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Assessing Worker Exposure to Vehicle Exhaust Emissions and Self-Reported Exposure Symptoms at the Lebombo Port of Entry, in Mpumalanga, South Africa

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Abstract: This study assessed workers' exposure to vehicle exhaust emissions and its health effects at the Lebombo Port of Entry. A quantitative cross-sectional design was adopted, and a structured questionnaire was administered on 209 adult workers to measure their knowledge on vehicle exhaust emissions exposures. Air samples were also collected from the participants using air sampling pumps. Data were analyzed using Statistical Package for Social Sciences, version 27. Logistic regression was performed to examine the association between dependent variables and some sociodemographic factors. Vocational certificates and associate degrees were attributed to workers in the South African Police Services and those in Agriculture: (Odds Ratio) = 2.83%, Confidence Interval (1.41–5.65) and (Odds Ratio) = 4.58%, Confidence Interval (2.10–9.99), respectively. Divorced males had a high level of knowledge and awareness of vehicle exhaust emission and their health effects: (Adjusted Odds Ratio) = 5.31%, Confidence Interval (1.08–26.14). Males had better knowledge of vehicle exhaust emission with carcinogenic effects: (Adjusted Odds Ratio) = 3.28%, Confidence Interval (1.11–9.67). Having an associate's degree as the highest level of education and irritation of nose and eyes were associated with lower awareness of vehicle exhaust emissions: (Adjusted Odds Ratio) = 0.42%, Confidence Interval (0.19–0.97) and (Adjusted Odds Ratio) = 0.31%, Confidence Interval (0.13–0.76), respectively. The diesel particulate matter concentration was higher during day shifts (0.027 mg/m^3) compared to night shifts (0.021 mg/m^3), $p = 0.001$. Seventy-one workers (34%) reported experiencing acute headaches often, and fewer workers (n = 31, 14.8%) reported to have never suffered from an acute headache. A majority of workers (71 (34%)) experienced acute irritation of nose and eyes often compared to a few (33 (16%)) workers who experienced the same less often. In addition, a majority of workers (84 (40.2%)) experienced acute fatigue and nausea often, while fewer workers (37 (17.7%)) experienced fatigue and nausea very often. The majority of workers (n = 116, 55.5%) suffered cough and sneezing more often compared to others. There is an urgent need for improved and effective controls to reduce workers' exposure to vehicle exhaust emissions.

Keywords: diesel particulate matter; health effects; personal protective equipment; pollution

Citation: Makhabane, Z.M.; Mokoena, K.K.; Rathebe, P.C. Assessing Worker Exposure to Vehicle Exhaust Emissions and Self-Reported Exposure Symptoms at the Lebombo Port of Entry, in Mpumalanga, South Africa. *Atmosphere* **2024**, *15*, 851. https://doi.org/10.3390/atmos15070851

Academic Editors: Christos Argyropoulos, Zoi Dorothea Pana, Changqing Lin and Daniele Contini

Received: 28 May 2024
Revised: 4 July 2024
Accepted: 16 July 2024
Published: 19 July 2024

1. Introduction

Air pollution is globally considered one of the leading causes of cardiovascular illnesses, respiratory diseases, neurological disorders, and premature deaths [1–3]. Air pollution causes almost 6 million premature births, almost 3 million underweight babies, and around 7 million premature deaths worldwide each year [4–6]. Between the 5 and 9 December 1952 in London, air pollution caused approximately 4000 deaths from diseases related to the respiratory system, such as bronchitis and pneumonia, and 8000 more deaths occurred in the following couple of months. The samples collected from victims showed that their livers were severely contaminated with fine particles, including most studied heavy metals (HMs) such as Zn, Pb, and Fe [7,8]. Particulate matter becomes contaminated with heavy metals and becomes a heavy metal focus. Large amounts of heavy metals can be inhaled with these particulate matters. Heavy metals are extremely dangerous for human and environmental health [9,10]. Some are toxic, carcinogenic, and fatal even at low concentrations [11,12]. They do not degrade easily in nature [13,14]. Even those that are nutrients for living things are harmful at high concentrations [5,15]. For this, particulate matters are very dangerous for human health.

Workers at ports of entry (POEs) are among a group of individuals at high risk of exposure to motor vehicle air pollutants such as diesel particulate matter (DPM). Air pollution has huge-ranging and profound effects on human health and well-being. Poor air quality has been depicted to be accountable for over 4 million deaths each year from outdoor pollutants, and with 2.3 million from indoor air pollution, and a wide range of cardiovascular, respiratory, and neurological diseases globally [16]. The study by Marin et al. [17] highlighted that according to the World Health Organization (WHO), 99% of the world's population lives in polluted air environments, and 2.83 million deaths (10.95%) among women and 3.62 million deaths (11.81%) among men have been attributed to air pollution. Zurita et al. [3] showed that POE workers in the US–Mexico San Ysidro/El Chaparral border were exposed to black carbon, nitrogen oxides, ultrafine particles (UFP), and DPM, which were related to respiratory effects such as asthma. Similarly, Sen et al. [18] highlighted that the incidence of upper respiratory tract illnesses among toll plaza workers was excessively high due to the lack of open space, the limited number of booths and collection cabins, the delayed collection process, and the average waiting time per vehicle in India. Pozzer et al. [19] and Ramamoorthy et al. [2] investigated the impact of ambient air pollution and the association between exposure to major ambient air pollutants and the incidence and mortality of lung cancer and some non-lung cancers. Results from Pozzer et al. [19] suggested long-term exposure to ambient air pollution (particularly traffic-related air pollution) to be associated with chronic diseases such as lung cancer, cardiovascular diseases, and respiratory conditions, with nitrogen dioxide (NO_2) being a recognized marker of traffic-related pollution. It is therefore evident that human exposure to vehicle exhaust emissions (VEEs) is associated with adverse health outcomes. VEEs refer to the emitted matter right from the exhaust pipe of a vehicle, either in the form of a gas or particle, such as DPM, ozone (O_3), fine particulate matter (PM2.5), carbon oxides (CO_x), nitrogen oxides (NO_x), and more. POEs facilitate the transit of a high volume of vehicles daily, and the process requires border workers to physically work proximal to vehicles during search and cargo inspections. Exhaust emissions depend on a variety of factors such as vehicle type, age, speed, and condition of the vehicle, as well as fuel used [20]. In urban cities, as vehicle speed slows, vehicle emissions contribute 75% and above of CO_2, NO_x, and PM emissions [21]. This percentage is, by far, higher than in rural cities. Traffic movements are also slowed down at border environments, which can therefore result in high VEE levels. Heavy-duty vehicles, especially those with older engines, are associated with increasing exposure to harmful pollutants due to inefficient combustion and catalytic treatment. This inefficient combustion leads to elevated levels of pollutants often inhaled by personnel at traffic-congested areas such as border posts [3,22].

