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Environmental Health Risk Assessment of Carbon Monoxide Exposure for Security Guards and Ticketing Officers at Safe N Lock Sidoarjo

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ABSTRACT Security guards and ticketing officers inhale the CO gas from motor vehicles, which can lead to health complaints like sore and watery eyes. The purpose of this study is to assess the health risks of CO gas exposure to the health of security guards and ticketing officers at Safe N Lock Sidoarjo. This research is descriptive, cross-sectional, and employs an ARKL approach. The population of 43 security guards and 7 ticketing officers at the same time became the sample. The research variables are CO gas concentration, temperature, humidity, wind speed, vehicle generation, fuel type, exposure frequency, exposure time, exposure duration, inhalation rate, average time, body weight, RfC, intake, and risk characterisation. The data collection technique uses direct measurement, interview sheets, and observation. The data processing technique involves computation of risk. We analysed the data using both univariate and risk analysis techniques. The results of the study showed an average CO concentration of 100.982 µg/m³. Security guard exposure time was 12 hours/day, while ticketing officers were 8 hours/day. Security guard exposure frequency was 261 days/year, while ticketing officers were 313 days/year. The highest duration of exposure was 25 years. The highest intake rate was 26.048 mg/kg/day with an RQ value of 0.086 mg/kg/day. The risk assessment concludes that the RQ value is less than 1, indicating a low risk of health disorders due to CO gas exposure. The researcher recommends that security guards and ticketing officers use personal protective equipment such as glasses and masks when working.

INDEX TERMS ARKL, Carbon monoxide, ticketing officers, security guards.

I. INTRODUCTION

Air is the source of life for all living things on earth, including humans [1]. Air quality in developing countries, especially in Southeast Asia and the Pacific, is poor, with 6.6 million deaths from air pollution worldwide in 2019 [2]. Air pollutants include carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), hydrocarbons (HC), chlorofluorocarbons (CFCs), lead (Pb), nitrogen dioxide (NO_2), and particulate matter (PM) [3]. CO gas is a gas produced from incomplete combustion with the physical characteristics of being colourless, odourless, tasteless, and non-irritating, but toxic and flammable, so CO gas is dubbed the "silent killer" that is dangerous to human health [4].

Safe N Lock Sidoarjo industrial and warehousing area is one of the largest industrial and warehousing areas in Eastern Indonesia. Safe N Lock Sidoarjo has a land area of ± 500 hectares with 600 tenants and will continue to grow following the market. The number of vehicles entering and exiting Safe N Lock is ± 1,500 units/day, such as cars, motorbikes, trucks, trontons, and other vehicles, which can increase the concentration of CO gas in the air. This is in line with research [5] that states that there is a relationship between the number of vehicles and the high emissions of carbon monoxide (CO).

The preliminary survey was conducted by means of observation, interviews, and direct measurements. Observations in the Safe N Lock area found that security guards and ticketing officers did not use personal protective

equipment in the form of masks. Interviews with 5 security guards and 2 ticketing officers regarding health complaints revealed that they all had health complaints such as sore and watery eyes, coughing, and shortness of breath due to exposure to smoke from motor vehicles. This is in line with research [6] stating that there is an effect of vehicle smoke exposure on the health quality of traffic police at Parepare Police Headquarters. The results of the interviews also show that 4 out of 7 security guards and ticket officers are smokers. This is one of the risk factors for respiratory complaints apart from exposure to motor vehicle smoke. In line with the research [7], it is stated that there is a relationship between the concentration of CO gas and smoking habits and respiratory complaints among satay sellers. Measurement of the physical quality of the air at the entrance of Safe N Lock obtained a temperature of 30.8ºC, humidity of 64.1%, and wind speed of 0.2 - 0.8 m/s. Measurement of CO gas concentration at the Safe N Lock entrance yielded a result of 681.356 µg/m³. Research [8] states that someone who is exposed to CO directly and continuously can have health impacts such as heart attack, coronary heart disease, Delayed Encephalopathy after Acute Carbon Monoxide (DEACMP), and cardiovascular disease.

The purpose of this study is to assess the major health risks due to exposure to carbon monoxide (CO) gas to the security guards and ticketing officers at Safe N Lock Sidoarjo.

II. METHODOLOGY

This type of research is descriptive cross-sectional. The research approach uses Environmental Health Risk Analysis (EHRA) to evaluate the health risks of security guards and ticketing officers at Safe N Lock Sidoarjo. The population and community sample used were 43 security guards and 7 ticketing officers, while the environmental sample in this study was the concentration of CO gas.

The sampling technique for security guards and ticketing officers uses non-probability sampling with the total sampling method, where the number of samples is equal to the population size. The CO gas sampling technique uses the appropriate Non-Dispersive Infra Red (NDIR) method, and the determination of air sampling points in the workplace refers.

The variables in this study are CO gas concentration, temperature, humidity, wind speed, vehicle generation, fuel type, exposure frequency, exposure time, exposure duration, inhalation rate, average time, body weight, RfC, intake, and risk characterisation. We collected data through interviews, direct measurements, and observations. Data analysis used univariate analysis and risk analysis, which referred to the RQ formula in the ARKL guidelines.

III. RESULT

A. MEASUREMENT OF PHYSICAL AIR QUALITY AT SAFE N LOCK SIDOARJO

Based on the TABLE 1 above, the average temperature is 31.7ºC. The average wind speed is 4 m/s. Humidity has an average value of 68%.

TABLE 1
AIR QUALITY MEASUREMENT AT SAFE N LOCK SIDOARJO

Parameter	Assessment	Result	Quality Standart	Category
Temperature	Minimum	30,1ºC	20ºC – 30ºC	Not Qualify
	Maximum	33,1ºC		Not Qualify
	Average	31,7 ºC		Not Qualify
Wind Speed	Minimum	0,8 m/dt	-	-
	Maximum	7,2 m/dt		-
	Average	4 m/dt		-
Humidity	Minimum	65,7%	40% – 70%	Qualify
	Maximum	71,2%		Not Qualify
	Average	68%		Qualify

B. MEASUREMENT OF CO GAS CONCENTRATION AT SAFE N LOCK SIDOARJO

Based on TABLE 2 above, the measurement results of CO gas concentration have an average value of 100.982 µg/m³, so that they are entirely included in meeting the quality standards.

