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Carbon Monoxide Poisoning in People: Recognition and Prevention

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ABSTRACT

Background: Carbon monoxide (CO) is a toxic gas that lacks discernible color or scent. Individuals may experience the impact of carbon monoxide (CO) emissions originating from a range of sources, such as gas stoves, water heaters, fireplaces, and motor vehicles. Objective: The objective of this study is to evaluate the perception and knowledge pertaining to symptoms, risk factors, causes, and preventative strategies of carbon monoxide (CO) poisoning among the general population in the Kingdom of Saudi Arabia (KSA).

Subjects and methods: The present investigation constitutes a cross-sectional study conducted on the overall population of the Kingdom of Saudi Arabia (KSA). The research focused on those who are not involved in the healthcare profession, utilizing an electronic survey as the primary data collection method. The questionnaire primarily comprises three sections: socio-demographic information, knowledge evaluation, and habitual factors and behaviours pertaining to carbon monoxide poisoning.

Results: Out of 568 participants, (52.8%) were aged between 18 to 25 years with (64.1%) being females. A significant proportion of the participants exhibited little knowledge (67.6%), unfavorable attitudes (72.4%), but shown commendable adherence to preventive measures (64.4%).

Conclusion: There was a lack of knowledge and a weakness in attitude. Nevertheless, preventive practices are highly motivating. Individuals who possess awareness of carbon monoxide (CO) poisoning tend to demonstrate superior levels of knowledge and adherence to safety precautions when compared to those who lack such awareness.

KEYWORDS: Carbon monoxide, poisoning, knowledge, Saudi Arabia.

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1. INTRODUCTION

Carbon monoxide (CO) is a toxic gas with significant health hazards. The substance lacks color and scent. Individuals may potentially encounter carbon monoxide (CO) emissions from several origins, such as furnaces, gas stoves, water heaters, fireplaces, gas heaters, and motor vehicles (Alberreet et al., 2019). Typically, individuals affected by this condition commonly exhibit non-specific and diverse symptoms, such as headaches, dizziness, nausea, malaise, disorientation, impaired orientation, and visual disturbances. In more severe instances, unconsciousness, coma, and convulsions may manifest. Asphyxiation leading to death may ultimately ensue, as documented in a recent study on carbon monoxide poisoning (Up To Date, 2021). Carbon monoxide (CO) poisoning is a significant global health challenge. Fire-related sources are responsible for the majority of carbon monoxide (CO) poisoning incidents, however non-fire-related CO poisoning leads to a significant number of visits to emergency departments (EDs), reaching up to 50,000 visits annually. Hence, it is considered one of the leading factors contributing to instances of poisoning and fatality in the United States, exhibiting a mortality rate ranging from 1 to 3 percent and resulting in approximately 1200 fatalities year (Manker & Perry et al., 2021). Based on data from the Global Health Data Exchange registry, the estimated global incidence of carbon monoxide (CO) poisoning in 2017 was 137 cases per million, with a corresponding mortality rate of 4.6 deaths per million. However, it is important to note that the reported death counts from CO poisoning between 1992 and 2017 experienced a decline of 36%. This decline may be attributed to challenges in data reliability across different countries and the potential misdiagnosis of CO poisoning cases. It is imperative to

implement cautious protocols and conduct more investigations (Mattiuzzi & Lippi et al., 2019).

