5 sticks are taken per day. Then, the anemia condition was assessed based on the levels of Hb, Ht, and erythrocytes of the respondents described on a frequency distribution table. The data were subjected to the Gamma statistical test using the SPSS version 22 software. In addition, the parameters used for anemia include if the male Hb level was <13.5–17.5 and the female <11.5–15.5 g/dl; male Ht levels <40–52% and female <36–48%; then, the erythrocytes in male <4.5–6.5 million and female <3.9–5.6 million. Then, the mild, moderate, and severe anemia was determined based on an interval of 1/3 below the lowest values for Hb, Ht, and erythrocyte counts.

The ethical clearance for this research was granted by the Ethical Commission of the Medicine Faculty, UNISULA Semarang with the reference No. 064/III/2020/Commission/Bioethics. Then, the Head of Clinical Pathology Laboratory, Muhammadiyah University of Semarang, consented to conduct the research after receiving the ethical clearance results.

Results

Tambaklorok is located in the Northern part of the city of Semarang in Indonesia. It is a coastal area populated with fishermen, traders, factory workers, and few other professions. The entire population of the city is divided into five hamlets, namely, 12, 13, 14, 15, and 16. The respondents were 104 in number consisting of 26 men and 48 women, with 1 person in teenagers' group (17–25 years), 29 adults (26–45 years), 63 elderly people (46–65 years), and 7 people above 65 years old. Mild anemia was common among the women and elderly and in overall, there were 41% of the population with mild anemia with Hb levels ± 10.9 g/%. The overview of the condition based on gender and age is shown in Table 1.

Table 1: Anemia distribution by gender and age

Gender and age	Result				Total
	Anemia	%	No anemia	%	
Gender					
Male	6	5.77	28	26.92	34
Women	37	35.57	33	31.7	70
Age					
Teenagers (17–25 years old)	3	2.8	0	0	3
Adult (26–45 years old)	5	4.8	24	4.8	29
Elderly (46–65 years old)	29	27.88	34	32.69	63
Old (>65 years old)	6	5.76	3	2.8	9

The description of anemia based on respondents' characteristics is detailed in Table 2.

Table 2: Hb, Ht, and erythrocyte levels based on respondent characteristics

Characteristics	Σ	Results											
		Hb levels				Ht levels				AE*			
		<n	%	n	%	<n	%	n	%	<n	%	n	%
Length of stay													
0–10 years	3	1	33.3	2	66.7	1	33.3	2	66.7	0	0.0	3	100.0
11–20 years	9	5	55.6	4	44.4	4	55.6	5	55.6	1	11.1	8	88.9
21–30 years	9	3	33.3	6	66.7	2	22.2	7	77.8	0	0.0	9	100.0
Over 30 years	83	32	38.6	51	61.4	25	30.1	58	69.9	7	8.4	76	91.6
Profession													
Fisherman	24	5	20.8	19	79.2	5	20.8	19	79.2	3	12.5	21	87.5
Traders	13	7	53.8	6	46.2	5	38.5	8	61.5	1	7.7	12	92.3
Factory workers	1	1	100.0	0	0.0	1	100.0	0	0.0	1	100.0	0	0.0
Fish Farmers	66	28	42.4	38	57.6	21	31.8	45	68.2	3	4.5	63	95.5
PPE													
Do not use	86	39	45.3	47	54.7	30	34.9	56	65.1	6	7.0	80	93.0
Incomplete	13	2	15.4	11	84.6	2	15.4	11	84.6	2	15.4	11	84.6
Complete	5	0	0.0	5	100.0	0	0.0	5	100.0	0	0.0	5	100.0
Smoker													
Yes	15	4	26.7	11	73.3	4	26.7	11	73.3	2	13.3	13	86.7
No	89	37	41.6	52	58.4	28	31.5	61	68.5	6	6.7	83	93.3
Frequent consumption of shellfish													
Yes	62	24	38.7	38	61.3	17	27.4	45	72.6	4	6.5	58	93.5
No	42	17	40.5	25	59.5	15	35.7	27	63.3	4	9.5	38	90.5

*AE: Anthal Eritrosit (the number of erythrocytes), <n: Less than normal, n: Normal.

Considering Table 2, the levels of Hb, Ht, and erythrocytes less than normal were Hb (41%), Ht (32%), and erythrocyte counts (8%), respectively. The levels of Hb, less than normal were common among respondents not using PPE, amounting to 39 respondents (45.3%). Low levels of Ht and erythrocytes were also observed in this group. The results of the statistical test showing the relationship between Hb, Ht, and the number of erythrocytes of the respondents are presented in Table 3.

Table 3: Result of statistical test of respondent's blood level

Bivariate Test		Result	
Respondent Characteristics	Hb, Ht, AE	Number of Respondents	p-value
Length of stay	Hb	104	0.683
	Ht	104	0.717
	AE	104	0.569
Profession	Hb	104	0.173
	Ht	104	0.507
	AE	104	0.196
PPE	Hb	104	0.001
	Ht	104	0.012
	AE	104	0.645
Smoker	Hb	104	0.246
	Ht	104	0.701
	AE	104	0.477
Consume shellfish	Hb	104	0.857
	Ht	104	0.373
	AE	104	0.577

Statistical Test: Gamma, Hb: Hemoglobin, Ht: haematocrit, PPE: Personal protective equipment, AE: Anthal eritrosit.

