COMPARISON OF CARBON MONOXIDE (CO) LEVELS IN THE BLOOD OF ACTIVE SMOKERS IN CIBEBER BASED ON AGE AND SMOKERS CATEGORY

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Abstracts

Data from the Central Bureau of Statistics in 2022 showed that the prevalence of the Indonesian population aged ≥ 15 years who smoke reached 28.26%. Cigarettes are harmful to health because they contain various chemicals that are toxic when inhaled and enter the bloodstream. One of these chemicals is carbon monoxide, which is a by-product of tobacco cigarettes. Measurement of CO in the blood can be used to monitor the level of CO poisoning. This study aimed to determine carbon monoxide levels in the blood of active smokers in Cibeber based on age and category of smokers. Subjects were examined for carbon monoxide levels using venous blood samples using the Conway microdiffusion cell method. The measurement results of carbon monoxide levels in the blood of adolescent smokers were 7.98 ppm to 82.04 ppm, adult smokers were 7.14 ppm to 89.32 ppm, and elderly smokers were 34.02 ppm to 97.88 ppm. While carbon monoxide levels in the blood of light smokers were 7.14 ppm to 50.93 ppm, moderate smokers were 23.1 ppm to 94.9 ppm, and heavy smokers were 81.24 ppm to 97.88 ppm. There is a difference in CO levels based on age with a p-value of 0.001 with a positive direction of comparison. The p-value of 0.0001 indicates a difference in CO levels based on category, where the blood CO levels of heavy smokers are higher than those of light and medium smokers.

Keywords : *Age, Carbon monoxide, Conway Microdiffusion method, Smoking category*

1. Introduction

Indonesia ranks third among the top 10 countries with the highest cigarette consumption rates globally, following China and India, surpassing Russia and the United States[1]. The data from the Central Bureau of Statistics in 2022 indicates that the prevalence of smokers aged ≥ 15 years in Indonesia has reached 28.26%. In West Java Province, the prevalence of adolescent smokers is 20.61%, while the prevalence of adult smokers is 36.92%, and the prevalence of elderly smokers is 29.88%[2].

Several factors contribute to a person consuming cigarettes, including social, pharmacological, and psychological factors. Social factors come from the immediate environment, such as parents and peers. From a pharmacological perspective, the nicotine content in cigarettes causes addiction. However, it's the psychological factors that often go unnoticed-smoking symbolizes maturity and attractiveness to the opposite sex, a revelation that can enlighten many[3].

When a cigarette is lit, it releases a staggering array of approximately 4,000 chemicals. These include carbon monoxide, carbon dioxide, hydrogen cyanide, ammonia, nitrogen oxides, and hydrocarbons, which comprise 92% of the smoke. The remaining 8% is composed of particulate matter, such as tar, nicotine, benzo[a]pyrene, phenol, cadmium, indole, and carsol. It's crucial to note that most of these substances are not just toxic but also carcinogenic, posing a severe threat to health[4].

The study conducted by Pan (2021) shows that the average concentration of CO exhaled by smokers is 6.9 ± 4.9 ppm, while for non-smokers it is 1.9 ± 0.5 ppm. The half-life of exhaled CO for smokers is approximately 273.3 minutes (4.6 hours) [5]. A study by Maga (2019) indicated that the average concentration of CO exhaled by smokers is 6.5 ppm, while for non-smokers it is 1.1 ppm[6].

Long-term exposure to carbon monoxide, whether in smokers or non-smokers, causes an increase in carboxyhemoglobin (COHb) concentration up to 10%, resulting in reduced haemoglobin capacity to carry oxygen and impaired oxygen release by haemoglobin at the tissue level, which is the primary pathophysiological mechanism of CO poisoning[7]. Chronic low-level exposure can lead to decreased cognitive function and neurological disorders. Symptoms of long-term carbon monoxide exposure include chronic fatigue, dizziness, paresthesia, polycythemia, stomach pain, and diarrhea[8].

Based on the number of cigarettes consumed, Lianzi and Pitaloka (2014) classified smokers as light smokers who consume 1 to 4 cigarettes per day, moderate smokers who consume 5 to 14 cigarettes per day, and heavy smokers who consume more than 15 cigarettes per day[9]. The number of cigarettes smoked per day can affect the amount of CO exhaled by smokers. It is estimated that smoking 20 cigarettes per day will increase the CO concentration from 15 to 34 ppm, and smoking 40 cigarettes per day will increase the CO concentration from 25 to 60 ppm[10].