A comprehensive review was undertaken to ascertain the prevalence of carbon monoxide poisoning in the Middle East and North Africa region. The analysis encompassed a time frame spanning from 2000 through 2021, revealing that carbon monoxide poisoning remains a substantial public health concern, despite its potential preventability. According to a study conducted by Emami-Razavi et al. (2014), it was found that a significant portion of individuals lack awareness regarding the full range of symptoms associated with carbon monoxide poisoning. A retrospective study was undertaken in Dammam, Kingdom of Saudi Arabia, with the objective of evaluating cases of carbon monoxide poisoning that occurred between the years 2004 and 2013. According to the study conducted by Mohammed et al. (2015), the results indicated that the winter seasons exhibited the highest incidence rate, accounting for 50% of the cases. Furthermore, it was found that the fire source was responsible for 64% of the incidents. Additionally, a significant majority of the deaths, namely 91%, were categorized as unintentional. Moreover, the study revealed that the majority of carbon monoxide-related deaths, amounting to 88%, occurred inside residential settings. The risk of some health hazards tends to escalate during winter seasons due to prolonged inside activities and increased usage of heaters. Additionally, public venues that formerly allowed smoking and Shishas in open areas often accommodate similar activities in enclosed locations, further contributing to the heightened risk. Furthermore, the absence of comparable studies in our specific field has served as a catalyst for undertaking this study. The objective of our study is to assess the overall perspective and level of awareness regarding carbon monoxide poisoning.

2. SUBJECTS AND METHODS

Study design and setting

This study is a descriptive cross-sectional investigation conducted among persons in Saudi Arabia who are 18 years of age or older. The study was conducted between July 4, 2021, and September 12, 2022, with the objective of evaluating the understanding and overall awareness of non-healthcare professionals regarding the habits, risk factors, and preventive measures related to carbon monoxide poisoning.

Sample Size and Technique

The determination of the sample size was conducted using Raosoft software, with a margin of error set at 5%, a confidence level of 95%, a population size of around 1,000,000, and a response distribution of 50%. The minimum required sample size for this study will be 400 participants. The participants will be selected using a convenience sampling technique. This study has a cross-sectional design, utilizing a one-stage sampling procedure. The construction of the questionnaire was informed by pertinent prior research. The survey's validity and reliability were assessed by a panel of reviewers, and then, a cognitive interview technique was employed to gather data through online interviews with a cohort of six participants. The distribution of the questionnaire will be conducted in a random manner. By employing electronic surveys as a method of data collection. The questionnaire is comprised of three primary sections. The first section collects participants' biographical information. The second section evaluates participants' understanding of carbon monoxide (CO) poisoning. The third section examines habitual characteristics that may be associated with CO poisoning.

Data management and analysis plan

The data was securely saved within the computer system, ensuring a high level of privacy and secrecy, despite the absence of any personally identifying information. The data analysis will be undertaken using the SPSS program, specifically the Descriptive Statistics module version 23. The statistical measures of means, standard deviations, and proportions will be utilized to assess the average ages and the proportions of males and females.

Statistical Analysis

The assessment of information pertaining to symptoms, risk factors, and causes was conducted through the utilization of questionnaires consisting of eight items, whereby the correct responses were predetermined. The knowledge level has been determined by calculating an overall knowledge score, with cutoff values set at 50% and 75%. The participants will be categorized into three primary groups based on their scores. A knowledge score below 50% is indicative of a low level of knowledge, whilst a number ranging from 50% to 75% is regarded to reflect a moderate degree of knowledge. Conversely, a score beyond 75% suggests a high level of knowledge.

3. RESULTS

A comprehensive sum of 568 individuals satisfied the established criteria for inclusion. Table 1 presents an overview of the socio-demographic characteristics of the participants. A majority of the participants (52.8%) fell within the age range of 18 to 25 years, while a significant proportion (64.1%) identified as females. The proportion of participants who possessed a university degree was 53%, while 37% were currently enrolled as students. In relation to marital status, a majority of 63.2% remained unmarried. The incidence of those who were aware of carbon monoxide poisoning was found to be 52.1%.