In South Africa, increasing on-road traffic results in copious emissions of health-damaging pollutants [23,24]. To curb the increasing vehicle emissions, South Africa has focused mainly on domestic public transportation infrastructure development. Few efforts have been channeled into mass transit systems, which has not afforded much protection from exposure to exhaust emissions in dense traffic environments such as POEs. It is therefore imperative to investigate the relationship between exposure to vehicle emissions and potential human health implications. The Lebombo border post comprises of a number of departments and work areas including offices and search/inspection points. There are relatively no records on yearly statistics regarding air pollution in the Lebombo POE.

Personnel in departments such as Immigration mostly work indoors. Port health workers often work in offices, and only a few are found at search points, except for environmental or facilities inspections. The working areas (offices and search points) are anticipated to present different likelihoods of worker exposure to VEEs. Workers in search points of the Lebombo POE are exposed to varying levels of VEEs during traffic movement across the border compared to those in the offices. The estimate in the number of vehicles passing through the border is 18,000 to 22,000 trucks and 40,000 to 68,000 light motor vehicles per day [25]. Those who are in search/inspection points are working without any protective measures against exposure, and their proximity is one of the contributing factors for exposure to the exhaust emissions. Usually, vehicles (e.g., trucks) do not switch off engines when stationary and being searched, despite the length of both time and queues; this could lead to inhalation of VEEs and result in negative health implications [3,22].

Despite international studies presenting evidence on exposure to VEEs in high traffic environments, the workers' exposure to VEEs at the South African POEs remains unknown. This study aimed to assess workers' exposure, particularly vehicle inspectors, to vehicle emissions and their health effects at the Lebombo POE.

2. Materials and Methods

2.1. Target and Study Population

The target population was comprised of 460 POE workers. From this group, 209 employees who worked as vehicle inspectors at the port's search points were calculated using an EpiInfo program and included in the study. The included participants were required to complete the questionnaire and use personal sampling pumps. The final sample size increased to 262 participants after incorporating a 25% contingency. This study was approved by the Faculty of Health Sciences ethics committee at the University of Johannesburg (REC-814-2020), conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from study participants prior to commencement of this study.

2.2. Study Area

The Lebombo POE is the second-largest land border post after the Beit Bridge POE. It is located in the Mpumalanga Province of South Africa, positioned between the terminus of the South African national road (N4) and the start of the Mozambican national road (EN4). The border environment has the following geo-coordinates; −25.442380 and 31.985747 [25].

This POE serves as the sole international entry point between the two countries. Operational hours are from 06:00 a.m. to 00:00 a.m., extending to 06:00 a.m. the following day during festive and Easter holidays. Study participants were purposefully selected from two departments, the South African Police Services (SAPS) and Agriculture, since they were the only departments that consented for participation. Those frequently stationed at the search points were identified, and their consent was obtained for inclusion in the research. The participants' normal working behavior and patterns were not disrupted.

2.3. Sampling

Sample Size Estimation

The base sample size was determined using the Centre for Disease Control and Prevention (CDC) program EPI INFO 7.2.4.0, resulting in a need for 209 participants from a target population of 460 border workers. The sample size of 209 was obtained with a confidence level of 95% at a 5% acceptable marginal error. After that, a 25% contingency was added to establish a final sample of 262. From this group of 262 workers, a subset was selected for the collection of DPM samples. In total, 108 workers wore sampling equipment as part of this process.

The selection of 108 workers was based on the data collection methodology and the different shifts worked by the employees. The day shift lasted 12 h (06 h 00 a.m. to 18 h 00 p.m.), while the night shift was 5 h long (18 h 00 p.m. to 23 h 00 p.m.), making the day shift almost three times longer than the night shift. To account for this, the day shift was divided into three 4 h segments, with each segment considered a separate sampling session. Therefore, the 12 h day shift yielded three samples (triplicate) on one filter paper in a cassette. To achieve this, six samples were collected per day using two air samplers (one per worker) over 36 days, requiring a total of 72 participants. In contrast, the night shift did not require triplicate sampling due to its shorter duration of 5 h. Two samples of over 4 h each were collected per night using two air samplers (one per worker) over 18 nights, necessitating a total of 36 participants.

2.4. Data Collection

A structured questionnaire, developed from the literature items [3,18,26], was utilized to collect data regarding workers' knowledge levels concerning VEEs and their health impacts, particularly focusing on DPM. The questionnaire consisted of four sections labelled A–D. Section A gathered demographic information such as race, gender, age group, marital status, educational qualification, and department affiliation. This section comprised six questions with predefined answer ranges, where participants marked their response with an "X". Section 2 aimed to assess the workers' awareness and understanding of vehicular exhaust emissions and their health effects. It comprised eight questions with multiple-choice answers and two True or False questions. Section 3 focused on identifying potential indicators of exposure to vehicular exhaust emissions, using a scale of 1 to 3 to measure the frequency of experiencing these indicators. Lastly, Section 4 aimed to determine the availability and utilization of protective measures against personal exposure to vehicular exhaust emissions. Section 4 included seven questions, three of which were "Yes" or "No" types, while the others required participants to select answers from provided ranges and fill in blank spaces with the number of hours and breaks provided at work.

The questionnaire's reliability was tested through piloting, where it was administered at least twice to non-study participants to ensure consistent understanding and satisfactory responses. The questionnaire's reliability was evaluated based on its ability to produce similar results repeatedly under similar circumstances, considering that the respondents were from the same population of border workers and worked under similar conditions. The questions were deemed clear and understandable, albeit not to the same degree for everyone, but almost equally so among the respondents. All questions required direct answers based on the options provided in the questionnaire.

Additionally, study participants were asked to wear air sampling equipment, including an air sampling pump with a 37 mm filter in an SKC cassette and a cyclone in their breathing zone (set at a flow rate of 2 L/min). There were two personal air sampling pumps. The type/s of the air sampling pumps were GilAir-3 basic, with serial numbers 17,302 and 16,963, respectively.

A standard operating procedure was developed to guide the operators of sampling instruments. Workstations where vehicle searching and cargo inspections were conducted were identified for locating participants wearing sampling equipment, including canopy1, canopy2, and the bypass office. Canopy1 and canopy2 were outdoor workstations where workers conducted vehicle searches and cargo inspections, while the bypass office was an indoor area for office work, expected to have minimal exposure levels. Workers who consented to participate were assisted in wearing the equipment. Data collection was conducted per shift (day and night shifts), with samples collected in triplicate for day shifts only. The pumps were calibrated and fitted with all necessary components before each measuring shift, which covered the entire work shift duration (12 h for day shifts and 5 h for night shifts) due to adjusted border operating hours during the COVID-19 pandemic. The pumps were switched off and removed from the workers at the end of a sampling shift, post-calibrated, and stored in handling bags before being taken to the laboratory for analysis. All equipment was then locked and stored until the following sampling shift.

The study sample included both male and female border workers above 18 years of age, with only permanently employed workers from the SAPS and the Department of

Agriculture included. Pregnant and medically unfit employees were excluded from the study to ensure that participants were fit and able to wear personal sampling equipment throughout the sampling period.