TABLE 2
MEASUREMENT OF CO GAS CONCENTRATION AT SAFE N LOCK SIDOARJO

Assessment	Result	Quality Standart	Category
Minimum	0	10.000 µg/m³	Qualify
Maximum	302,825		Qualify
Average	100,982		Qualify

C. CALCULATION OF VEHICLE GENERATION AT SAFE N LOCK SIDOARJO

Based on the TABLE 3 above, the total number of vehicles entering and exiting during the study was 87 vehicles with an average of 29 vehicles.

TABLE 3
VEHICLE GENERATION AT SAFE N LOCK SIDOARJO

Sampling Code	Measurement Duration	Vehicle Generation (units)
Entrance Gate (Sampling Point 1)	1 hour	32
Exit Gate (Sampling Point 2)		47
Block AA (Sampling Point 3)		8
Total		87
Average		29

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D. IDENTIFY THE TYPE OF MOTORCYCLE FUEL AT SAFE N LOCK SIDOARJO

Based on the TABLE 4 above, many large vehicles use diesel fuel or solar.

TABLE 4
TYPES OF MOTOR FUEL AT SAFE N LOCK SIDOARJO

Type Of Vehicle	Type Of Motor Fuel
Car	Pertalite/Pertamax
Pick Up	Pertalite/Pertamax
Colt Diesel Engkel	Solar
Fuso	Solar
Tronton	Solar
Wing Box	Solar
Tandum Tangki	Solar

E. HAZARD IDENTIFICATION

Based on the TABLE 5 above, the agent that poses a risk of causing health problems to security guards and *ticketing* officers is carbon monoxide (CO) in ambient air. The source of particulate matter (CO) in ambient air is motor vehicles with an average concentration of 100.982 µg/m^3. Health complaints due to CO gas by security guards and ticketing officers are described in the table below as supporting data in completing the hazard identification stage :

TABLE 5
IDENTIFICATION OF CO GAS HAZARDS AT SAFE N LOCK SIDOARJO

Source	Potential environmental media	Risk Agent	Measurable Concentration		
			Minimum	Maximum	Average
Motorized vehicles entering and exiting Safe N Lock Sidoarjo	Ambient Air	Carbon monoxide (CO)	0,0	302,825	100,982

Based on the TABLE 6 above, most health complaints experienced by security guards and ticketing officers are sore and watery eyes with a percentage of 32%.

F. DOSE RESPONSE ASSESMENT

The risk agent in this study is carbon monoxide, for which the CO gas Reference Concentration (RfC) value is not yet available in the Integrated Risk Information System (IRIS) list of the Environmental Protection Agency (EPA), so the RfC value is obtained from the RfC calculation which refers to the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023. The reference dose of CO gas that has been calculated using the RfC formula yields a result of 1.157 mg/kg/day or the equivalent of 1,157 µg/kg/day.

G. EXPOSURE ASSESMENT

1. Gender

TABLE 6
RECAPITULATION OF INTERVIEW RESULTS COMPLAINTS AGAINST SECURITY GUARDS AND TICKETING OFFICERS AT SAFE N LOCK SIDOARJO

Complaints	Amount	Percentage
Shortness of breath	7	14
Chest pain	1	2
Cough	8	16
Sore throat	2	4
Sore and watery eyes	16	32
Headache	2	4
Nausea	0	0
Vomiting	1	2
Weakness	1	2
Coma with seizures	0	0
Slow breathing	1	2
History of respiratory disorders	1	2

Based on the FIGURE 1 above shows that the majority gender of security guards and ticketing officers are male, with a percentage of 96% or 48 people.

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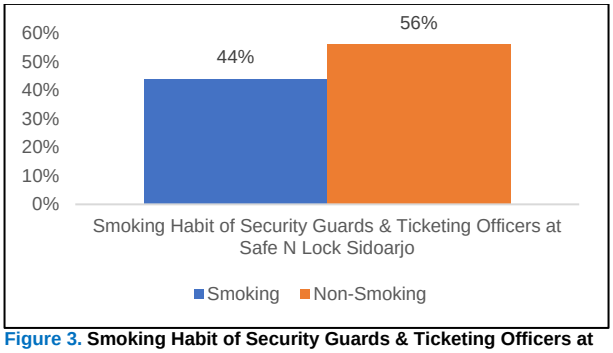

Figure 3. Smoking Habit of Security Guards & Ticketing Officers at Safe N Lock Sidoarjo

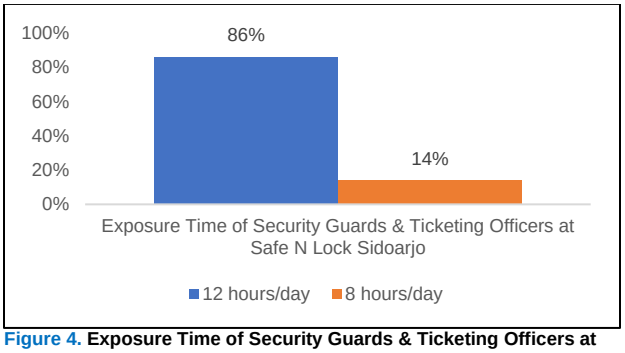

Figure 4. Exposure Time of Security Guards & Ticketing Officers at Safe N Lock Sidoarjo

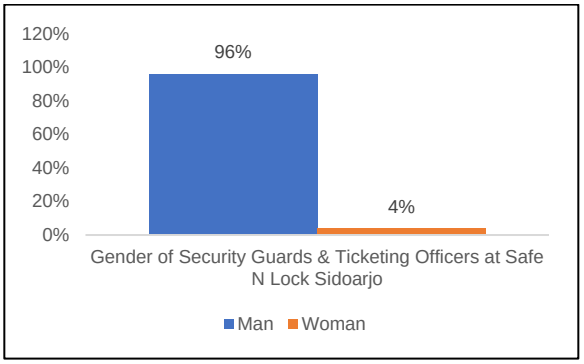

Figure 1. Gender of Security Guards & Ticketing Officers at Safe N Lock Sidoarjo

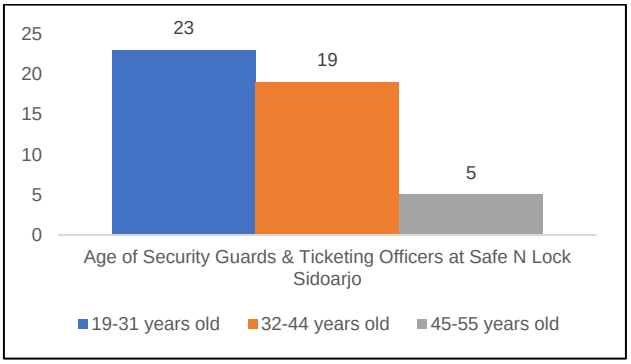

Figure 2. Age of Security Guards & Ticketing Officers at Safe N Lock Sidoarjo

2. Age

Based on the FIGURE 2 above shows that most security guards and ticketing officers are between the ages of 19 and 31.