Table 1. Socio-Demographic characteristics of participants (n=568)

Study data	N (%)
Age group	
18 – 25 years	300 (52.8%)
26 – 30 years	99 (17.4%)
31 – 40 years	79 (17.4%)
41 – 50 years	52 (09.2%)
>50 years	38 (06.7%)
Gender	
Male	204 (35.9%)
Female	364 (64.1%)
Educational level	
Uneducated	28 (04.9%)
Secondary or below	204 (35.9%)
University degree	301 (53.0%)
Postgraduate	35 (06.2%)
Occupational status	
Self-employed	72 (12.7%)
Non-healthcare provider	177 (31.2%)
Student	211 (37.1%)
Unemployed	108 (19.0%)
Marital status	
Single	359 (63.2%)
Married	182 (32.0%)
Divorced or widowed	27 (04.8%)
Heard of carbon monoxide poisoning	
Yes	296 (52.1%)
No	272 (47.9%)

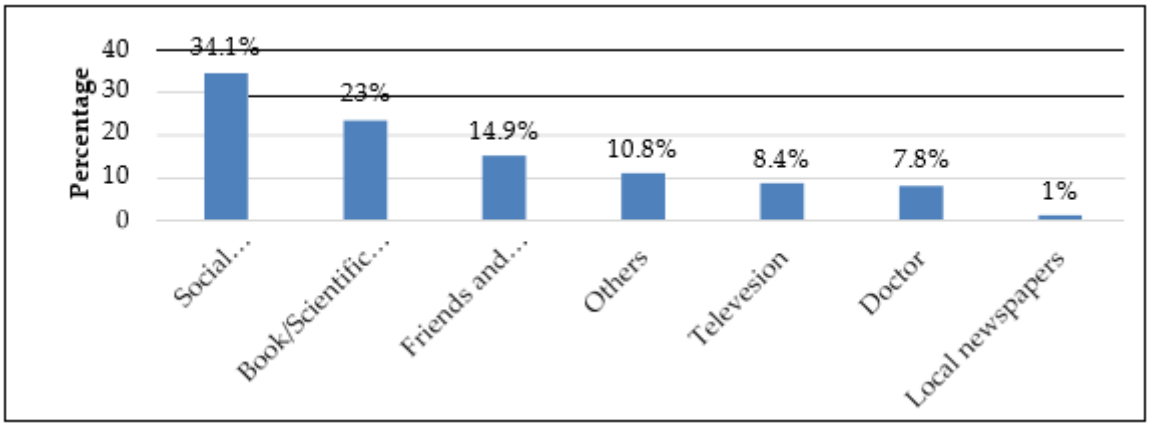

Figure 1. Sources of carbon monoxide poisoning information

According to the data presented in Figure 1, those who were aware of carbon monoxide (CO) poisoning primarily obtained knowledge through social networking sites (34.1%), followed by book/scientific publications (23%) and friends and family (14.9%).

Table 2. Assessment of knowledge of symptoms, risk factors and causes of CO poisoning (n=568)

Knowledge statement	Correct Answer N (%)
Carbon monoxide has an odor that characterizes its emission	149 (26.2%)
Carbon monoxide is a distinctive color	57 (10.0%)
Most cases of carbon monoxide poisoning occur in certain seasons of the year	88 (15.5%)
Do you think everyone is susceptible to carbon monoxide poisoning?	262 (46.1%)
How dangerous is carbon monoxide poisoning to human health?	254 (44.7%)
Choose what is a source of carbon monoxide *	
Fire smoke	429 (75.5%)
Coal combustion	382 (67.3%)
Car exhaust	362 (63.7%)
Smoking/Hookah	281 (49.5%)
Heater/Fireplace	247 (43.5%)
Clogged ventilation system	198 (34.9%)
Dye spray	171 (30.1%)
Carbon monoxide poisoning has symptoms that distinguish it from others	34 (06.0%)
Signs or symptoms of carbon monoxide poisoning *	
Tiredness and fatigue	321 (56.5%)
Loss of focus	310 (54.6%)
Headache	280 (49.3%)
Nausea/Vomiting	260 (45.8%)
Rapid breathing	250 (44.0%)
Chest and abdominal pain	229 (40.3%)
Harmful effects on muscles	214 (37.7%)
Coma	212 (37.3%)
Spasm	156 (27.5%)
Neurological disorders	136 (23.9%)
Death before symptoms appear	120 (21.1%)
Total knowledge score (mean ± SD)	9.51 ± 5.75
Level of knowledge	
Poor	384 (67.6%)
Moderate	148 (26.1%)
Good	36 (06.3%)

* Variable with multiple response answers.