2.5. Pilot Study

Sixty-seven participants, who did not form part of the main study, were purposively selected from various departments (48 police officials, 11 agriculture inspectors, and 8 immigration officials) at the Lebombo border post to participate in the research pilot study. Purposive sampling was chosen because these departments have many workers at the border, and those workers are stationed to work in the targeted areas where data would be collected, such as heavy motor vehicle (e.g., trucks) search points, offices, and light vehicle search points. The pilot study participants consisted of 18 males and 49 females.

The selection of participants involved the researcher approaching each department to request the participation of willing individuals in a pilot study. The results of this pilot study would not be used for conclusive purposes regarding the outcomes of the actual study but rather for testing the reliability and validity of the questionnaire. Participants were selected based on their workstations around the border, with 37 officials from truck search points, 19 from the offices, and 11 from light motor vehicles.

All participants were proficient in speaking and reading English, making them eligible to answer the questionnaire based on their understanding. Additionally, all participants confirmed that they were in good health to participate, with none reporting challenges of illnesses that could prevent them from participating in the pilot study.

The age range of the participants met the selection criteria for the study. None of the participants were younger than 18 years old, and none were older than 60 years old.

The data collection process for the pilot study followed a similar process to that which would be followed for collecting the actual field data during the main research. Participants were informed of their rights and responsibilities while participating in the study, including the right to ask questions if they encountered any challenges during the questionnaire completion process. Participants were informed that their participation would not be compensated and that they entered the study freely and could withdraw their participation at any time.

Each participant received their own questionnaire and was encouraged to complete it individually without assistance from others. Participants were given enough time to read through and fill out the questionnaire based on their understanding. They were not permitted to take the questionnaires home and were given a week to complete all the questions.

It was observed that while some participants found the questionnaire easy to complete, others found it challenging. Some participants struggled with multiple-choice questions, resulting in untidy/questionable responses, leading them to request new questionnaires to start again.

Participants noted that the questionnaires were informative, despite requiring careful consideration of the answer choices. Some participants completed the questionnaires within 15 min, while others took longer, up to the maximum time limit of 20 min. Participants took the completion of the questionnaires seriously, striving to be as honest as possible and avoiding leaving questions unanswered or abandoning the questionnaire midway.

2.6. Data Analysis

Air samples of DPM were analyzed at Chemtech Laboratory Services CC, an accredited laboratory, to determine DPM concentrations (mg/m^3). DPM analysis was based on its composition, which included elemental carbon (EC), organic carbon (OC), and total carbon (TC). Laboratory analysis revealed that these components of DPM were present in varying concentrations across all three sampling points (workstations). The following analysis was undertaken by the laboratory to analyze the DPM: a HORIBA MEXA 1370PM Super Low Mass Particulate Matter Analyzer was used to determine the OC, EC, and TC on samples collected on quartz filters. Calibration was performed with sulfur di-oxide (SO_2) at 1435 ppm and carbon dioxide (CO_2) at 7.4 mole %. Nitrogen gas (N_2) at 99.999% purity and oxygen gas (O_2) at 99.995% purity were used as carrier gases. Compressed air was used to activate the valves.

The data were then analyzed using one-way Analysis of Variance (ANOVA) in SPSS (version 27). Descriptive statistical analysis was used to identify frequencies (n) and percentages (%) to answer all questions in the questionnaire. Adjusted odds ratios were obtained using Multivariate Logistic Regression to establish the probability of factors associated with exposure to DPM (outcome) due to working at the POE. The statistical significance of relationships among the variables was determined using confidence intervals, mean values, and p-values for DPM concentration data. The CDC program EPI INFO 7.2.4.0 was used to calculate the Crude Odds Ratios, as it helped visualize the data. The data were then presented in figures and tables.

Regarding the analysis of exposure indicators to DPM, a range of frequency descriptive terms was used to determine the occurrence and extent of exposure. These terms included "Never", which denoted that the participant had not experienced any exposure indication or symptom of DPM. "Less often" meant that the participant did not experience exposure symptoms to DPM regularly. "Often" indicated that the participant experienced DPM exposure indicators or symptoms frequently or regularly, while "Very often" represented that the participant experienced exposure indications to DPM more frequently.

3. Results

All 209 workers who participated in completing the questionnaires returned them, resulting in a 100% return rate. While the questions on the questionnaire were clear, not everyone understood them to the same degree, but they were generally understandable to the respondents. More than 90% of the participants provided almost similar responses.

3.1. Social Demographic Information of Workers

Of the 209 workers, 93 (44.5%) were men, and 116 (55.5%) were women. The largest proportion of study participants, 58 (27.8%), were aged between 34 and 38 years. There were 29 (13.9%) workers each in the age groups of 44–48 years and 49–53 years (Table 1).

Table 1. Distribution of sociodemographic characteristics and crude odds ratio for workers working under SAPS versus in Agriculture.

	Total		Department Where Respondent Belongs to				Crude Odds Ratio	95% CI
			SAPS		Agriculture			
Characteristics	**n**	**%**	**N**	**%**	**n**	**%**		
Total	209	100%	169	80.9%	40	19.1%		
Age Group								
29–33 years	56	26.8%	47	83.9%	9	16.1%	Reference	Reference
34–38 years	58	27.8%	50	86.2%	8	13.8%	1.20	0.43–3.36
39–43 years	37	17.7%	31	83.8%	6	16.2%	0.99	0.32–3.06
44–48 years	29	13.9%	23	79.3%	6	20.7%	0.73	0.23–2.31
49–53 years	29	13.9%	18	62.1%	11	37.9%	0.31	0.11–0.88
Gender								
Male	93	44.5%	75	80.6%	18	19.4%	0.98	0.49–1.95
Female	116	55.5%	94	81.0%	22	19.0%	Reference	Reference
Marital Status								
Single	136	65.1%	111	81.6%	25	18.4%	0.94	0.42–2.12
Married	57	27.3%	47	82.5%	10	17.5%	Reference	Reference
Divorced	13	6.2%	10	76.9%	3	23.1%	0.71	0.16–3.05
Widowed	3	1.4%	1	33.3%	2	66.7%	0.11	0.01–1.29

Table 1. *Cont.*

Characteristics	Total		Department Where Respondent Belongs to				Crude Odds Ratio	95% CI
			SAPS		Agriculture			
	n	%	N	%	n	%		
Educational Qualification								
Vocational certificate	106	50.7%	105	99.1%	1	0.9%	2.83	1.41–5.65
Associate degree	54	25.8%	51	94.4%	3	5.6%	4.58	2.10–9.99
Bachelor's degree	48	23.0%	13	27.1%%	35	72.9%	Reference	Reference
Master's degree	1	0.5%	0	0.0%	1	100%	2.69	0.16–46.27

CI is the 95% confidence intervals, Reference means a variable which was considered safe to compare others with during data analysis.

