Journal of Pioneering Medical Sciences
Received: December 15, 2025 | Accepted: February 20, 2026 | Published: April 05, 2026
Volume 15, Issue 03, Pages 138-144

DOI https://doi.org/10.47310/jpms2026150321

Occupational Hazard Awareness and Safety Practice Gaps among Gas Station Workers in Makkah, Saudi Arabia: A Mixed-Methods Study

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Abstract **Background:** Gas station workers are regularly exposed to a range of occupational and environmental hazards, particularly from fuel vapours and workplace conditions. Although the health effects of gasoline exposure are well documented, there is limited evidence on workers' awareness of these risks and their adherence to safety practices, especially in high-density urban settings such as Makkah. **Objective:** This study aimed to assess occupational hazard awareness and safety practices among gas station workers in Makkah, Saudi Arabia. **Methods:** A mixed-methods approach with a convergent design was employed, combining structured interviews (n=62) with direct workplace observations. Workers were recruited from gas stations across multiple districts in Makkah. Quantitative data were collected using a structured interview questionnaire and analysed descriptively, while qualitative observational data were recorded in the field and analysed thematically. The observational component was used to compare and validate self-reported practices. **Results:** More than half of the participants (54.8%) reported experiencing at least one work-related health symptom, most commonly headaches (38.7%), cough (30.6%) and dizziness (14.5%). Nearly 60% had experienced at least one occupational incident, including fuel contact with skin or eyes and fire-related events. Only 19.4% demonstrated adequate awareness of occupational hazards and 41.9% reported no prior safety training. A clear gap was observed between reported attitudes and actual practices, as the use of personal protective equipment was limited during field observation. **Conclusion:** Gas station workers in Makkah show low levels of hazard awareness and poor adherence to safety practices, with inadequate training contributing to unsafe working conditions. Strengthening regulatory enforcement, ensuring mandatory safety training and improving compliance with personal protective equipment use are essential to reduce occupational risks and protect worker health.

Key Words Occupational Safety, Gas Station Workers, Hazard Awareness, Personal Protective Equipment, Occupational Risks, Safety Training

INTRODUCTION

Gasoline is a primary source of energy for transportation and represents a significant source of chemical exposure in occupational environments. As a complex mixture of hydrocarbons, gasoline releases volatile organic compounds (VOCs), including benzene, toluene, ethylbenzene and xylene, commonly referred to as BTEX compounds [1]. Among these, benzene has been widely recognized as a hazardous substance associated with both acute and chronic health effects. Reported outcomes range from relatively mild symptoms, such as headache and throat irritation, to more serious conditions including liver and kidney dysfunction, blood disorders, neurological impairment and various forms of cancer [2-5].

Beyond direct occupational exposure, gasoline also contributes to broader environmental health concerns. Pollutants generated during fuel combustion, such as carbon monoxide, nitrogen oxides and fine particulate matter, have a well-established impact on air quality and are linked to respiratory and cardiovascular diseases [6,7]. These environmental exposures further compound the health burden associated with gasoline use.

Gas station workers represent a particularly vulnerable occupational group due to their continuous exposure to these hazards. Their daily tasks place them in close proximity to fuel pumps, where they are exposed to fuel vapours, vehicle exhaust emissions and direct contact with petroleum products.

Exposure may occur through inhalation, dermal contact, or, in some cases, ingestion of contaminated materials. In addition to chemical hazards, workers are also subject to physical strain, including prolonged standing and repetitive tasks, which may contribute to fatigue and musculoskeletal discomfort [2,5]. Despite these risks, the extent to which workers recognize and respond to such hazards remains uncertain.

The increasing global demand for gasoline, driven by population growth and economic development, has further intensified these occupational risks. Data from the United States Energy Information Administration indicate a substantial rise in gasoline consumption over recent decades, reflecting broader global trends [9]. As a result, the number of gas stations and associated workforce has expanded, increasing the number of individuals exposed to these occupational hazards [8]. At the same time, epidemiological evidence continues to highlight the elevated health risks faced by workers in this sector.