The analysis of the knowledge assessment pertaining to symptomatic features, risks, and hazards factors associated with carbon monoxide (CO) poisoning (as presented in Table 2) reveals notable deficiencies in understanding across various knowledge statements. These include a lack of awareness regarding the characteristic odor of CO emissions (26.2%), the distinctive color of CO (10%), the seasons during which CO poisoning is most prevalent (15.5%), the susceptibility of all individuals to CO poisoning (46.1%), and the detrimental impact of CO poisoning on human health (44.7%). Carbon monoxide (CO) poisoning has several manifestations.

Some individuals may exhibit symptoms at a higher rate (6%) compared to others. Nevertheless, the participants demonstrated knowledge regarding the primary origins of carbon monoxide (CO), with fire smoke being the most

widely recognized source (75.5%). This was closely followed by coal combustion (67.3%) and car exhaust (63.7%). However, respondents exhibited less awareness regarding the contribution of other sources such as heater/fireplace (43.5%), blocked ventilation systems (34.9%), and dye spray. In relation to the clinical characteristics of carbon monoxide (CO) poisoning, participants demonstrated knowledge that the most frequently reported indicators were exhaustion and tiredness (56.5%), followed by diminished concentration (54.6%), headache (49.3%), nausea and vomiting (45.8%), and fast respiration (44%). The mean score for overall knowledge was 9.51, with a standard deviation of 5.75. The distribution of knowledge levels was as follows: 67.6% had little knowledge, 26.1% had moderate knowledge, and 6.3% had strong knowledge.

Table 3. Assessment of participants' attitude/lifestyle and prevention practices regarding CO poisoning (n=568)

Attitude statement	Yes (%)
Do you smoke (cigarettes or shisha) or accompany others in closed or poorly ventilated areas to smoke?	213 (37.5%)
Use of heater in enclosed or poorly ventilated spaces (e.g., in an enclosed bedroom)?	166 (29.2%)
Do you light fire/charcoal/wood for heating or cooking in closed or poorly ventilated areas?	103 (18.1%)
Do you use incense in enclosed or poorly ventilated places?	326 (57.4%)
Do you run your car engine in a closed or poorly ventilated location (e.g., in a garage)?	96 (16.9%)
Are you exposed to car exhaust?	195 (34.3%)
Do you own water heaters in poorly ventilated areas?	99 (17.4%)
Do you maintain ventilation and air conditioning fans and change filters regularly?	314 (55.3%)
Attitude score (mean ± SD)	2.66 ± 1.73
Level of attitude	
Negative	411 (72.4%)
Neutral	141 (24.8%)
Positive	16 (02.8%)
Prevention practices statement	
Do you think using windows and air vents helps get rid of carbon monoxide buildup?	484 (85.2%)
Do you think annual maintenance of ventilation systems, heaters and gas appliances could reduce the carbon monoxide risk?	458 (80.6%)
Do you think having a carbon monoxide detector in the home is important?	422 (74.3%)
Do you think education is important to prevent carbon monoxide poisoning?	524 (92.3%)
Practices score (mean ± SD)	3.32 ± 1.12
Level of practices	
Poor	96 (16.9%)
Moderate	106 (18.7%)
Good	366 (64.4%)