Table 1 also indicates that out of the 209 workers, the majority, 136 (65.1%), were single, while only 3 (1.4%) were widowed. Regarding education, most workers, 106 (50.7%), had vocational certificates as their highest level of education. In contrast, only one (0.48%) participant held a master's degree as their highest qualification. The majority of workers, 169 (80.9%), belonged to the SAPS department, with only 40 (19.1%) belonging to the Department of Agriculture, as shown in Table 1.

Workers aged between 49 and 53 years were significantly less likely to work for SAPS, with an odds ratio (OR) of 0.31%, CI (0.11–0.88). All workers with vocational certificates and some with associate's degrees belonged to SAPS, while those with bachelor's degrees belonged to the Agriculture department, with odds ratios of 2.83%, CI (1.41–5.65) and 4.58%, CI (2.10–9.99), respectively. There was no difference in employment between SAPS and Agriculture at the POE based on gender or marital status.

3.2. Worker Knowledge and Awareness of VEEs and Their Health Effects

Divorced male workers, as indicated in Table 2, exhibited greater knowledge and awareness of vehicular exhaust emissions (VEEs) and their health effects compared to married male workers, with an adjusted odds ratio (AOR) of 5.31%, CI (1.08–26.14).

Table 2. Marital status, workers' level of knowledge and awareness on VEEs.

Characteristics	Total		Gender			
			Male		Females	
	N	%	n	%	n	%
Total	209	100%	93	44.5%	116	55.5%
Marital Status						
Single	136	65.1%	63	46.3%	73	53.7%
Married	57	27.3%	28	49.1%	29	50.9%
Divorced	13	6.2%	2	15.4%	11	84.6%
Widowed	3	1.4%	0	0.0%	3	100.0%
Assessing workers' level of knowledge and awareness on vehicular exhaust emissions and their health effects						
Which substance/s in motor vehicle emissions have a potential carcinogenic effect?						
Lead	31	14.8%	13	41.9%	18	58.1%
Sulfur oxides	33	15.8%	15	45.5%	18	54.5%
Ozone	26	12.4%	7	26.9%	19	73.1%
Benzene	56	26.8%	24	42.9%	32	57.1%
All of the above	50	23.9%	28	56.0%	22	44.0%
None of the above	9	4.3%	4	44.4%	5	55.6%
No idea	4	1.9%	2	50.0%	2	50.0%

Male workers more frequently identified ozone as a substance in motor vehicle emissions with potential carcinogenic effects compared to female workers, with an AOR of 3.28%, CI (1.11–9.67) (Table 3).

Table 3. Association between marital status and workers' level of knowledge and awareness on VEEs.

Characteristics	Crude Odds Ratio	95% Confidence Interval	Adjusted * Odds Ratio	95% Confidence Interval
Marital Status				
Single	0.89	0.48–1.66	1.12	0.60–2.08
Married	Reference	Reference	Reference	Reference
Divorced	0.19	0.04–0.93	5.31	1.08–26.14
Widowed	0.0	Undefined	1972328769	0.00
Assessing workers' level of knowledge and awareness on vehicle exhaust emissions and associated health effects				
Which substances in motor vehicle emissions have a potential carcinogenic effect?				
Lead	0.60	0.23–1.40	1.59	0.62–4.09
Sulfur oxides	0.70	0.27–1.58	1.52	0.61–3.80
Ozone	0.30	0.10–0.81	3.28	1.11–9.67
Benzene	0.60	0.27–1.27	1.75	0.78–3.92
All of the above	Reference	Reference	Reference	Reference
None of the above	0.63	0.15–2.62	1.62	0.37–7.10
No idea	0.80	0.10–6.03	1.19	0.14–9.94

* Adjusted for age, gender, marital status, and educational qualification, Reference means a variable which was considered safe to compare others with during data analysis.

Most workers, 68 (78.2%), who identified exhaust emissions as a source of air pollution from motor vehicles, were employed by the SAPS department. Similarly, most of the workers, 45 (77.6%), who selected "all of the above" as the main pollutants from motor vehicles were from SAPS. Additionally, 39 SAPS workers (88.6%) identified the speed of the vehicle as a factor affecting the composition of VEEs. Among SAPS workers, 45 (77.6%) identified elderly people as a population group especially susceptible to adverse health effects from motor vehicle pollution. Furthermore, 25 SAPS workers (92.6%) identified border gate workers as the group most likely to be exposed to motor vehicle air pollution.

Regarding specific knowledge about motor vehicle emissions, 96 SAPS workers (79.3%) correctly identified the statement "Fuels in developing countries often have a high lead and Sulphur content" as false. Conversely, 98 SAPS workers (82.4%) correctly identified the statement "All motor vehicles are equally polluting" as true. Additionally, 31 SAPS workers (79.5%) correctly identified carbon monoxide as the only motor vehicle air pollutant that can adversely affect the respiratory tract. Moreover, 59 SAPS workers (89.4%) correctly identified carbon monoxide as the only substance in motor vehicle emissions that can produce toxic health effects. Lastly, 46 SAPS workers (82.1%) correctly identified benzene as a substance in motor vehicle emissions with potential carcinogenic effects (Table 4).

Table 4. Workers' level of knowledge and awareness on VEEs and their health effects by departments.

Characteristics	Total		Department Where Respondent Belongs to				Crude Odds Ratio	95% Confidence Interval
			SAPS		Agriculture			
	n	%	n	%	n	%		
Total	209	100%	169	80.9%	40	19.1%		
Motor vehicles become a source of air pollution as a result of:								
Refueling losses	4	1.9%	3	75.0%	1	25.0%	0.84	0.08–8.53
Evaporative emissions	49	23.4%	43	87.8%	6	12.2%	2.00	0.74–5.41
Exhaust emissions	87	41.6%	68	78.2%	19	21.8%	Reference	Reference
Crank case losses	28	13.4%	24	85.7%	4	14.3%	1.70	0.52–5.43
Reckless driving	20	9.6%	16	80.0%	4	20.0%	1.12	0.33–3.74
All of the above	20	9.6%	15	75.0%	5	25.0%	0.84	0.27–2.60
None of the above	1	0.5%	0	0.0%	1	100.0%	0.00	Undefined