Given this context, understanding workers' awareness of occupational hazards and their adherence to safety practices is essential. Limited awareness, inadequate training and poor compliance with protective measures can significantly increase the risk of adverse health outcomes. Therefore, assessing both knowledge and actual workplace behaviour is critical for developing effective interventions aimed at improving occupational safety in this setting.

LITERATURE REVIEW

Previous studies have highlighted important gaps in occupational health awareness and safety practices among gas station workers. In Guyana, Morrison and Rose [11] reported that although workers demonstrated some level of compliance with basic safety requirements, their understanding of occupational hazards remained limited. The authors emphasized the need for structured training programs to improve awareness and reduce workplace risks. Similarly, Johnson and Umoren [12] found that gas station workers were exposed to multiple occupational hazards and frequently experienced health symptoms such as headache, nausea and cough due to exposure to gasoline vapours and vehicle exhaust. Despite these risks, the study reported low awareness of occupational hazards and poor adherence to personal protective equipment (PPE) use.

Behavioural factors influencing PPE compliance have also been explored. A study on resistance to PPE use among gas station attendants found that workers often avoided protective equipment due to discomfort, lack of availability, forgetfulness and underestimation of workplace risks [13]. These findings suggest that awareness alone may not be sufficient to ensure safe practices, as workplace culture and practical barriers also play a role.

Other studies have highlighted discrepancies between perceived and actual safety behaviour. Cezar-Vaz *et al.* [14] reported that while more than 60% of workers claimed to be aware of occupational hazards, a high proportion (94.1%) had experienced workplace incidents, indicating a gap between knowledge and practice. Similarly, Rocha *et al.* [15] observed that although workers reported using various forms of PPE, direct observation revealed that only basic items such as uniforms and boots were consistently used. This mismatch between reported and observed behaviour underscores the importance of combining self-reported data with observational methods when assessing occupational safety.

Overall, existing literature suggests that gas station workers face significant occupational risks, with persistent gaps in awareness, training and compliance with safety measures. However, most studies have been conducted in settings outside Saudi Arabia and limited research has explored these issues within the local context.

Research Gap and Study Rationale

Although the health effects of gasoline exposure and associated occupational hazards have been widely studied, there remains a lack of research focusing specifically on workers' awareness of these risks and their actual safety practices, particularly in Saudi Arabia. This gap is especially relevant in Makkah, a city characterized by a high density of gas stations and a large, dynamic population.

Makkah has a population exceeding 1.5 million residents and receives more than 20 million visitors annually [16]. The city contains approximately 955 operational gas stations distributed across its districts [17], resulting in a large workforce regularly exposed to occupational hazards. Despite this, there is limited evidence assessing whether workers in this setting are adequately informed about workplace risks or whether they follow appropriate safety practices.

Understanding awareness and behaviour in this context is essential for identifying gaps in occupational safety systems and informing targeted interventions. In particular, examining both self-reported knowledge and actual workplace practices can provide a more accurate picture of existing challenges and help guide policy, training programs and regulatory enforcement.

Study Aim

This study aimed to assess occupational and environmental health awareness among gas station workers in Makkah, Saudi Arabia and to evaluate their adherence to safety practices, including the use of personal protective equipment. In addition, the study sought to compare workers' self-reported knowledge and practices with observed workplace behaviour in order to identify gaps between awareness and actual safety compliance.

METHODS

Study Design

This study adopted a mixed-methods approach using a convergent design, in which quantitative and qualitative data were collected concurrently and integrated during interpretation. The combination of methods allowed for a more comprehensive understanding of occupational health awareness and safety practices among gas station workers, as well as comparison between reported behaviours and actual practices [24].

The quantitative component consisted of a structured interview questionnaire used to assess workers' knowledge, experiences and perceptions. The qualitative component involved direct field observations, which were conducted to validate and complement the self-reported data by capturing real workplace behaviours and conditions.

Study Location and Population

The study was conducted in Makkah, Saudi Arabia, a city with a population exceeding 1.5 million residents and hosting more than 20 million visitors annually [16]. The city covers an area of approximately 850 square kilometres and is characterized by a high density of gas stations, with around 955 operational stations distributed across different districts [17].