In relation to the evaluation of participants' attitudes and lifestyles regarding carbon monoxide (CO) poisoning, the findings from Table 3 indicate the presence of a negative attitude towards certain behaviors. Specifically, a significant proportion of participants expressed a negative attitude towards activities such as smoking or being in the presence of smokers in closed or poorly ventilated areas (37.5%), using heaters in enclosed or poorly ventilated spaces (29.2%),

lighting fires or using charcoal/wood for heating or cooking in closed or poorly ventilated areas (18.1%), running car engines in closed or poorly ventilated locations (16.9%), being exposed to car exhaust (34.3%), and having water heaters in poorly ventilated areas (17.4%). On the other hand, a positive attitude was observed towards the use of incense in enclosed or poorly ventilated areas (57.4%) and the practice of maintaining ventilation, air conditioning fans, and regularly changing filters (55.3%). The mean score for the total attitude was 2.66, with a standard deviation of 1.73. The majority of participants (72.4%) exhibited a negative attitude, while 24.8% had a neutral attitude, and only 2.8% displayed a positive attitude. In relation to prevention practices, a significant proportion of the participants demonstrated commendable adherence to preventive measures, as evidenced by their responses to the following inquiries: 85.2% acknowledged the efficacy of utilizing windows and air vents to mitigate carbon monoxide (CO) accumulation, 80.6% recognized the potential risk reduction associated with annual maintenance of ventilation systems, heaters, and gas appliances, 74.3% emphasized the importance of possessing a CO detector in their residences, and 92.3% acknowledged the significance of education in preventing CO poisoning. The average score for prevention practices was found to be 3.32 (standard deviation = 1.12). Among the participants, 64.4% shown good activities, while 18.7% exhibited moderate practices, and 16.9% displayed poor behaviors.

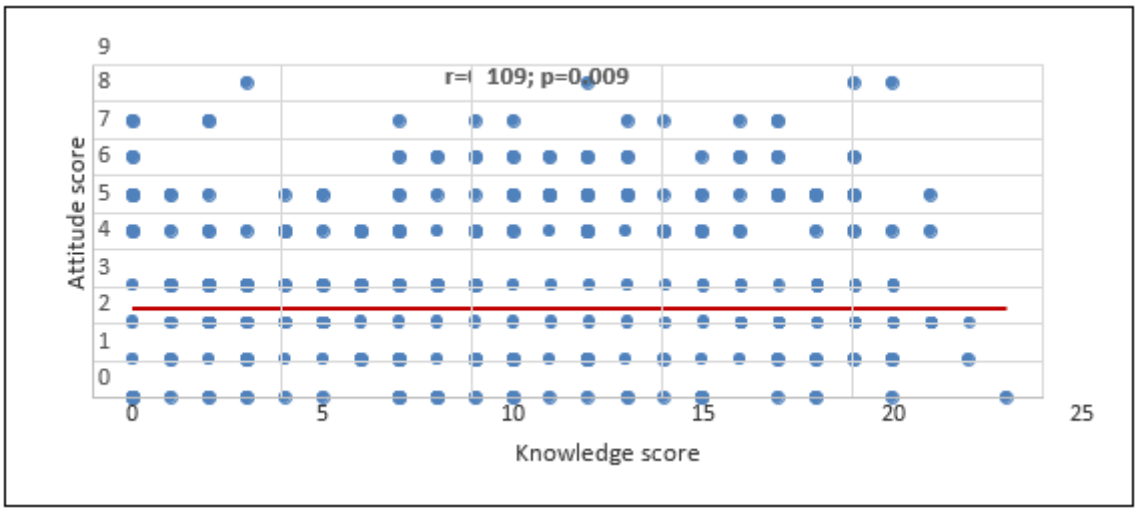

Figure 2. Correlation of knowledge score and attitude score

Figure 2 illustrates a noteworthy positive association between knowledge and attitude scores (r=0.109; p=0.009).

4. DISCUSSION

Knowledge about CO poisoning

This study aims to assess the degree of knowledge among the general population in Saudi Arabia regarding the signs and symptoms, risk factors, sources, and preventive strategies associated with carbon monoxide poisoning. In general, the provided information was inadequate. Approximately 70% of the participants were categorized as possessing a low degree of knowledge, with 26.1% demonstrating a moderate level of awareness, while a mere 6.3% exhibited a high level of understanding. In line with our research findings, Dianat and Nazari (2011) and Pach et al. (2010) have also observed a lack of awareness regarding carbon monoxide (CO) poisoning among both the general population and students. The characteristics of participants' age, gender, educational level, and employment status were not deemed to be important determinants of knowledge. According to a study conducted in Poland, it was observed that non-medical students exhibited inadequate understanding on carbon monoxide (CO) poisoning, while medical students achieved significantly higher scores on a CO poisoning knowledge assessment compared to their non-medical counterparts (Dianat & Nazari et al., 2011).