3. Smoking Habits

Based on the FIGURE 3 above shows that most security guards and ticketing officers do not smoking, with a percentage of 56%

4. Exposure Time

Based on FIGURE 4 above, it shows that most of the exposure time is 12 hours/day with a percentage of 86%.

5. Exposure Frequency

Based on FIGURE 5 above, it shows that most of the exposure frquency is 216 days/year with a percentage of 86%.

6. Exposure Duration

Based on FIGURE 6 above shows that most of the exposure duration is 4 years with a percentage of 38% or 19 people.

7. Body Weight

Based on FIGURE 7 above, it shows that most security guards and ticket officers have a weight range of 63 kg - 76 kg with a percentage of 49% or 24 people.

8. Intake Calculation

The intake calculation was carried out on all security guards and ticketing officers. It can be seen that the highest CO concentration intake value was 26.048 mg/kg/day in the respondent with the code R38, who was known to be a security guard aged 53 and had worked for 25 years at Safe N

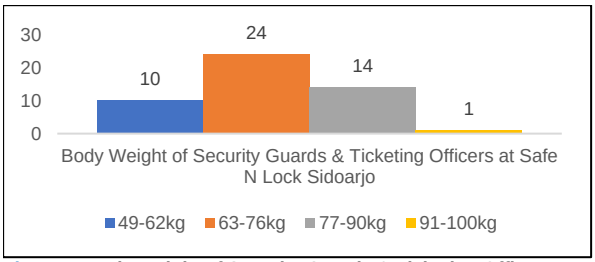

Figure 5. Body Weight of Security Guards & Ticketing Officers at Safe N Lock Sidoarjo

Lock Sidoarjo, while the lowest CO concentration intake value was 0.846 mg/kg/day in the respondent with code R25, who was known to work as a security guard, was 23 years old, and had only been working at Safe N Lock Sidoarjo for 1 year.

H. RISK QUOTIENT

The RQ results for all security guards and ticketing officers at Safe N Lock Sidoarjo have an RQ of ≤ 1, which means that there is no risk at the minimum, average, or maximum RfC concentrations. Therefore, it can be concluded that security guards and ticketing officers at Safe N Lock Sidoarjo are not at risk of health impairment due to exposure to carbon monoxide (CO).

B. MEASUREMENT OF CO GAS CONCENTRATION AT SAFE N LOCK SIDOARJO

The findings from this study indicate that the concentration of CO gas at Safe N Lock Sidoarjo, with an average of 100.982 µg/m³, falls within acceptable quality standards. However, the data suggests that prolonged exposure, especially among security guards working 12 hours/day, may contribute to the development of respiratory symptoms. The common complaints among security guards and ticketing officers, such as sore and watery eyes, support previous studies that link CO exposure to eye irritation and respiratory distress. These health issues, although not severe at the time of measurement, highlight the need for preventive measures to reduce exposure.

The average number of motorized vehicles generated is 29 units/hour. Research [21][22] shows that the more motorized vehicles are generated, the more emissions are produced, and vice versa.

The results of the measurement of the physical quality of the ambient air have a temperature above the quality standard, with a wind speed including gentle gusts, and humidity below the quality standard so that the average concentration of CO gas is below the quality standard. This is in line with research [23] stating that high temperatures make air conditions become loose so that the concentration of pollutants becomes low, while for strong wind speeds the pollutants will spread widely so that the concentration decreases, and for low humidity the concentration of pollutants becomes low because high humidity makes the pollutants react with water vapor, causing the concentration of pollutants to become high.

Furthermore, the suggestion to enhance as a mitigation strategy is highly relevant. Several studies have indicated that urban green spaces can absorb CO and other pollutants, improving air quality and reducing the risks associated with vehicle emissions. Implementing such environmental modifications not only improves air quality but also contributes to the overall health and well-being of workers in industrial settings. This is in line with research [24] stating that RTH is very necessary in the industrial era, especially in big cities, even more so if the place is designated as an industrial and warehousing area, so that RTH functions as a producer of oxygen, absorbs rainwater, and absorbs air pollutants.

C. CALCULATION OF VEHICLE GENERATION AT SAFE N LOCK SIDOARJO

The average vehicle generation is 29 units. This is because most workers arrive at 07:00 - 08:00 WIB and the sampling time is a time when operational activities in the majority of companies in Safe N Lock Sidoarjo are distributing to both consumers and picking up goods from suppliers, so that the number of vehicles leaving is greater than the number of vehicles entering.

This is reinforced by the results of the ambient air laboratory test that the CO concentration at point 1 is 0.123 µg/m^3, point 2 is 302.825 µg/m^3, and point 3 is 0.0 µg/m^3. This is in line with research [25] stating that as the number of motorized vehicles increases, the concentration of pollutants increases, and conversely, as the number of motorized vehicles decreases, the concentration of pollutants decreases.

There is no limit to the number of vehicles entering and exiting the Safe N Lock Sidoarjo area, so Safe N Lock Sidoarjo on behalf of PT. Griya Prima Amanda already has an Andalalin (Traffic Impact Analysis) document. The document has been issued a Decree approved by the Regent of Sidoarjo and is valid during operations.

D. IDENTIFY THE TYPE OF MOTORCYCLE FUEL AT SAFE N LOCK SIDOARJO

Large vehicles that enter the Safe N Lock Sidoarjo area are cars, pickups, diesel Colt Engkel trucks, Fuso trucks, tronton trucks, wing boxes, and tankers. Identification of the type of fuel for large vehicles engines at Safe N Lock shows that the majority use diesel.