Table 4. *Cont.*

Characteristics	Total		Department Where Respondent Belongs to				Crude Odds Ratio	95% Confidence Interval
			SAPS		Agriculture			
	n	%	n	%	n	%		
What are the main pollutants from motor vehicles?								
Carbon monoxide	18	8.6%	14	77.8%	4	22.2%	1.01	0.28–3.60
Nitrogen oxides	31	14.8%	29	93.5%	2	6.5%	4.19	0.90–19.94
Ozone	25	12.0%	22	88.0%	3	12.0%	2.12	0.55–8.21
Particulate matter	24	11.5%	17	70.8%	7	29.2%	0.70	0.24–2.10
Lead	20	9.6%	14	70.0%	6	30.0%	0.67	0.22–2.10
Benzene	14	6.7%	13	92.9%	1	7.1%	3.80	0.45–31.50
Carbon dioxide	9	4.3%	6	66.7%	3	33.3%	0.60	0.13–2.63
Sulfur dioxide	7	3.3%	6	85.7%	1	14.3%	1.73	0.19–15.72
Acid aerosols	3	1.4%	3	100.0%	0	0.0%	Undefined	Undefined
All of the above	58	27.8%	45	77.6%	13	22.4%	Reference	Reference
What factors affect the composition of motor vehicle exhaust emissions?								
Fuel type and quality	8	3.8%	4	50.0%	4	50.0%	0.25	0.04–1.63
Geographical factors	29	13.9%	24	82.2%	5	17.2%	1.20	0.25–5.89
Maintenance of vehicle	37	17.7%	28	75.7%	9	24.3%	0.80	0.18–3.39
Damage of vehicle	39	18.7%	34	87.2%	5	12.8%	1.70	0.35–8.22
Speed of vehicle	44	21.1%	39	88.6%	5	11.4%	1.95	0.41–9.38
Type and operating condition of engine	25	12.0%	17	68.0%	8	32.0%	0.53	0.12–2.43
Use of emission control device	12	5.7%	11	91.7%	1	8.3%	2.80	0.25–30.51
All of the above	15	7.2%	12	80.0%	3	20.0%	Reference	Reference
Which population group may be especially susceptible to adverse health effects from motor vehicle pollution?								
Children	49	23.4%	39	79.6%	10	20.4%	0.90	0.27–2.93
People who live at high elevations	27	12.9%	20	74.1%	7	25.9%	0.65	0.18–2.40
People who smoke	15	7.2%	15	100.0%	0	0.0%	Undefined	Undefined
People with cardiovascular (heart) diseases	16	7.7%	11	68.8%	5	31.3%	0.50	0.12–2.10
Elderly people	58	27.8%	45	77.6%	13	22.4%	0.80	0.25–2.50
People with respiratory (lung) diseases	13	6.2%	13	100.0%	0	0.0%	Undefined	Undefined
All of the above	27	12.9%	22	81.5%	5	18.5%	Reference	Reference
None of the above	3	1.4%	3	100.0%	0	0.0%	Undefined	Undefined
No idea	1	0.5%	1	100.0%	0	0.0%	Undefined	Undefined
Which group of people have an increased chance of exposure to motor vehicle air pollution?								
Traffic police	18	8.6%	12	66.7%	6	33.3%	0.90	0.20–4.11
Pedestrians	21	10.0%	20	95.2%	1	4.8%	8.90	0.90–91.20
People who live on highly trafficked streets	25	12.0%	20	80.0%	5	20.0%	1.80	0.40–8.23
Parking garage attendants	16	7.7%	11	68.8%	5	31.3%	0.98	0.20–4.80
Toll-booth workers at bridges or tunnels	20	9.6%	14	70.0%	6	30.0%	1.04	0.23–4.73
People who drive buses, taxis, trucks	20	9.6%	17	85.0%	3	15.0%	2.52	0.50–13.80
Urban roadside street vendors	20	9.6%	17	85.0%	3	15.0%	2.52	0.50–13.80
Gasoline station workers	14	6.7%	13	92.9%	1	7.1%	5.80	0.60–60.61
Border gate workers	27	12.9%	25	92.6%	2	7.4%	5.60	0.90–35.71
All of the above	13	6.2%	9	69.2%	4	30.8%	Reference	Reference
None of the above	9	4.3%	8	88.9%	1	11.1%	3.60	0.33–38.80
No idea	6	2.9%	3	50.0%	3	50.0%	0.44	0.06–3.24
Fuels in developing countries often have a high lead and sulfur content.								
True	88	42.1%	73	83.0%	15	17.0%	Reference	Reference
False	121	57.9%	96	79.3%	25	20.7%	0.80	0.40–1.60
All motor vehicles are equally polluting.								
True	119	56.9%	98	82.4%	21	17.6%	Reference	Reference
False	90	43.1%	71	78.9%	19	21.1%	0.80	0.40–1.60
Which motor vehicle air pollutants can adversely affect the respiratory tract?								
Nitrogen oxides	27	12.9%	23	85.2%	4	14.8%	0.96	0.23–3.98
Ozone	19	9.1%	17	89.5%	2	10.5%	1.42	0.25–8.11
Lead	34	16.3%	27	79.4%	7	20.6%	0.64	0.18–2.30
Sulfur oxides	17	8.1%	11	64.7%	6	35.3%	0.31	0.08–1.21
Particulate matter	23	11.0%	18	78.3%	5	21.7%	0.60	0.20–2.40
Carbon monoxide	39	18.7%	31	79.5%	8	20.5%	0.65	0.20–2.20
All of the above	35	16.7%	30	85.7%	5	14.3%	Reference	Reference
None of the above	10	4.8%	9	90.0%	1	10.0%	1.50	0.15–14.60
No idea	5	2.4%	3	60.0%	2	40.0%	0.25	0.03–1.90

Table 4. *Cont.*

Characteristics	Total		Department Where Respondent Belongs to				Crude Odds Ratio	95% Confidence Interval
			SAPS		Agriculture			
	n	%	n	%	n	%		
Which substances in motor vehicle emissions can produce toxic health effects?								
Carbon monoxide	66	31.6%	59	89.4%	7	10.6%	2.15	0.80–5.80
Lead	49	23.4%	35	71.4%	14	28.6%	0.64	0.30–1.52
Both carbon monoxide and lead	64	30.6%	51	79.7%	13	20.3%	Reference	Reference
None of the above	30	14.4%	24	80.0%	6	20.0%	1.02	0.35–3.01
Which substance/s in motor vehicle emissions have a potential carcinogenic effect?								
Lead	31	14.8%	26	83.9%	5	16.1%	1.83	0.60–5.80
Sulfur oxides	33	15.8%	29	87.9%	4	12.1%	2.55	0.80–8.64
Ozone	26	12.4%	21	80.8%	5	19.2%	1.50	0.50–4.72
Benzene	56	26.8%	46	82.1%	10	17.9%	1.62	0.64–4.10
All of the above	50	23.9%	37	74.0%	13	26.0%	Reference	Reference
None of the above	9	4.3%	6	66.7%	3	33.3%	0.70	0.20–3.22
No idea	4	1.9%	4	100.0%	0	0.0%	Undefined	Undefined

Reference means a variable which was considered safe to compare others with during data analysis, Undefined refers to a variable under which no value was found during analysis.

3.3. Possible Exposure Indications to VEEs

According to Table 5, workers with an associate's degree as their highest educational level were less likely to believe that all motor vehicles were equally polluting compared to workers with a bachelor's degree, with an adjusted odds ratio (AOR) of 0.42%, CI (0.19–0.97). Similarly, workers who experienced irritation of the nose and eyes very often were less likely to believe that all motor vehicles were equally polluting, with an AOR of 0.31%, CI (0.13–0.76).

Table 5. Association between workers' educational qualification and acute symptoms of exposure to VEEs.