Furthermore, within the context of the designated knowledge evaluation, a significant number of our participants demonstrated a deficiency in their understanding of the fundamental knowledge claims. For example, the survey participants shown limited comprehension about the characteristics of carbon monoxide (CO) emissions, with 26.2% lacking understanding in this area. Additionally, 10% of respondents were unaware of the distinctive hue associated with CO. Furthermore, 15.5% were unfamiliar with the season during which CO poisoning is most prevalent, and 6% were unaware of the diverse range of symptoms associated with CO poisoning. Similarly, it has been observed that the participants in our study exhibited a satisfactory comprehension of the primary contributors to carbon monoxide (CO) emissions, such as fire smoke (75.5%), coal combustion (67.3%), car exhaust (63.7%), and smoking (49.5%). However, it is worth noting that a significant proportion of respondents were less informed about the role of heater/fireplace (43.5%), clogged ventilation systems (34.9%), and dye spray (30.1%) as additional sources of CO. A systematic review was conducted in the Middle East and

North Africa, revealing that the annual incidence of carbon monoxide (CO) poisoning was 13.37 per 100,000 inhabitants. The majority of these incidents occurred during the winter seasons, with gas heaters identified as the primary cause of these occurrences (Alberreet et al., 2019). In a separate study conducted in Riyadh, it was shown that the combustion of coal or firewood constituted the primary source of carbon monoxide (Waseem et al., 2016). In the context of Nigeria, it was observed that out of the 157 participants surveyed, a significant majority of 73.4% shown a limited comprehension regarding the sources of carbon monoxide poisoning. According to Afolayan et al. (2014), despite a majority (60.5%) of individuals having received prior education on carbon monoxide (CO) poisoning, there appears to be a lack of attention towards the health risks associated with CO poisoning caused by indoor electrical generators. This suggests the need for additional efforts to raise awareness on this particular hazard.

Similarly, the participants had a limited comprehension of the indicators and clinical characteristics associated with carbon monoxide poisoning. The data obtained from our study indicates that the participants had a lower level of awareness regarding the symptoms and clinical aspects that are widely recognized. According to a study conducted by Popiołek et al. (2021), it was observed that medical students possess a substantial understanding of the potential risks associated with carbon monoxide (CO) exposure. These risks include fatality, symptoms such as headache, dizziness, weakness, damage to the nervous system, loss of consciousness, apnea, nausea, vomiting, heart palpitations, hypotension, and somnolence. A study conducted by Raub et al. (2000) found that exposure to carbon monoxide (CO) during pregnancy is associated with an elevated risk of short-term complications, including fetal death, persistent cerebral lesions, and developmental abnormalities.