The target population included gas station workers responsible for fuel pumping services. To enhance geographic representation, gas stations were selected from multiple districts across the city. Workers present at the selected sites were invited to participate voluntarily. Of more than 100 workers approached, 62 agreed to participate, resulting in an approximate participation rate of 62%.

Although an effort was made to include workers from different locations, the sampling approach was largely convenience-based and therefore may not fully represent all gas station workers in Makkah.

Data Collection Instruments

Structured Interview Questionnaire: A structured interview questionnaire was used as the primary tool for quantitative data collection. The questionnaire was administered electronically using Google Forms, a widely used platform that allows efficient data collection and organization [18].

The questionnaire was designed to capture key aspects of occupational health and safety, including:

- Demographic characteristics and employment history
- Duration and frequency of occupational exposure
- Self-reported health status and symptoms
- Awareness and knowledge of occupational hazards
- Participation in safety training programs
- Perceptions and use of personal protective equipment (PPE)
- History of occupational incidents and accidents

While the questionnaire covered relevant domains, no formal scoring system or validated scale was used to quantify awareness levels and responses were interpreted descriptively.

Observational Study

Direct observation was conducted as the qualitative component of the study to assess actual workplace practices and environmental conditions. The observational approach allowed the researcher to document real-time behaviours and identify discrepancies between reported and observed practices [19].

Observations focused on the following aspects:

- Actual use of personal protective equipment by workers
- Compliance with occupational health and safety standards
- Workplace environmental conditions, including ventilation and exposure context
- Presence of unsafe practices or safety violations

Observational data were recorded as field notes during site visits. Although no formal checklist was used, observations were guided by predefined areas of interest related to occupational safety.

Data Analysis

Quantitative data collected through the questionnaire were analysed using the built-in analytical tools of Google Forms, which provide summary statistics such as frequencies and percentages, along with basic graphical representations [18]. The analysis remained descriptive in nature and did not include inferential statistical testing.

Qualitative observational data were analysed thematically by identifying recurring patterns related to worker behaviour, safety practices and workplace conditions. These findings were then compared with the questionnaire results to identify consistencies and discrepancies between reported knowledge and actual practices. This integrative approach allowed for a more nuanced understanding of occupational safety behaviours among workers.

RESULTS

Demographic and Employment Characteristics

A total of 62 gas station workers participated in the study. All participants were workers who performed fuel pumping services. All participants were males, as this job is for male only. The age distribution of participants revealed that 80% were ranging from 20 to 35 years old and 20% being 36 years or older. This indicates that the workforce is mostly young people.

The result showed that 54.8% of participants have worked in the same job for 1 -3 years and 27.4% of them have worked for 4 to 6 years in the same job. Approximately 17.8% of participants have worked in gas stations for 7 years of more. This finding indicates high rate of employment turnover as the majority of workers do not continue in the same job beyond six years. It is not explained why in this study. It could be because of something related to health issues or it could be because of other reasons? This query could be an opportunity for conducting a future investigation to clarify this question.

Work Schedule and Exposure Patterns

The study revealed intensive work schedules with significant implications for occupational exposure. The participants reported that 96.8% work during all week's days (seven days) and 3.2% of the participants work between 4 to 6 days

of the week. The result showed that 100% of participants work between 10 to 12 hours each working day.

By taking into consideration the results of exposure duration of the working hours each day (10-12 hours daily) and the exposure frequency (predominantly seven days weekly), it gives an indication that gas station workers face substantial health risk of exposing to the toxic chemicals that emits volatile organic compounds, including benzene, toluene, ethyl benzene and xylene [2,20].

Smoking Status and General Health

Regarding smoking habits among gas station workers, 74.2% of participants stated being non-smokers, while 25.8% acknowledged as smokers. Smoking has a variety of health consequences including common symptoms like coughing and shortness of breath [21]. These symptoms overlap with those associated with occupational exposure to gasoline vapour, as documented in multiple studies [2,5,20]. The aim of this question was to understand the general health status of the participants, identify factors that may affect their health and link them to health symptoms that may appear as a result of working at gas stations.

Notably, observational data showed that there was no smoking cases occurred close to or around gasoline pumping devices by workers, indicating compliance among gas station workers with the critical safety requirement prohibiting smoking at gas stations.