Based on Table 3, the relationship between the use of PPE with the levels of Hb, Ht, and AE resulted in a p-value of 0.001 and 0.012, respectively, which were <0.05. This is an indication of a significant relationship between the use of PPE with Hb, Ht, and AE. However, the statistical tests involving other factors such as length of stay, profession, smoker, and consumption of shellfish resulted in p-value above 0.05, meaning there was no significant relationship between these factors and the levels of Hb, and Ht, and AE.

Discussion

The majority of the respondents profession, 83, had a length of stay longer than 30 years, with 38.6% having Hb, 30.1% Ht, and 8.4% AE lower than normal. Comparing the length of stay in the exposed area with a length of work, these results are in line with a previous research which stated that there was a relationship between length of work and exposure to Pb. According to Rustanti and Mahawati (2011), there was a positive correlation between length of work and exposure to Pb among fish farmers in Tambaklorok [17]. Normally, exposure to Pb is chronic, meaning it enters the body for a long time, even for many years, while accumulating in the blood. Its toxicity is highly dependent on this chronic exposure thereby leading to health effects such as anemia.

The respondents were mainly fishermen, traders, factory workers, though with other odd jobs. However, about 42.4%, from respondents from fish farmers profession had Hb levels less than normal (anemia). Only one factory worker was found with anemia, while 53.8% of traders and 20.8% of fishermen were found with low levels of Hb. However, the percentage of Ht and AE counts was slightly lower compared with Hb. This could be due to Pb exposure for the first time would have an impact on the synthesis of heme, thereby reducing the Hb levels. Also, under certain conditions, Pb decomposes in the air, reacts with oxygen to form Pb oxide at a certain temperature, and inhaled in form of small particles usually <5 microns, thereby resulting to its toxicity through inhalation [18]. This is likely to happen to people in areas with high exposure, such as the fishermen, traders, factory workers, and other professions. This could be the reason this research accounted for about 41% of respondents with mild anemia.

According to the results, most of the respondents did not use the PPE. This could impact on the majority having Hb, Ht, and AE levels less than normal. Based on laboratory results, respondents using the PPE in their place of work did not experience anemia in the form of normal Hb, Ht, and erythrocyte counts. Therefore, there is a significant relationship between the use of PPE with the levels of Hb and Ht. The results are in line with a previous research which stated that the incomplete or non-use of PPE resulted in higher levels of Pb among workers compared with those using it. However, the use of PPE could only minimize the exposure to Pb but does not guarantee 100% protectionexposure [19]. So, other factors of respondents are not wearing PPE, smokers, and Frequent consumption of shellfish.

A research conducted by Qoriah *et al*., (2015) showed that smokers among metal casting workers had higher levels of Pb (56.2%) compared with non-smokers [20]. Rustanti and Mahawati (2011) also

showed a significant relationship between smoking habits and the levels of Pb in the blood, the higher the number of cigarettes smoked, the higher the levels of Pb. Furthermore, the absorption levels of Pb in the respiratory mucosa are influenced by smoking habits. The Pb content in cigarettes contributes to the level of exposure in the blood through its smoke and the number of cigarettes impacts on the exposure level [21].

Smoking correlated with higher National Institutes of Health Stroke Scale (NIHSS) scores on admission for small-vessel occlusion. Conversely, it was associated with lower NIHSS scores on admission for cardioembolism.

Among the respondents consuming shellfish, about 38.7, 27.4, and 6.5% had levels of Hb, Ht, and erythrocytes counts, respectively, lower than normal.

Lead Pb Exposure to Pb can occur from many sources but usually arises from industrial use that is around Tambak Lorok Waters like Tanjung Mas Harbor. It can occur from fishing vessels which are accidentally shedding their vessels fuel into the waters, too. Based on the result of the analysis, the accumulation of Pb in the body of Macridiscus sp. is not exceeding the MWI value yet. MTI values mussels which contaminated by Pb are high. It means the mussels are still safe for Pb consumption [22].

The Pb content in the soft tissue of the virgin shellfish (*Anadara granosa* L) in the Tanjung Emas Semarang waters is quite high [23].

The port in this region is very close to Tambaklorok where this study was conducted and its activities including that of other industries in the region could potentially increase the Pb in the city. These include paper factories common with wastes such as Hg, Pb, Cd, and Cr; ceramic factories with Cd, Pb, Zn wastes; workshops with Cd, Pb, Zn, and HCl wastes; car body factories with Pb wastes; ship repair workshops with Pb, and Cu wastes, as well as textile factories with Pb and Cu wastes. There are also many domestic waste disposal sites around the Tambaklorok area, common with used battery slabs and other Pb-containing materials. Furthermore, paints used in painting ships within the area contain compounds such as PbCO3 and Pb3O4, which could enter the estuary and cause high levels of Pb.

This study has provided us that *Macridiscus* sp. that taken from Tambaklorok water is not safe to be consumed by people at that time. It has contaminated by heavy metals such as Pb, Al, Fe, Cu, and Mn. It can impact to body health if we consume it in excess. Besides that, This study may also provide an evaluation of relevant government policy related to waste and fishing village management environmentally [24].

For 38.6% of residents with over 30 years of stay, 42.2% with profession, 45.3% not wearing PPE, 26.7% smokers, and 38.7% of respondents of Tambaklorok had anemia. Furthermore, about 41% of these respondents had anemia with a significant relationship established between the use of PPE and the levels of of both Hb and Ht in their blood.

Conclusion

The conclusion is generally, 41% of Tambaklorok residents in Semarang had mild anemia based on the industrial activities in the region.

Acknowledgments

This study was support to the Institute for Research and Community Service, Universitas Muhammadiyah Semarang. The research was funded by Universitas Muhammadiyah Semarang.

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