Characteristics	Crude Odds Ratio	95% Confidence Interval	Adjusted Odds Ratio	95% Confidence Interval
Demographic variables				
Educational qualification				
Vocational certificate	0.76	0.38–1.51	0.72	0.36–1.46
Associate degree	0.42	0.19–0.95	0.42	0.19–0.97
Bachelor's degree	Reference	Reference	Reference	Reference
Master's degree	0.0	Undefined	0.00	0.00
Acute symptoms of exposure to vehicle exhaust emissions (e.g., diesel particulate matter)				
Irritation of nose and eyes				
Never	Reference	Reference	Reference	Reference
Less often	0.90	0.36–2.05	0.87	0.35–2.16
Often	1.10	0.53–2.16	1.03	0.50–2.13
Very often	0.33	0.14–0.76	0.31	0.13–0.76

Adjusted for age, gender, marital status, and educational qualification. Reference means a variable which was considered safe to compare others with during data analysis.

Seventy-one workers (34%) reported often experiencing acute headaches, while fewer workers (31 (14.8%)) reported never experiencing acute headaches (Figure 1).

The majority of workers (71 (34%)) often experienced acute irritation of the nose and eyes, while fewer workers (33 (16%)) experienced irritation of the nose and eyes less often (Figure 1).

A majority of workers (n = 84, 40.2%) experienced acute fatigue and nausea often, while fewer workers (n = 37, 17.7%) experienced fatigue and nausea very often, as shown in Figure 1.

In Figure 1, more workers (n = 116, 55.5%) suffered from coughing and sneezing very often, whereas fewer workers (n = 6, 2.9%) never experienced coughing and sneezing.

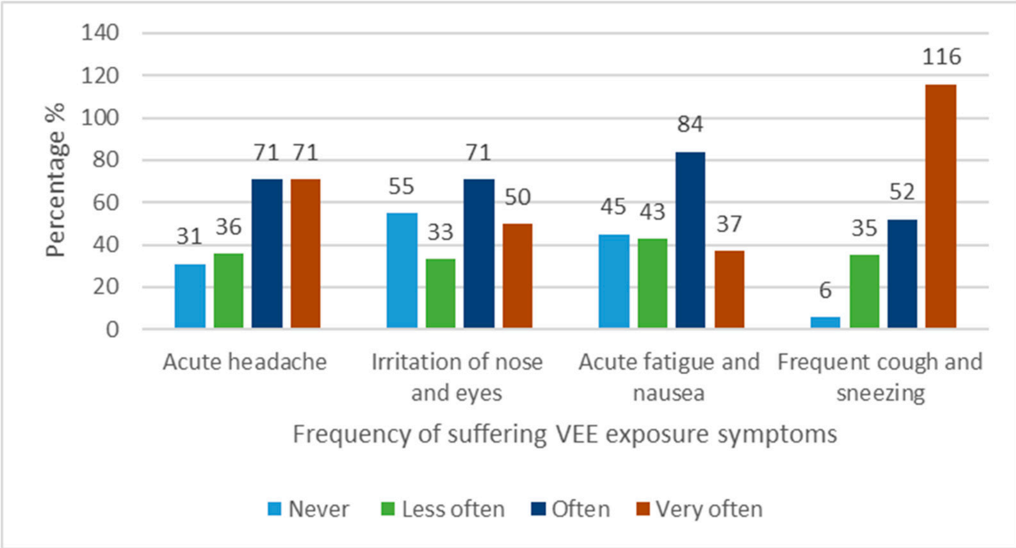

Figure 1. Frequency of suffering VEE exposure symptoms.

Availability and use of protective measures against personal exposure to VEEs.

More workers (n = 121, 58%) out of 209 used dust masks as personal protective equipment (PPE) to prevent exposure to VEEs (Table 6). However, this type of PPE was found to be irrelevant for preventing worker exposure to VEEs.

Table 6. Workers' age groups and PPE use.

	Total		**Use of PPE by Respondent**			
			No		**Yes**	
Characteristics	**n**	**%**	**n**	**%**	**n**	**%**
Total	209	100%	88	42.1%	121	57.9%
Demographic Factors						
Age group						
29–33 years	56	26.8%	33	58.9%	23	41.1%
34–38 years	58	27.8%	15	25.9%	43	74.1%
39–43 years	37	17.7%	17	45.9%	20	54.1%
44–48 years	29	13.9%	12	41.4%	17	58.6%
49–53 years	29	13.9%	11	37.9%	18	62.1%
Establishing the availability and use of protective measures against personal exposure to vehicle exhaust emissions						
Use of PPE during work shift is enforced through:						
Total	209	100%	88	42.1%	121	57.9%
Border management laws/orders/regulations	52	24.9%	28	53.8%	24	46.2%
Departmental laws/orders/regulations	61	29.2%	28	45.9%	33	54.1%
Personal interest/s or discretion	96	45.9%	32	33.3%	64	66.7%

Among the participants, as shown in Table 6, 64 (66.7%) out of 96 (45.9%) used personal interest/discretion to enforce PPE use during work shifts, while fewer workers (n = 24, 46.2%) out of 52 (24.9%) used border management laws/orders/regulations for enforcement.

The majority of workers (n = 151, 72.2%) had breaks of more than 30 min, whereas fewer workers (1 (0.48%)) had breaks between 10 and 15 min, as described in Figure 2.

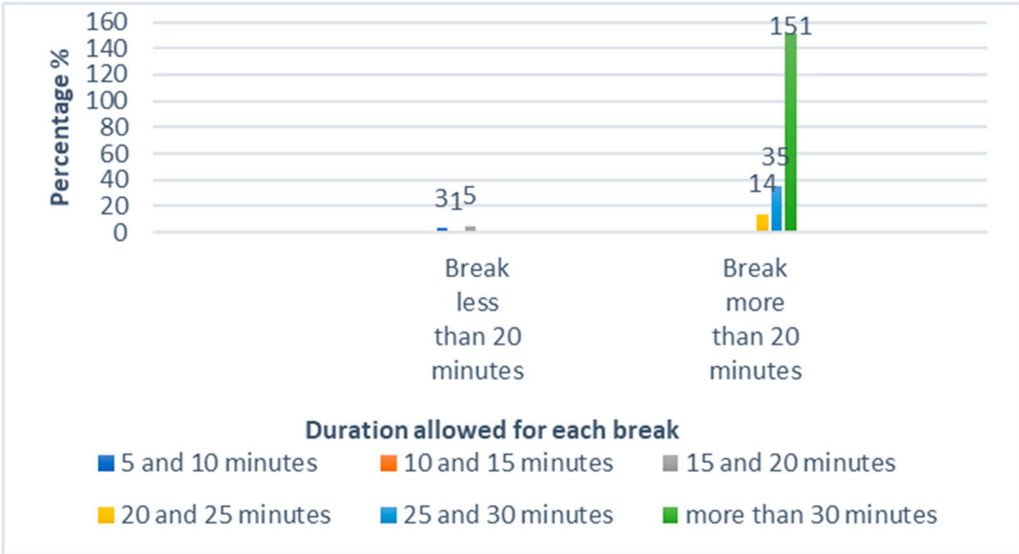

Figure 2. Duration allowed for each break.