Determining carbon monoxide (CO) levels in the blood using the Conway micro diffusion cell method requires skill to obtain accurate results. The Conway method is also a rapid screening method for the visual detection of palladium metal colour. The application of the Conway micro diffusion cell method for quantitative analysis is performed by measuring the absorption of the reaction between palladium chloride and potassium iodide solution[11].

Khairina's (2019) research shows that COHb levels in the blood of the elderly are higher than in adolescents and adults[12]. Age is a vulnerable factor for every individual, as increasing age causes a reduction in lung tissue elasticity, making it easier to be exposed to CO gas[13]. The elderly are among those at risk of CO poisoning if they are continuously exposed[14]. The importance of this understanding can also be applied in Cibeber Village.

Cibeber Village is located in South Cimahi District, Cimahi City, West Java Province, with an area of 427.110 hectares. Cibeber Village is a densely populated area. In 2021, the male population reached 14,680 people, while the female population was 14,423[15]. Based on a survey conducted by researchers in 2 neighbourhoods (RWs) in Cibeber Village, not only adults and the elderly have smoking habits, but also adolescents, who are influenced by various factors, one of which is social interaction. Even though everyone knows the dangers of smoking, people continue to smoke with the reasoning that smoking or not smoking will still result in illness. This can be seen in daily life at home and in public places.

Based on the above background, the purpose of this study was to determine carbon monoxide levels in the blood of active smokers in Cibeber based on age and category of smokers. This study is expected to provide information about the impact of smoking habits on CO levels in the body.

2. Methods

2.1 Design Research

This study uses primary data directly obtained from respondents through questionnaires regarding age and smoker category. It uses a cross-sectional design, where the researcher takes the variables to be measured as samples and examines them at a specific time. Smokers willing to become respondents and meet the inclusion criteria will be included as subjects for the study.

2.2 Data Analysis

Data processing uses statistical tests to describe a variable, and it is processed using the SPSS program. Normal data will be processed using the One-Way ANOVA test, while non-normal data will be processed using the Kruskal-Wallis test. The data obtained from the research results will be presented in tables.

3. Result

3.1 Respondents' CO Levels Based on Age

The results of the study on carbon monoxide levels in active smokers based on age can be seen in Table 3.1

Table 3. 1 Respondents' CO Levels Based on Age

Age Variable (years old)	(n)	Precentage (%)	Range CO concentration (ppm)	Average CO concentration (ppm)
Youth (12-25)	15	33,4%	7,98–82,04	40,1
Adult (26-45)	15	33,3%	7,14–89,32	59,5
Elderly (46-65)	15	33,3%	34,02–97,88	72,1

Based on Table 3.1 above, the respondents in this study were 45 samples of active smokers with an age range of teenagers, adults, and the elderly, each with 15 respondents. Elderly smokers had the highest average CO levels of 72.1 ppm.

3.2 Respondents' CO Levels Based on Smoking Category

The results of the study on carbon monoxide levels in active smokers based on age can be seen in Table 3.2.

Table 3. 2 Respondents' CO Levels Based on Smoking Category

Smoking Category Variable (pcs)	(n)	Precentage (%)	Range CO concentration (ppm)	Average CO concentration (ppm)
Light (1-4)	14	31,1%	7,14–50,93	40,2
Moderate (5-14)	25	55,6%	23,1-94,9	57,5
Heavy (≥ 14)	6	13,3%	81,24–97,88	72,1

Based on Table 3.2, it can be seen that out of 45 respondents, based on the category of smokers, there were 14 people (31.1%) who were light smokers, 25 (55.6%) who were moderate smokers, and 6 people (13.3%) who were heavy smokers.

3.3 Numerical Univariate Test Results

The data results were subjected to a numerical univariate test to determine whether the levels of carbon monoxide (CO) in the blood of active smokers were high or normal in the respondent sample. The results can be seen in Table 3.3

Table 3. 3 Numerical Univariate Test Results

Variable	Mean	Median	SD	Min - Maks
Based on Age				
Youth	40,1	32	21,2	7,98 – 82,04
Adult	59,5	65,8	21,8	7,14 – 89,32
Elderly	72,1	75,4	21,1	34,02 – 97,88
Based on smoking category				
Light	40,2	32	21,2	7,14 – 50,93
Moderate	57,5	65,8	21,6	23,1 – 94,9
Heavy	72,1	75,4	21,1	81,24 – 97,88

Based on Table 3.3. It can be seen that the lowest level of carbon monoxide (CO) in the blood of active smokers is 7.14 ppm, indicating that the level is normal, the normal limit allowed according to Varlet (2013) is 1 μmol/mL which is equivalent to 28 ppm(16). While the highest level, namely 97.88 ppm, indicates that the level of carbon monoxide in the blood of active smokers exceeds the normal limit of carbon monoxide in the blood.