Health Symptoms and Occupational Illnesses

Participants were asked whether they had experienced illnesses or health symptoms due to working at gas stations. Their answer included a list of health issues as shown in Figure 1. Approximately 45.2% of the participants reported having no symptoms and claiming that their overall health is okay. On the other hand, a total of 54.8% had experienced some health issues attributed to working at gas stations. Around 38.7% of the participants reported having headache, 30.6% have experienced coughing, 14.5% had suffered from dizziness, 11.3% had complained of difficulty breathing, 3.2% had reported throat irritation, 3.2% had complained of musculoskeletal disorders (MSD) due to prolonged standing and 1.6% had experienced nausea/vomiting. These reported health symptoms are consistent with the findings of several previous studies that identified them as primary manifestations of occupational exposure among gas station workers [1,12,20]. The high occurrence of headaches and coughing is mainly concerning, as these symptoms may indicate significant exposure to VOCs.

Occupational Incidents and Accidents

The results revealed that gas station workers had experienced various incidents in the workplace (Figure 2). In particular, 25.8% had experienced fires, 12.9% experienced collisions between vehicles and workers, 29% had fuel splashed in their eyes and 53.2% had fuel contact on skin. In contrast, 40.3% of workers had experienced no incidents. Based on these findings, approximately 60% of workers had

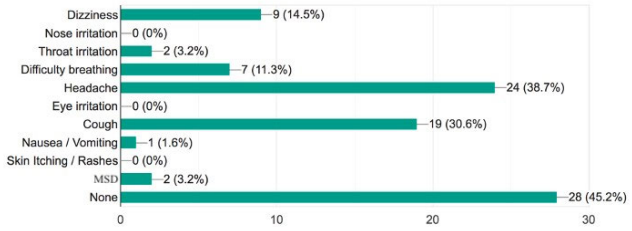

Figure 1: Health issues and symptoms experienced by gas station workers

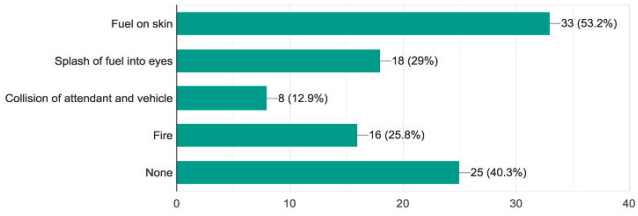

Figure 2: Occupational incidents experienced by gas station workers

experienced at least one workplace incident. This result aligns closely with the findings of Cezar-Vaz *et al.* [14], who reported that approximately 94.1% of gas station workers had experienced occupational incidents.

Attitudes Towards Personal Protective Equipment (PPE)

Participants were asked about their opinions regarding the importance of using PPE, such as wearing masks and gloves while performing their work duties. The results revealed that 50% responded that using PPE is important, 30.6% expressed uncertainty about the importance of PPE and 19.4% answered negatively regarding wearing PPE. This finding is consistent with prior research indicating that gas station workers did not wear masks and gloves [13-15].

However, the observational records noted that the majority of gas station workers did not wear masks and gloves while performing their work duties, they only wore uniforms, shoes and sandals. This result aligns with the findings of Rocha *et al.* [15] who noted that notwithstanding workers' claims of wearing comprehensive PPE, merely boots and uniforms were actually used by workers of gas stations. This study endorses the advice of Rocha *et al.*, advocating for more oversight of workers by the competent authority to ensure compliance with the use of PPE.

Awareness of Occupational and Environmental Risks

The findings revealed that 19.4% of participants recognized the potential health and environmental hazards associated with working at gas stations. In contrast, 25.8% of participants reported being uninformed of occupational health and environmental hazards.

The remaining participants (54.8%) reported a lack of understanding about occupational risks. This finding indicates that gas station workers have relatively little awareness. It is in

line with the Johnson and Umoren study, which found a poor PPE compliance among gas station attendants and a low level of understanding of occupational hazards [12].