Overall, 121 (57.9%) out of 209 workers used PPE as a protective measure against exposure to vehicle emissions. Most of the workers (n = 64, 66.7%) out of 96 (45.9%) enforced the use of PPE as a protective measure against exposure to vehicle emissions during work shifts through personal interest/discretion (Table 6).

Workers aged between 34 and 38 years did not use PPE as a protective measure against personal exposure to VEEs compared to workers aged between 29 and 33 years (AOR = 0.25, CI 0.11–0.56). Additionally, workers who used personal interest/discretion to enforce the use of PPE during work shifts never used those protective measures against personal exposure to VEEs compared to workers who used border management laws/orders/regulations (AOR = 0.37, CI 0.17–0.78), as displayed in Table 7.

Table 7. Association between workers' age groups and PPE use.

Characteristics	Crude Odds Ratio	95% Confidence Interval	Adjusted * Odds Ratio	95% Confidence Interval
Demographic variables				
Age group				
29–33 years	Reference	Reference	Reference	Reference
34–38 years	0.24	0.11–0.54	0.25	0.11–0.56
39–43 years	0.59	0.26–1.37	0.62	0.26–1.48
44–48 years	0.49	0.20–1.22	0.53	0.20–1.39
49–53 years	0.43	0.17–1.07	0.50	0.18–1.42
Establishing the availability and use of protective measures against personal exposure to vehicle exhaust emissions				
Use of PPE during work shift is enforced through:				
Border management laws/orders/regulations	Reference	Reference	Reference	Reference
Departmental laws/orders/regulations	0.73	0.35–1.53	0.67	0.29–1.54
Personal interest/s or discretion	0.43	0.21–0.86	0.37	0.17–0.78

* Adjusted for age, gender, marital status, and educational qualification, Reference means a variable which was considered safe to compare other.

3.4. Particulate Exposure Level

Table 8 displays, more importantly, the mean and standard deviation of the concentration of DPM around the port. There were 252 measurements conducted in the study, with a mean of 0.0239 mg/m^3 ± 0.015 for diesel particulate matter concentration.

Table 8. Particulate exposure level.

Variable	N	Mean (mg/m^3)	SD ±
Total	252	126.50	72.890
Concentration of diesel particulate matter (mg/m^3)	252	0.0239	0.0155

In the 252 overall measurements of DPM concentration, the *p*-value of 0.001 showed statistical significance, as shown in Table 9. The mean value for hours of exposure for <12 h (which was 5 h for the night shift) was 0.021, which was lower than the mean value for hours of exposure for >12 h (which was 12 h for the day shift), which was 0.027 in the concentration of DPM (mg/m^3). These results suggest that the concentration of DPM was higher during the day than at night. Thus, working at night was less likely to expose workers to DPM than working during the day. There was no difference in means and standard deviations for the day shift and night shift by workstation and type of carbon measured.

Table 9. DPM mean concentrations for night and day shifts.

Variable Total = 252	Overall Mean	SD	Hours of Exposure <12 h (Night Shift)			Hours of Exposure >12 h (Day Shift)			*p*-Value
			N	Mean	SD ±	N	Mean	SD ±	
Total	126.50	72.89	126	133.50	72.697	126	119.50	72.697	0.128
Concentration of diesel particulate matter (mg/m^3)	0.03	0.02	126	0.021	0.012	126	0.027	0.017	0.001
Post of work	2.00	0.82	126	2.00	0.82	126	2.00	0.82	1.000
Shift worked									
Type of carbon measured	2.00	0.82	126	2.00	0.82	126	2.00	0.82	1.000

4. Discussion

Workers at the Lebombo POE, particularly those frequently involved in vehicle searches and cargo inspections at specific points around the port, are more likely to be exposed to VEEs compared to workers in office roles. Employees with vocational certificates and associate's degrees as their highest educational qualifications were predominantly found in the SAPS department, while those with bachelor's degrees were more common in the Agriculture department. This trend may be attributed to the fact that many SAPS workers undergo on-the-job training and typically enter the department with at least a grade 12 qualification, depending on the position. The literature has highlighted education as a non-significant factor in employee performance in the police sector, both domestically and internationally. For instance, results of a study by Windani et al. [27] showed that the variable level of education had no positive and significant effect on employee performance, while the competency variable had a positive and significant effect on employee performance, and the work experience variable had no positive and significant effect on employee performance. This justifies why these officials in the SAPS department in the current study had an averagely lower educational level compared to their counterparts. In contrast, employees in the Agriculture department are typically hired with a formal bachelor's or associate's degree from a university or university of technology upon entry into the department.

Divorced male workers in the present study were significantly more likely to be knowledgeable and aware of vehicle exhaust emissions (VEEs) and their health effects compared to married male workers. This finding aligns with a study by Kim et al. [28] that examined the relationship between marital status and exposure to air pollution in relation to depressive symptoms among the elderly. The study found that married individuals were less likely than unmarried individuals to experience depressive symptoms due to exposure to various-sized air particulate matter (PM) pollutants, such as PM10, PM2.5, and NO_2. This suggests that being in a married relationship may offer some degree of protection against exposure to air pollution. Therefore, the knowledge and awareness of divorced males in this study could be attributed to their exposure experiences, as they fall under the category of unmarried individuals.

Male workers were significantly more likely than female workers to select ozone as a substance in motor vehicle emissions with potential carcinogenic effects. This finding is consistent with a study by Bakehe [29], which found that males were more aware that NO_2 was a key determinant of chronic exposure to traffic-related pollution. Ethan et al. [30] identified NO_2 and ozone, among other air pollutants, as course indicators of traffic pollution. The study also highlighted that females tend to commute shorter distances and spend more time indoors than males, potentially leading to greater exposure and thus greater knowledge among males regarding traffic-related pollution. Kim et al. [31] supported the notion that women spend more time at home than men. This supports the idea that males are more likely than females to be aware of pollution exposures and take precautionary measures to protect themselves. Women were found to be at a higher risk for a decline in cognitive function associated with increased exposure to air pollutants, such as PM10 and PM2.5–10, in Korea [32]. In the same study, females appeared to have limited knowledge about air pollutants, their exposures, and health effects compared to males. This supports the notion that there is a gender-based difference in knowledge of air pollution and exposure.

Workers with an associate's degree were significantly less likely to believe that all motor vehicles are equally polluting compared to those with a bachelor's degree, potentially exposing them to diesel particulate matter (DPM). This suggests that lower educational attainment or literacy levels may contribute to DPM exposure among workers at POEs. Kim et al. [31] and Zurita et al. [3] identified low literacy as a contributing factor to personal exposure to ambient air pollution and VEEs in America, respectively. Education has long been recognized as having a profound positive impact on population health, including reducing exposure to particulate matter [33]. The study suggested that individuals with higher education levels were more aware of the harmful effects of air pollution and were more likely to take appropriate self-protection measures, such as checking the daily air quality index, avoiding outdoor activities, or wearing respirators when air quality was poor. Raufman et al. [34] investigated the impact of environmental health literacy (EHL) on household air pollution-associated symptoms in Kenya. They found that higher health literacy was associated with a lower risk of experiencing air pollution-related symptoms among participants with high EHL. This provides empirical evidence that higher literacy can protect against exposure to air pollution, including traffic-related pollutants like DPM.