Diesel is known to produce greater CO gas emissions than motor fuels such as pertalite and pertamax. This is in line with research [26] proving that carbon monoxide exhaust emissions in motor vehicles that use diesel as fuel are proven to be 59% greater than in vehicles that run on gasoline such as pertalite and pertamax. Research [21] has similarly concluded that diesel has a higher CO content than pertalite or pertamax.

The correlation between high CO concentrations and vehicle emissions is consistent with other studies showing that increased vehicle mobility contributes to elevated pollutant levels. The quality of the air, including temperature, wind speed, and humidity, plays a crucial role in the dispersion of CO in the environment. As indicated in our study, the temperature exceeded quality standards, potentially exacerbating the concentration of CO in the air. This finding aligns with research [27] suggesting that high temperatures and low humidity facilitate the accumulation of pollutants.

The effort to reduce pollutants caused by emissions from diesel-fueled vehicles is reforestation. This is in line with

research [28] [29] on the benefits of reforestation, which is that it produces oxygen as the main component in the respiratory process of humans and other living things, as well as lowering temperatures and absorbing pollutants caused by the combustion of motor vehicle engines.

E. HAZARD IDENTIFICATION

At the hazard identification stage, findings were found in the form of health complaints in security guards and ticketing officers in the form of sore and watery eyes with a percentage of 32%. One thing in this study was the absence of personal protective equipment (PPE) among workers, particularly masks and goggles. Research has shown that proper use of PPE can significantly reduce exposure to harmful airborne pollutants. The lack of PPE in this study underscores the importance of workplace safety regulations and interventions aimed at minimizing exposure to environmental hazards.

Preventive measures against health complaints at the hazard identification stage are to use complete Personal Protective Equipment. This is in line with research [1] [30] stating that not using Personal Protective Equipment (PPE) can increase the risk of health complaints.

F. DOSE RESPONSE ASSESMENT

The risk agent in this study is carbon monoxide, for which the CO gas Reference *Concentration* (*RfC*) value is not yet available in the *Integrated Risk Information System* (IRIS) list of the *Environmental Protection Agency* (EPA).

The study states that CO gas is included in the reference concentration or RfC with the effect of respiratory tract irritation, so that the RfC value is obtained from the RfC calculation which refers to the CO gas ambient air chemical parameter quality standard of 10, 000 μg/m^3 which is then converted to 10 mg/m^3, then substituted into the default values in the ARKL guidelines from the Director General of PP and PL of the Ministry of Health in 2012, namely R = 0.83 m3/hour, tE = 8 hours/day, fE = 350 days/year, Dt = 30 years, Adult Wb = 55 kg, tavg = 30 years x 365 days = 10,950 days, then entered into the RfC formula as follows:

$$RfC = \frac{C \; x \; R \; x \; tE \; x \; fE \; x \; Dt}{Wb \; x \; tavg}$$

$$RfC = \frac{10\frac{mg}{m3} x \; 0{,}83\frac{m3}{jam} x \; 8\frac{jam}{hari} x \; 350\frac{hari}{tahun} x \; 30 \; tahun}{55 \; kg \; x \; 10.950 \; hari}$$

RfC = 1,157 mg/kg/hari ≈ 1.157 μg/kg/hari

The reference dose of CO gas used comes from the above calculation, which is 1.157 mg/kg/day or equivalent to 1,157 μg/kg/day.

G. EXPOSURE ASSESMENT

1. Gender

Most security guards and ticketing officers are male, with a percentage of 96% or 48 people. The lung capacity of a male individual is greater than that of a female. This is in line with research [31] stating that age, gender, weight, and race are factors that influence lung capacity between individuals. Research [32] has the same opinion that the vital capacity of the lungs of men is 6.0 liters and women is 4.2 liters. This shows that a man's lung capacity is greater than that of a woman.

2. Age

Security guards and ticketing officers at Safe N Lock Sidoarjo are mostly aged 19–31 years old, with a percentage of 49% or 23 people. People aged 20-40 will experience physical decline at the age of 40 and above. Researchers argue that as people get older, physical strength decreases if it is not balanced with a healthy lifestyle. This is in line with research [33] stating that there is a correlation between nutritional status and the quality of human physical health.

Efforts that can be made to reduce and/or prevent the accelerated decline in lung quality are to stop smoking and use PPE when in locations that intersect with motorized vehicles. This is in line with research [34] stating that the decline in lung quality begins around the age of 35. The factors that influence the accelerated decline in lung quality are smoking and air pollution. Muscle strength begins to decline, especially after the age of 40.

3. Smoking Habits

The definition of habit according to the Big Indonesian Dictionary is a pattern of behavior that is done repeatedly. Smoking affects health complaints, especially respiratory complaints. This is in line with research [35] stating that the ρ value is 0.01 so that H0 is rejected, it can be concluded that there is a correlation between smoking and respiratory complaints.

The results of research related to smoking habits among security guards and ticket officers show that the majority do not smoke. The researcher assumes that from the results of the interview, most respondents, both security guards and ticketing officers, are aware of the negative effects of smoking, so they decide not to smoke to maintain their health, especially their lungs. This is in line with research [36] stating that there is a relationship between passive smokers' knowledge of the effects of cigarette smoke on prevention efforts with a ρ value of 0.006 (ρ value <0.05).

The efforts that can be made by respondents, the majority of whom do not smoke, are to remind active smokers to smoke in smoking areas or areas where there are no passive smokers. The efforts that can be made for active smokers are to smoke in special smoking areas or places that are free from passive smoking, and to reduce smoking habits in two ways, namely behavioral and pharmacological approaches or using medication. This is in line with research [37] stating that the impact of lifelong smoking habits, pipe/cigar smoking, and smoking duration varies for various causes of death, and that quitting smoking is effective in reducing the risk of death from all causes.

4. Exposure Time

Exposure time can be defined as the length of time worked in 1 day. Security guards work 12 hours/day, while ticket officers work 8 hours/day. Researchers argue that the longer the working hours, the longer the exposure to CO pollutants, so that security guards are potentially at greater risk from CO gas exposure than ticket officers. This is in line with the Environmental Health Risk Analysis Guidelines of the Directorate General of PP and PL of the Ministry of Health which states that the default value for exposure time is 8 hours/day [38]. Research [3] states that exposure time is one of the factors that influence the risk value of non-carcinogenic substances in respondents, the longer the exposure time, the higher the risk received.