3.4 Bivariate

3.4.1 Normality and Homogenocity

The results of the normality test of carbon monoxide levels based on age and category of smokers obtained a p value (Sig) > 0.05, so it can be stated that the data on carbon monoxide levels in the blood of active smokers based on age and category of smokers are normally distributed. The value of 0.05 is a reference value to determine whether the data is normally distributed or not normally distributed. If the value obtained is > 0.05, then the data is normally distributed, but if the value obtained is <0.05, then the data is not normally distributed. The results of the homogeneity test of carbon monoxide levels based on age and category of smokers obtained a p value (Sig) > 0.05, meaning that the sample group has the same or homogeneous variance.

3.4.2 ANOVA Result

After the normality test was conducted, the data results were normally distributed. Next, the One-Way Anova test (parametric test) was conducted. The One-Way Anova test is used to compare the average in samples or groups of more than two. The results of the Anova test can be seen in table 3.4.

Table 3. 4 ANOVA result

Variable		One-Way Anova	*Post Hoc*
Based on Age			
Youth	Adult	0,001	0,05
	Elderly		0,00
Adult	Youth		0,05
	Elderly		0,34
Elderly	Youth		0,00
	Elderly		0,34
Based on Smoking Category			
Light	Moderate	0,0001	0,000
	Heavy		0,000
Moderate	Light		0,000
	Heavy		0,004
Heavy	Light		0,000
	Moderate		0,004

**p-value* < 0,05 difference

Based on Table 3.4, the results of the One-Way Anova test of carbon monoxide levels based on age and category of smokers obtained a p value (Sig) <0.05, this indicates a difference in carbon monoxide levels in the blood of active smokers based on age and category of smokers. After the results of the One-Way Anova test were known, a further test was carried out, namely Post Hoc, which is useful for further exploring which groups are significantly related. The results of the Post Hoc test between CO levels based on age showed differences in CO levels in the blood of adolescent smokers with the elderly and adults. While there was no difference in the CO levels of adult and elderly smokers. The results of the Post Hoc test between CO levels based on the category of smokers showed differences in CO levels in the blood of light, moderate, and heavy smokers.

4. Discussion

Tobacco smoke contains various chemicals that are known to be harmful to human health, including free radicals, nicotine, and carbon monoxide (CO), which play an essential role in toxicology. CO in exhaled breath (eCO) and carboxyhemoglobin (COHb) are non-invasive objective measurements to assess smoking status. The total amount of CO in the blood (TBCO) as an alternative to COHb for determining CO exposure can be done using the airtight gas syringe–gas chromatography-mass spectrometry (AGS-GC-MS) method.

This study used the more straightforward Conway method to determine blood CO levels.

The research subjects were strategically chosen from the Cibeber Village, particularly from the densely populated RW 04 and RW 12. This area was selected due to its prevalent smoking habits, which are observed in both home and public settings, across all age groups from teenagers to the elderly.

The number of research subjects in the heavy smoker category was the most minor, namely six people (13%) and the largest category of moderate smokers, with a total of 25 people (55%). Moderate smokers with a smoking rate of between 5 and 16 cigarettes per day are the most subjects, according to research data conducted by Sundari (2015), with the number of moderate smokers being 70.9%.

This study used the Conway microdiffusion method, which uses sulfuric acid for the destruction of carboxyhemoglobin (COHb). Simple forensic laboratories still use this method for semi-quantitative testing by observing the grey layer (Pd metal) formed on the surface of the $PdCl_2$ liquid. Quantitative measurements are continued by reacting the remaining $PdCl_2$ with excess KI to produce Pd metal and I_2. The I_2 formed will react with the remaining KI to produce a brown KI_3 complex, and its absorbance is measured using a spectrophotometer at a wavelength of 415 nm.

The reaction between $PdCl_2$ and KI is an oxidation-reduction reaction that produces evaporated I_2 to correct the evaporation; in this study, the reaction optimization time was measured by measuring a series of $PdCl_2$ concentrations reacted with KI and the reaction optimization time was obtained was 10 minutes seen from the correlation coefficient value with an R^2 value of 0.9917, so that all measurements of the absorbance of the $PdCl_2$ standard and the remaining $PdCl_2$ from the sample reaction were incubated for 10 minutes after the addition of $PdCl_2$.