Workers who experienced irritation of the nose and eyes very often, a symptom of exposure to VEEs in the current study, were significantly less likely to believe that all motor vehicles were equally polluting compared to workers who never experienced such irritation. This finding aligns with a study in Kenya where eye irritation was identified as a symptom of exposure to household air pollution [34]. Environmental health literacy (EHL), a domain of health literacy that includes the ability to search for, understand, evaluate, and use environmental health information to make informed choices and reduce health risks, may influence behavioral changes. This could include recognizing all motor vehicles as equally polluting to ensure health and safety. Workers who never experienced irritation of the nose and eyes may have considered all vehicles a source of harmful exposure to health and, therefore, took protective measures seriously to minimize their exposure [1].

Workers aged between 34 and 38 years comprised the majority, with 58 (27.8%) in the study sample. This group was less likely to use PPE against personal exposure to VEEs compared to workers aged between 29 and 33 years. Several reasons could explain why this age group did not use PPE. Workplace familiarity, lack of orientation on PPE usage, and more might have been factors. Alemu et al. [35] reported that 62% of construction workers did not use PPE during their daily work, citing reasons such as unavailability of PPE, lack of orientation on PPE usage, discomfort with PPE, perceived unimportance of PPE, and lack of understanding of its necessity.

The group aged between 29 and 33 years might use PPE more due to their higher level of health literacy [34]. Age, level of education, term of employment, years of experience, availability of safety training, PPE utilization training, perception of injury risk, knowledge of PPE, safety briefings before work, and availability of enforcement or pressure to use PPE were identified as independent variables influencing PPE use [26].

Workers who used personal interest or discretion to enforce the use of PPE during work shifts did not use those protective measures against personal exposure to VEEs compared to workers who followed border management laws, orders, or regulations. This finding makes sense, as personal discretion implies no formal obligation or pressure to enforce PPE usage. Rumchev et al. [26] highlighted that the great majority of mine workers did not wear protective equipment from dust exposure (90.1%) and worked long, 12 h instead of 8 h shifts (90.6%), which could have been a result of personal interest or discretion to enforce the use of PPE in the mine in Australia. Alemu et al. [35] highlighted that pressure to use PPE could be an effective enforcement strategy. The study concluded that the main reasons for non-utilization of PPE were unavailability of the materials and the absence of orientation on using PPE. The presence of PPE use training, presence of safety training, safety orientation, and governmental supervision, however, were regarded as factors associated with PPE utilization. These findings indicate that strict organizational enforcement measures, prior knowledge of safety measures, and the number of safety trainings attended can contribute to optimal personal use of PPE at work.

The concentration of diesel particulate matter (DPM) was significantly higher during day shifts compared to night shifts. The study also found that most participants experienced exposure symptoms such as acute headache, acute irritation of the nose and eyes, acute fatigue and nausea, as well as cough and sneezing, which were more associated with exposure to DPM [36]. Rumchev et al. [26] reported that short-term health effects from exposure to DPM include symptoms of throat and bronchial irritation, cough, phlegm, and neurophysiological issues. These findings are plausible, considering factors such as shift duration and weather conditions such as heat and wind patterns [3]. The longer day shifts, compared to the shorter night shifts, could support longer periods of DPM emissions and dispersions during the day at the port than during the night. Due to the COVID-19 restrictions during the data collection period, data were collected during the month of June 2020, in a winter season. It was a moderately cold season with some light wind as Lebombo is a very hot area. Daytime weather conditions are typically hotter and windier, as is the situation at the Lebombo POE, especially in summer, which could likely explain the persistent and continuous dispersion of DPM emissions in large amounts around the port during the day compared to during the night.

This study is the first of its kind in the South African border post context and contributes to the existing literature on workers' exposure to VEEs at POEs [3]. It establishes a baseline for future epidemiological studies in this area. However, there are some limitations to consider.

All symptoms were self-reported, and the current study did not consider other confounders such as socioeconomic behavior like smoking and exposure to indoor air pollution, which might have introduced recall bias, as workers may exaggerate exposure conditions to draw attention to their employer. Additionally, only two out of five departments (SAPS and Agriculture) participated in the study, which may misrepresent the target population. It is important to highlight that they were the only departments at the border post from which consent was obtained. The rest of the departments did not give consent due to fear of exposure to COVID-19. The study also did not cover the busiest border operation times, such as the festive season and Easter holidays, when the border operates 24 h a day. Seasonal effects, including rainfall, wind patterns, and temperature, were not considered, despite findings from Zurita et al. [3] suggesting that seasons and wind direction can influence vehicle emissions and exposure patterns to DPM. Furthermore, the study was conducted at only one border post, limiting the generalizability of the findings. Only levels of different forms of carbon were monitored due to financial constraints since the study received no external funding. The study did not investigate possible effects of other socioeconomic behaviors, such as smoking and exposure to other pollution sources like indoor air pollution sources resulting from activities such as burning biofuels.

5. Conclusions

This study is the first of its kind to quantify the exposure of South African border post workers to VEEs. It revealed a low level of knowledge and awareness among workers regarding VEE exposure and its health effects. The use of available PPE to prevent exposure to DPM was found to be poor and ineffective, primarily due to a lack of strict implementation measures and proper monitoring. The study established exposure indicators (health symptoms due to VEE exposure), highlighting the need for measures to reduce workers' exposure to VEEs.

The improvement and effective implementation of mitigation measures to reduce exposure are necessary, as high pollutant levels at the border post may pose health risks to the exposed population. Given the identified gaps, a health study to identify possible adverse health effects and quantify risks experienced by current border workers, as well as the quantity and components of DPM exposure (organic carbon, elemental carbon, and total carbon), is also recommended.

Author Contributions: Conceptualization, Z.M.M., K.K.M. and P.C.R.; methodology, Z.M.M., K.K.M. and P.C.R.; validation, Z.M.M., K.K.M. and P.C.R.; formal analysis, Z.M.M., K.K.M. and P.C.R.; investigation, Z.M.M., K.K.M. and P.C.R.; resources, Z.M.M., K.K.M. and P.C.R.; data curation, Z.M.M., K.K.M. and P.C.R.; writing—original draft preparation, Z.M.M., K.K.M. and P.C.R.; writing—review and editing, Z.M.M., K.K.M. and P.C.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of the Faculty of Health Sciences (Ethics clearance number: REC-814-2020), University of Johannesburg.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: All data are available upon reasonable request from the corresponding author. The data are not publicly available due to privacy.

Conflicts of Interest: The authors declare no conflicts of interest.

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