Prevention from exposure to air pollutants using personal protective equipment such as masks and goggles. This is in line with research [39] [40] stating that the use of personal protective equipment or PPE is very important in order to avoid work accidents, protect oneself from the risk of work-related health problems, and as a responsibility to oneself and the institution.

5. Exposure Frequency

The frequency of exposure for security guards is 261 days/year, while for ticketing office staff it is 313 days/year. The calculation is as follows:

1 year = 365 days
1 year = 52 weeks
Holidays = 2 days (security guard), and 1 day (ticketing officer)
So, the frequency of exposure to security guards
= 365-(2 days off x 52 weeks)
= 365-104
= 261 days/year, while the
Frequency of exposure to ticketing officers
= 365-(1 day off x 52 weeks)
= 365-52
= 313 days/year

The frequency of exposure of security guards and ticketing officers at Safe N Lock Sidoarjo is greater than the default value set in the Environmental Health Risk Analysis Guidelines of the Directorate General of PP and PL of the Ministry of Health, which is 250 days/year [38]. This shows that the frequency of exposure of security guards and ticketing officers has an impact on the amount of CO gas pollutants inhaled by respondents over the course of a year. The amount of exposure that each respondent receives will have an impact on the level of health risk to security guards and ticketing officers.

Preventive measures to minimize air pollutants are the use of personal protective equipment such as masks and goggles. This is in line with research [41] stating that $\rho < 0.001 < \alpha = 0.05$, which means that there is a relationship between the use of PPE and respiratory disorders among furniture workers in Medan Satria District, Bekasi City.

6. Exposure Duration

From the interviews with all respondents, it was found that the majority, 19 people, had been exposed for 4 years and had worked at Safe N Lock Sidoarjo. In terms of exposure duration, the study found that security guards with longer work tenures (up to 25 years) showed higher intake levels of CO. This suggests that cumulative exposure over time could increase health risks, which is in line with other studies indicating that long-term exposure to CO is linked to chronic health conditions such as cardiovascular diseases. Research [42] has stated that the duration of exposure has a correlation with the concentration of CO gas in the blood so that a long duration of exposure causes an increase in the concentration of CO gas in the blood.

7. Body Weight

Most of the respondents' body weight ranged from 63 kg to 76 kg, with 24 people. The researcher argues that the greater a person's body weight, the smaller the intake of CO gas is produced. This is in line with research [33] [43] stating that the greater a person's body weight, the greater the lung capacity, so that the air exposed to CO gas is also inhaled more, therefore a large body weight will affect the Risk Quotient value. This is proven from the results of this study that the security guard with the highest body weight, 100 kg, has an intake value of 2,876 mg/kg/day, while the security guard with the lowest body weight, 54 kg, has an intake value of 4,258 mg/kg/day.

8. Intake Calculation

The calculation of CO intake levels for security guards and ticketing officers at Safe N Lock Sidoarjo showed that the highest intake level was 26.048 mg/kg/day, while the lowest was 0.846 mg/kg/day. The highest intake results include exceeding the CO gas Reference Concentration value of 1,157 mg/kg/day, which means that daily exposure received by security guards with the highest intake value can have a bad impact on health. This is known because the respondent with the highest intake value has been exposed for 25 years, with other supporting factors such as a body weight of 69 kg, age of 53 years, exposure time of 12 hours/day, and frequency of exposure for 261 days/year.

The lowest intake result does not exceed the CO gas Reference Concentration value of 1,157 mg/kg/day, which means that the daily exposure received by the security guard with the lowest intake value has not had an adverse effect on health. This is known because of the duration of exposure or having worked for only 1 year at the age of 23, as well as other supporting factors such as body weight of 85 kg, exposure time of 12 hours/day, and frequency of exposure for 261 days/year.

From the highest and lowest intake results described above, it can be concluded that the intake value is related to the duration of exposure, age, CO gas concentration, exposure time, and frequency of exposure. This is in line with research [44] that states that the intake value has a correlation between chemical concentration, age, and frequency, time and

duration of exposure, but the intake value is inversely proportional to body weight and the average period or T_{avg}, so that the greater the body weight, the smaller the intake value.

H. RISK QUOTIENT

All the security guards and ticketing officers at Safe N Lock Sidoarjo have an RQ value of less than 1, which means there is no risk at the lowest, average, or highest RfC concentrations. This means that the security guards and ticketing officers at Safe N Lock Sidoarjo are not at risk of getting sick from being exposed to carbon monoxide (CO).

The results of the researcher's analysis prove that the main factor affecting the RQ value is the duration of exposure. Respondents with code R38 had an exposure duration of 25 years and an RQ value of 0.086, which is greater than the RQ value for all other respondents. Those respondents with code R38 had a greater health risk than respondents with codes R9, R25, and R42, who each had an exposure duration of 1 year. This is in line with research [3] stating that the main factor influencing 48 people, or 67.79% of respondents who have an RQ value of ≤ 1, is duration of exposure. Long duration of exposure makes the intake value received by the respondent greater.

V. CONCLUSION

While the study found that the overall risk of health impairment due to CO exposure is low (RQ ≤ 1), it is essential to consider the long-term effects of exposure, particularly for individuals working for extended periods. The study recommends regular monitoring of air quality, the introduction of PPE for workers, and the promotion of environmental strategies such as increasing green spaces to reduce pollutant concentrations. These measures will help ensure the health and safety of workers in high-risk environments like Safe N Lock Sidoarjo, contributing to the broader goal of improving occupational health standards.