The creation of the $PdCl_2$ standard curve was made by 3-day regression according to the measurement time. The standard measurements produced R2 regression coefficient values of 0.9961, 0.9985, and 0.9968, respectively; these values are by the criteria for good linearity with $R^2 \geq 0.990$. The calculation was carried out using the one-point method, and the absorbance standard used was the absorbance value of 0.3 mL of initial $PdCl_2$, which corresponds to the $PdCl_2$ taken after the reaction; for the calculation, it was adjusted to the initial $PdCl_2$ volume that reacted with the blood sample of 1.5 mL.

This study's findings on the average carbon monoxide levels in the blood of active smokers, which align with research conducted by Khairina (2019) provide a sense of reassurance about the study's validity. The highest level found in elderly active smokers further supports the study's alignment with existing research(12).

The study results of carbon monoxide levels in active smokers of adolescents obtained varying levels, with the lowest level being 7.98 ppm and the highest level 82.04 ppm. The half-life of carbon monoxide at body temperature is around 5-6 hours. Hilyah's research (2021) found that variations in carbon monoxide levels in the blood can be caused by the number of cigarettes consumed and the short time interval between one cigarette and the next. This can cause an increase in carbon monoxide levels in the blood(17).

The results of the study showed that the highest level was 97.88 ppm in the research subject with sample code L8 in the elderly category and was a heavy smoker; the high CO levels in the subject were caused by the ageing process, which caused reduced elasticity of the lung tissue so that CO increased in the blood. The results of this study are the same as those conducted by Hasan (2017) who stated that respiratory efficiency decreases with age. If exposed to other factors, such as pollution and having a smoking habit, respiratory system disorders will appear more clearly(18).

According to Varlet (2013), the limit for carbon monoxide levels is one μmol/ml of blood, which, when multiplied by the molecular weight of CO, is equal to 28 ppm. Research results show that the average level of carbon monoxide in the blood of elderly smokers in the heavy smoker category is 72.1 ppm, with the lowest level being 7.14 ppm and the highest level being 97.88 ppm(16). According to Hilyah's groundbreaking research (2021), 39 individuals, predominantly moderate and heavy smokers, exhibited CO levels that surpassed the standard limit. The number of cigarettes consumed daily was found to directly influence exhaled CO levels, a significant discovery(17).

The results of this study's rigorous normality test, which examined data on active smokers based on age, smoker categories, and carbon monoxide levels, revealed a normal distribution. This meticulous process instills confidence in the validity of the subsequent One-Way ANOVA test (a parametric test) used to compare carbon monoxide levels in the blood of active smokers based on age and smoker categories.

The results of the One-Way ANOVA test between carbon monoxide levels and age categories obtained a p-value of 0.001, which is less than the standard significance level of 0.05. This value indicates statistically significant differences in carbon monoxide levels in the blood of active smokers in adolescence, adulthood, and the elderly. This was based on previous research conducted by Khairina (2019), which found differences in carbon monoxide levels in the blood of smokers based on age differences(12). The ageing of the respiratory system in the elderly is associated with structural and functional decline, resulting in increased breathing work compared to younger subjects. Changes in lung function due to ageing increase residual volume in the lungs by about 50% between the ages of 20 and 70 years.

The results of the One-Way ANOVA test between carbon monoxide levels and the category of smokers obtained a p-value of 0.0001, which indicates a difference in carbon monoxide levels in the blood of active smokers based on the category of smokers. This is based on Hilyah's research (2021), which states that there is a difference in carbon monoxide levels in the blood of smokers based on the number of cigarettes consumed per day(17). The more cigarettes consumed and the more frequent the smoking frequency, the more CO will be in the blood according to a half-life of 5-6 hours at body temperature and will remain in the blood for about 8 hours.

5. Conclussion

a. Carbon monoxide levels in the blood of active smokers aged teenagers range from 7.98 ppm to 82.04 ppm, while in active smokers aged adults, it ranges from 7.14 ppm to 89.32 ppm, and in active smokers aged elderly, it ranges from 34.02 ppm to 97.88 ppm.
b. The study also revealed distinct carbon monoxide levels in the blood of light, moderate, and heavy smokers. Light smokers showed levels ranging from 7.14 ppm to 50.93 ppm, moderate smokers from 23.1 ppm to 94.9 ppm, and heavy

smokers from 81.24 ppm to 97.88 ppm.

c. The study found statistically significant differences in carbon monoxide levels in the blood of active smokers across different age groups. The p-value of 0.001 and a positive comparison direction underscore the importance of these findings.

d. These findings have profound implications for public health and smoking cessation programs. By understanding the variations in carbon monoxide levels among different categories of smokers, we can tailor interventions to better support those at higher risk. Our research, with a p-value of 0.0001, shows that the carbon monoxide levels in the blood of light smokers are lower than those of moderate and heavy smokers, providing a clear direction for targeted interventions.

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