Attitude/Lifestyle toward CO poisoning

The respondents exhibited a predominantly unfavorable attitude towards carbon monoxide poisoning. Around 72.4% of the participants exhibited a negative attitude, whereas 24.8% maintained a neutral stance, and less than 3% displayed a positive attitude. To the best of our current understanding, this research represents the inaugural inquiry in Saudi Arabia aimed at assessing the degree of attitudes towards carbon monoxide poisoning. This study makes a significant contribution to the existing body of literature and warrants further exploration. Furthermore, it was observed that the participants in our research exhibited a favorable disposition towards the use of incense in confined or inadequately ventilated spaces (57.4%), as well as the upkeep of ventilation systems and air conditioning fans (55.3%). In contrast, the participants demonstrated a pessimistic disposition in the given scenario, including engaging in smoking or being in the presence of individuals smoking in enclosed areas with limited ventilation (375%); being exposed to car exhaust (34.3%); utilizing a heater in enclosed areas with limited ventilation (29.2%); igniting fire, charcoal, or wood (18.1%); and operating a car engine in a confined area with limited ventilation (16.9%). According to a study conducted by Popiołek et al. (2021), a significant proportion of students in Poland (51.2%) utilize a bath room water heater. Interestingly, a majority of these students hold the belief that they are not susceptible to carbon monoxide (CO) poisoning. During the period of observation in Iran, it was found that non and free standing heaters were the primary sources of inadvertent carbon monoxide (CO) poisoning, as reported by individuals. Remarkably, it was found that none of the households that were searched have a carbon monoxide (CO) detector at the time of the occurrence, hence exacerbating the challenges faced by the authorities (Dianat & Nazari et al., 2011).

Prevention practices

In relation to preventive measures, it was found that around 64.4% of individuals exhibited a high degree of adherence to these behaviors, whereas 18.7% shown a moderate level, and 16.9% displayed a low level of adherence. It is noteworthy that those who were aware of carbon monoxide (CO) poisoning shown much higher levels of engagement in preventative measures compared to those who were not familiar with it. However, the respondents who were current students had a lower level of engagement in preventative efforts compared to the other respondents. Further investigations are required to ascertain the levels of preventative practices and discover the factors influencing them. In contrast, our findings revealed that a majority of the respondents exhibited sufficient levels of engagement in all of the preventive measures. The significance of carbon monoxide (CO) detectors in residential settings was also examined by Emami et al. (2014). Based on the findings presented in their reports, it was observed that a significant majority of Iranis, specifically 89.1%, expressed the belief that the utilization of carbon monoxide (CO) detectors would prove beneficial in reducing mortality rates associated with CO poisoning. Additionally, a substantial proportion of respondents, amounting to 84.4%, acknowledged the importance of opening windows as a preventive measure against CO leakage. Furthermore, an overwhelming majority of participants, accounting for 93.8%, indicated that their fuel burning devices underwent expert inspection at the onset of the winter season. In contrast to the findings reported by Hajjar et al. (2016), it was seen that a majority (55.6%) of the individuals surveyed did not adhere to safety measures concerning carbon monoxide (CO). Furthermore, only a small percentage (1.7%) possessed a CO safety alarm. Consequently, a significant prevalence of suffocation and mortality cases (89.1%) was observed within the sample population.

Correlation of the knowledge, attitude, and prevention practices (KAP)

The study found a statistically significant positive association ($p=0.009$) between knowledge and attitude scores, as well as between knowledge and practices scores ($p<0.001$). This suggests that individuals with higher levels of knowledge tend to exhibit more positive attitudes and engage in better prevention activities. Nevertheless, the statistical analysis revealed that there was no significant link between the attitude score and practices ($p=0.711$). Further investigation is necessary to establish the validity of the actual correlation matrix pertaining to Knowledge, Attitudes, and Practices (KAP).

5. CONCLUSION

There were a lack of awareness and positive attitudes regarding carbon monoxide poisoning, however the implementation of preventive measures is encouraging. The attitudes of individual participants appear to be more positive. However, those who are aware of carbon monoxide (CO) poisoning tend to demonstrate a higher level of awareness and engage in more effective preventive measures compared to those who are not informed about this issue. The significance of public awareness lies in its ability to identify deficiencies in information and attitude. While carbon monoxide (CO) poisoning is a significant public health concern, it is important to note that preventive measures can effectively mitigate this issue. Various laws and ideas have been put out to address this matter. Therefore, it is imperative to reassess tactics and commitments, while also increasing public knowledge, in order to mitigate CO exposure, particularly in residential environments. Additional research is required to enhance the identification of the overall knowledge level and awareness pertaining to positive attitudes and preventive measures in order to ascertain the determinants that impact the comprehension of carbon monoxide poisoning, its clinical manifestations, risk factors, and etiology.

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