REFERENCES

[1] A. Lestari, "ANALISIS RISIKO KESEHATAN LINGKUNGAN AKIBAT PAJANAN CO PADA PEDAGANG DI PASAR KEBALEN KOTA MALANG," 2021. Accessed: Jun. 07, 2024. [Online]. Available: https://mhjeh.widyagamahusada.ac.id/index.php/mhjeh/article/view/2

[2] H. Jusuf, E. Prasetya, and N. Igirisa, "ANALISIS RISIKO KESEHATAN LINGKUNGAN PAJANAN PARTICULATE MATTER (PM 10) DAN KARBON MONOKSIDA (CO) PADA MASYARAKAT DI DESA BUATA KECAMATAN BOTUPINGGE," *Jurnal Sulolipu : Media Komunikasi Sivitas Akademika dan Masyarakat*, vol. 23, no. 1, pp. 187–198, 2023, [Online]. Available: https://ojs3.poltekkes-mks.ac.id/index.php/medkasi/article/view/428

[3] Y. K. Anggelina, N. Amalia, F. J. Anggraini, and Z. Rodhiyah, "Analisis Risiko Pajanan Karbon Monoksida (CO) terhadap Pedagang Pasar Tradisional Kota Jambi," *Al-Ard: Jurnal Teknik Lingkungan*, vol. 8, no. 1, pp. 46–55, 2022, [Online]. Available: http://jurnalsaintek.uinsby.ac.id/index.php/alard/index

[4] S. A. F. B. Mentari, F. Firdani, and S. P. Rahmah, "ANALISIS RISIKO PAJANAN GAS KARBON MONOKSIDA (CO) PADA PEDAGANG DI SEPANJANG JALAN DEPAN PASAR BANDAR BUAT KOTA PADANG," *Jurnal Keselamatan Kesehatan Kerja dan Lingkungan (JK3L)*, vol. 2, no. 2, pp. 71–82, 2021, Accessed: Jan. 17, 2024. [Online]. Available: http://jk3l.fkm.unand.ac.id/index.php/jk3l/article/view/27/22

[5] A. Sasmita, M. Reza, S. Elystia, and S. Adriana, "ANALISIS PENGARUH KECEPATAN DAN VOLUME KENDARAAN TERHADAP EMISI DAN KONSENTRASI KARBON MONOKSIDA DI JALAN JENDERAL SUDIRMAN, KOTA PEKANBARU," *Jurnal Teknik Sipil*, vol. 16, no. 4, pp. 269–279, 2022, Accessed: Jan. 17, 2024. [Online]. Available: https://ojs.uajy.ac.id/index.php/jts/article/view/5452

[6] N. Qamarya, I. Rahim, and A. Majid, "PENGARUH RISIKO PAPARAN ASAP KENDARAANTERHADAP KUALITAS KESEHATAN PADAPOLANTAS POLRES KOTA PAREPARE," *Jurnal Ilmiah Manusia dan Kesehatan*, vol. 5, no. 1, pp. 468–474, 2022, Accessed: Jan. 17, 2024. [Online]. Available: https://jurnal.umpar.ac.id/index.php/makes/article/view/710

[7] A. R. Wijaya and D. A. Putri, "Determinan Keluhan Subyektif Pernafasan Pada Penjual Sate di Kota Palembang," *Jurnal Kesehatan Masyarakat Indonesia*, vol. 17, no. 3, pp. 40–47, 2022, Accessed: Jan. 17, 2024. [Online]. Available: https://jurnal.unimus.ac.id/index.php/jkmi/article/view/9345

[8] M. A. Rizaldi, R. Azizah, M. T. Latif, L. Sulistyorini, and B. P. Salindra, "Literature Review: Dampak Paparan Gas Karbon Monoksida Terhadap Kesehatan Masyarakat yang Rentan dan Berisiko Tinggi," *Jurnal Kesehatan Lingkungan Indonesia*, vol. 21, no. 3, pp. 253–265, Oct. 2022, doi: 10.14710/jkli.21.3.253-265.

[9] D. Emilia Rahma *et al.*, "Pengaruh Kondisi Lingkungan Fisik Terhadap Perubahan Suhu Udara Di Universitas Negeri Malang," *Jurnal MIPA dan Pembelajarannya*, vol. 3, no. 4, pp. 151–162, 2023, doi: 10.17977/um067v3i4p151-162.

[10] W. Widjonarko and M. Maryono, "Spatial Regression Modelling Impact of Population Movement Intensity and Land Use to Air Temperature in Semarang City, Indonesia," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, Nov. 2021. doi: 10.1088/1755-1315/887/1/012003.

[11] D. Purnowo, A. Setiawan, and Yusmaniar, "Pengaruh Faktor Suhu dan Kelembaban pada Lingkungan Kerja terhadap Pertumbuhan dan Perkembangan Mikroba," *JRSKT - Jurnal Riset Sains dan Kimia Terapan*, vol. 9, no. 2, pp. 45–54, May 2024, doi: 10.21009/jrskt.092.01.

[12] R. Wangintan, M. Yani, H. Hardjomidjojo, and T. June, "Evaluation of Air Pollution Control Management in Jakarta by Crossed-Impact Matrix Multiplications Applied to Classification (MICMAC)," in *IOP Conference Series: Earth and Environmental Science*, Institute of Physics, 2024. doi: 10.1088/1755-1315/1358/1/012044.

[13] A. Irna, Hafsan, and Alfian, "Introduksi Trichoderma sp. Pada Tanaman Cabai (Capsicum frutescens)," *Teknosains: Media Informasi Sains dan Teknologi*, vol. 17, no. 1, pp. 108–115, 2023, Accessed: Dec. 31, 2024. [Online]. Available: https://journal.uin-alauddin.ac.id/index.php/teknosains/article/view/34817/17254

[14] A. P. Sujalu and L. A. Milasari, "INVENTARISASI JENIS TANAMAN SEBAGAI PENYERAP POLUTAN PADA RUANG TERBUKA HIJAU DI KOTA SAMARINDA (Studi Kasus: Taman Samarendah)," *Jurnal AGRIFOR*, vol. 23, no. 2, pp. 337–344, 2024, doi: 10.31293/agrifor.v23i2.

[15] R. Vella *et al.*, "Influence of land cover change on atmospheric organic gases, aerosols, and radiative effects," *Atmos Chem Phys*, vol. 25, no. 1, pp. 243–262, Jan. 2025, doi: 10.5194/acp-25-243-2025.

[16] Menteri Kesehatan Republik Indonesia, *Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2023 Tentang*

Peraturan Pelaksanaan Peraturan Pemerintah Nomor 66 Tahun 2014 Tentang Kesehatan Lingkungan. 2023. [Online]. Available: www.peraturan.go.id

[17] M. Abdy and W. Sanusi, "Karakteristik Kategori Kecepatan Angin di Kota Majene dengan Pendekatan Rantai Markov," *SAINTIFIK*, vol. 6, no. 1, pp. 85–90, Jan. 2020, doi: 10.31605/saintifik.v6i1.305.

[18] Badan Standarisasi Nasional, *SNI 19-71196-2005 Tentang Udara Ambien - Bagian 6: Penentuan Lokasi Pengambilan Contoh Uji Pemantauan Kualitas Udara Ambien*. 2005.

[19] S. M. Rohmah, R. Rachmaniyah, R. Rusmiati, K. Khambali, and I. Sulistio, "KONDISI KUALITAS UDARA DAN KELUHAN KESEHATAN MASYARAKAT AKIBAT PAPARAN GAS AMONIA PADA LOKASI LUMPUR LAPINDO," *Jurnal Sanitasi Lingkungan*, vol. 3, no. 2, pp. 53–60, Nov. 2023, doi: 10.36086/jsl.v3i2.1804.

[20] K. R. T. P. Sari, E. M. Indrawati, and A. P. Nevita, "Analisis Perbedaan Suhu dan Kelembaban Ruangan Pada Kamar Berdinding Keramik," *Jurnal Inkofar*, vol. 1, no. 2, pp. 2581–2920, 2020, Accessed: Dec. 31, 2024. [Online]. Available: https://media.neliti.com/media/publications/464210-none-b064e826.pdf

[21] S. A. Ma'ruf, Milana, Martias, and N. Hidayat, "Optimasi Hasil Uji Emisi Gas Buang Sepeda Motor dengan Penambahan Carbon Cleaner," *Jurnal Teknologi dan Pendidikan Vokasi Indonesia*, vol. 1, no. 2, pp. 159–170, 2023, Accessed: Dec. 31, 2024. [Online]. Available: https://www.bing.com/ck/a?!&&p=5adce0f36448283cecfc2400348b7fd68b012e978326b31133b22f38e6c39894JmltdHM9MTczNTUxNjgwMA&ptn=3&ver=2&hsh=4&fclid=2aba7173-41fc-6914-33fa-651f40fd684a&psq=Optimasi+Hasil+Uji+Emisi+Gas+Buang+Sepeda+Motor+dengan+Penambahan+Carbon+Cleaner&u=a1aHR0cHM6Ly9qdHB2aS5wcGoudW5wLmFjLmlkL2luZGV4LnBocC9qdHB2aS9hcnRpY2xlL3ZpZXcvMjYjOn46dGV4dD1FbWlzaSUyMGdhcyUyMGJ1YW5nJTIwcGFkYSUyMHNlcGVkYSUyMG1vdG9yJTIwbWVuamFkaSUyMGlzdSxjYXJib24lMjBjbGVhbmVyJTIwcGFkYSUyMGJhaGFuJTIwYmFrYXIlMjBwZXJ0YWxpdGUlMjBST04lMjA5MC4&ntb=1

[22] R. Eviendy, M. Z. Asy'Ari, Z. L. Sukra, and E. Peranginangin, "Carbon Emission and Economical Impact of Conversion Yamaha N-Max 150cc into Electric Motorcycle," in *IOP Conference Series: Earth and Environmental Science*, Institute of Physics, 2024. doi: 10.1088/1755-1315/1324/1/012094.

[23] Sulistyono, "Kerugian Ekonomi dan Lingkungan Sebagai Dampak Kemacetan Transportasi Kendaraan Bermotor Pengguna BBM Fosil," *Majalah Ilmiah Swara Patra*, vol. 12, no. 2, pp. 12–21, 2022, Accessed: Dec. 31, 2024. [Online]. Available: https://www.bing.com/ck/a?!&&p=4a67058fda5d572ce8265aa4334455cc2a265cccc993098ab8b55b7445331304JmltdHM9MTczNTUxNjgwMA&ptn=3&ver=2&hsh=4&fclid=2aba7173-41fc-6914-33fa-651f40fd684a&psq=Kerugian+Ekonomi+dan+Lingkungan+Sebagai+Dampak+Kemacetan+Transportasi+Kendaraan+Bermotor+Pengguna+BBM+Fosil&u=a1aHR0cHM6Ly9qdXJuYWwudW50aWRhci5hYy5pZC9pbmRleC5waHAvUkVQL2FydGljbGUvZG93bmxvYWQvNTI5LzQyNQ&ntb=1

[24] I. Hanafi, B. S. Haryono, and Sukanto, "Deskripsi Kondisi Ruang Terbuka Hijau dan Upaya-Upaya Untuk Menekan Peningkatan Emisi CO2 di Kota Batu," *Jurnal Ilmiah Ilmu Administrasi Negara*, vol. 9, no. 1, pp. 73–86, 2022, Accessed: Dec. 31, 2024. [Online]. Available: https://jurnal.unigal.ac.id/dinamika/article/view/6993

[25] T. Taufik *et al.*, "Prediksi Gas Karbon Monoksida (CO) dari Sumber Kendaraan Bermotor dengan Metode Gaussian Line Source Berbasis Sistem Informasi Geografis," *Jurnal Sumberdaya Alam dan Lingkungan*, vol. 9, no. 3, pp. 91–101, Dec. 2022, doi: 10.21776/ub.jsal.2022.009.03.2.

[26] M. Ferdnian, "ANALISIS UJI EMISI GAS BUANG KENDARAAN BERMOTOR DAN DAMPAKNYA TERHADAP LINGKUNGAN DI KOTA BALIKPAPAN (KAL-TIM)," *Jurnal Transmisi*, vol. 12, no. 1, pp. 15–24, 2019, Accessed: Sep. 20, 2024. [Online]. Available: https://jurnal.unmer.ac.id/index.php/jtmt/article/download/4488/pdf

[27] S. Fahad *et al.*, "Responses of rapid viscoanalyzer profile and other rice grain qualities to exogenously applied plant growth regulators under high day and high night temperatures," *PLoS One*, vol. 11, no. 7, Jul. 2016, doi: 10.1371/journal.pone.0159590.

[28] M. R. Abidin, R. Umar, and M. A. Tabbu, "Penyerapan Emisi Gas Karbon Dioksida (CO2) dalam Menganalisis Kecukupan Ruang Terbuka Hijau (RTH) Pada Kawasan Center Point Of Indonesia (CPI) Kota Makassar ," *Indonesian Journal of Fundamental and Applied Geography*, vol. 1, no. 1, pp. 18–25, 2023, Accessed: Dec. 31, 2024. [Online]. Available: https://journal.lontaradigitech.com/IJFAG/article/view/49/43

[29] V. Rasiah and S. K. Florentine, "Characterizing selected soil attributes of different land-use management to assess reforestation benefits of deforested riparian buffers," *Ecol Process*, vol. 7, no. 1, Dec. 2018, doi: 10.1186/s13717-018-0151-7.

[30] R. Yuliarti, K. Khambali, and R. Rusmiati, "Risk Analysis of Exposure to NH3 And H2S Gas to Workers in The Small Industrial Environment of Magetan Regency in 2021," *International Journal of Advanced Health Science and Technology*, vol. 2, no. 3, pp. 169–174, Jun. 2022, doi: 10.35882/ijahst.v2i3.7.

[31] Benjamin, Delgado, and T. Bajaj, *Physiology, Lung Capacity*. 2023. Accessed: Dec. 30, 2024. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK541029/

[32] W. R. B. Santosa and P. R. Gayatri, "Pengaruh Jenis Kelamin dan Masa Kerja Terhadap Tingkat Ventilasi," *Judika (Jurnal Nusantara Medika)*, vol. 4, no. 2, pp. 126–131, 2020, Accessed: Dec. 31, 2024. [Online]. Available: https://ojs.unpkediri.ac.id/index.php/akper/article/view/15385

[33] W. O. R. Juhanda, R. Tosepu, and A. Yasin, "ANALISIS RISIKO KESEHATAN LINGKUNGAN AKIBAT PAJANAN KARBON MONOKSIDA (CO) PADA PEDAGANG JALAN KEDONDONG PASAR ANDUONOHU KOTA KENDARI," *MEDIKA ALKHAIRAAT : JURNAL PENELITIAN KEDOKTERAN DAN KESEHATAN* , vol. 5, no. 3, pp. 322–331, 2024, Accessed: Dec. 30, 2024. [Online]. Available: https://jurnal.fkunisa.ac.id/index.php/MA/article/view/169

[34] H. E. Cho, "Understanding Changes in the Respiratory System with Ageing," *Annals of Cardio Pulmonary Rehabilitation*, vol. 3, no. 2, pp. 27–34, 2023, Accessed: Dec. 30, 2024. [Online]. Available: https://www.eacpr.org/archive/view_article?pid=acpr-3-2-27

[35] R. Kentkhute, R. A. R, and A. Usup, "ANALISIS PENJALARAN API PUNTUNG ROKOK TERHADAP LAHAN GAMBUT," *Jurnal Rekayasa Lingkungan*, vol. 22, no. 2, pp. 1–17, 2022, Accessed: Apr. 06, 2023. [Online]. Available: https://journal.ity.ac.id/index.php/JRL/article/download/143/115

[36] F. D. Ambarwati, E. Y. Y. Vinsur, and A. Syukkur, "Hubungan Pengetahuan Perokok Pasif Tentang Dampak Asap Rokok dengan Upaya Pencegahannya di Perumahan Mulya Garden, Kecamatan Sukun, Kota Malang," *Jurnal Riset Kesehatan Nasional*, vol. 8, no. 2, pp. 170–178, 2024, Accessed: Dec. 31, 2024. [Online]. Available: https://ejournal.itekes-bali.ac.id/jrkn/article/view/621

[37] Holipah, H. W. Sulistomo, and A. Maharani, "Tobacco smoking and risk of all-cause mortality in Indonesia," *Public Library of Science One (PLOS One)*, vol. 15, no. 12, 2020.

[38] N. Besmanto *et al.*, *Pedoman Analisis Risiko Kesehatan Lingkungan (ARKL)*. Direktorat Jendral PP dan PL Kementerian Kesehatan, 2012.

[39] A. S. Lestari, N. A. Fajar, Y. Windusari, and Novrikasari, "Literature Review: Kepatuhan Pekerja Terhadap Kebijakan Pemakaian Alat Pelindung Diri (APD) untuk Pencegahan Penyakit Akibat Kerja," *Health Information: Jurnal Penelitian*, vol. 15, no. 3, pp. 1–8, 2023, Accessed: Dec. 30, 2024. [Online]. Available: https://myjurnal.poltekkes-kdi.ac.id/index.php/hijp/article/view/1336/1270

[40] A. K. Juliadita, K. Khambali, P. Hermiyanti, and J. P. Myers, "Risk analysis of NO2 and SO2 gas exposure for leather tannery workers industry at Magetan," *International Journal of Advanced Health Science and Technology*, vol. 2, no. 5, Oct. 2022, doi: 10.35882/ijahst.v2i5.117.

[41] A. P. Adjani and P. A. Siregar, "Faktor-Faktor yang Berhubungan dengan Keluhan Gangguan Pernapasan pada Pekerja Mebel di Kecamatan Medan Satria Kota Bekasi," *MEDIA KESEHATAN MASYARAKAT INDONESIA*, vol. 22, no. 1, pp. 54–59, Feb. 2023, doi: 10.14710/mkmi.22.1.54-59.

[42] R. I. Chairunnisaa, "ANALISIS RISIKO KESEHATAN LINGKUNGAN PAJANAN KARBON MONOKSIDA (CO) PADA PEDAGANG TETAP DI SEKITAR KAMPUS 1 UIN JAKARTA," 2022. Accessed: Jun. 07, 2024. [Online]. Available: https://repository.uinjkt.ac.id/dspace/handle/123456789/67250

[43] F. A. Imandini, Khambali, Ngadino, Rachmaniyah, and Teguh Mubawadi, "Risk Analysis H2S And NH3 Exposure to Local Community Around Benowo Landfill Surabaya," *International Journal of Advanced Health Science and Technology*, vol. 3, no. 4, pp. 235–240, Aug. 2023, doi: 10.35882/ijahst.v3i4.279.

[44] M. I. Shafarina, Rachmaniyah, and E. Sari, "Analisis Risiko Pajanan Gas Nitrogen Dioksida pada Petugas Parkir di Pasar Kapasan Surabaya," *Jurnal Keselamatan Kesehatan Kerja dan Lingkungan (JK3L)*, vol. 4, no. 2, pp. 91–102, 2023, [Online]. Available: http://jk3l.fkm.unand.ac.id/index.php/jk3l/index