The observational record also noted lack of awareness among gas station workers about the health and environmental hazards that exist in the workplace. It was observed that a large number of workers did not use PPE. Moreover, in some cases, it was observed that some workers were eating snacks and drinking beverages or water while performing their work duties, which thus heightening the risk of getting a chemical substance and showing inadequate risk perception.

Training and Education

Workers' training programs enhance awareness and knowledge of potential occupational hazards, enabling individuals to adopt behaviours and practices that mitigate exposure to risks and promote a safe working environment [23]. In this regard, the participants were questioned if they had received in any training courses on handling occupational hazards. According to the results, 41.9% of workers had not received any work-related training. However, 58.1% of respondents indicated that they had participated in various training courses covering topics such as emergency evacuation, fire extinguisher use, handling gasoline spills on the ground and handling gasoline splashes on the body.

The discovery that 41.9% of workers had received no job-related training is concerning and indicates a failure to meet basic occupational health and safety standards. According to Occupational Safety and Health Administration (OSHA) standards, employers are required to provide workers with appropriate safety training before engaging in potentially hazardous activities [22].

Observational: Environmental Conditions

Effects of Climate and Temperature: Makkah is recognized by a hot climate for most months of the year. During the summer season the temperatures reaching up to 45°C. Elevated temperatures boost the evaporation rate of gasoline at gas stations, resulting in higher VOC concentrations in the atmosphere.

Inadequate Ventilation

Most gas stations were found to lack efficient ventilation systems for reducing harmful air concentrations in worker areas. Although gas stations are often constructed as open spaces with roofs covering the pump areas. It was observed that gas stations frequently exhibit insufficient air current, particularly under conditions of high temperatures and minimal wind movement.

Idling of Vehicles

The observational records showed that most vehicle drivers kept their vehicles engines running while refuelling, Despite the availability of warning signs at all stations stating the need to do so. Leaving engines running while refilling raises the risk of fire and contributes to extra exhaust emissions.

DISCUSSION

This study highlights important occupational health concerns among gas station workers in Makkah, particularly related to chemical exposure, workplace safety practices and limited awareness of occupational hazards. The findings are consistent with previous research indicating that gas station workers are regularly exposed to multiple risks in their work environment, yet often lack adequate knowledge and protection [1,2,12,20]. Beyond confirming existing evidence, this study provides local insight into how these risks are experienced and managed in a high-demand urban setting.

Health Impacts and Symptom Patterns

More than half of the participants (54.8%) reported experiencing at least one health-related symptom, with headache (38.7%) and cough (30.6%) being the most commonly reported. These findings are consistent with previously documented symptoms associated with exposure to BTEX compounds and fuel vapours [1,2,12,20]. The work patterns observed in this study, particularly long working hours (10-12 hours per day) and extended weekly schedules, suggest continuous and cumulative exposure to volatile organic compounds. This sustained exposure likely contributes to the frequency of reported symptoms.

In addition to chemical-related symptoms, a smaller proportion of workers reported musculoskeletal discomfort (3.2%), which may be attributed to prolonged standing and repetitive physical tasks. Although less frequently reported, this finding reflects the physical demands of the occupation and highlights the need for a broader occupational health approach that addresses both chemical and ergonomic risks.

Occupational Incidents and Safety Concerns

The high proportion of workers reporting occupational incidents (approximately 60%) is a significant concern. Frequent exposure to fuel contact with the skin (53.2%) and eyes (29.0%) indicates inadequate protective measures and unsafe work practices. Such exposures may lead to both immediate irritation and potential long-term health consequences. The reported occurrence of fire-related incidents (25.8%) further emphasizes the presence of serious safety hazards in the workplace.

The lack of formal training among a substantial proportion of workers (41.9%) may partly explain these findings. Previous evidence has shown that structured training programs improve workers' awareness and reduce exposure to occupational hazards [23]. The absence of training in this study suggests gaps in employer responsibility and regulatory enforcement, which may contribute to unsafe practices and increased risk of injury.

Knowledge Gaps and Awareness Deficiencies

A key finding of this study is the low level of occupational hazard awareness, with only 19.4% of workers demonstrating adequate knowledge. This indicates that the majority of workers may not fully understand the risks

associated with their work environment. Limited awareness can directly affect behaviour, as workers are less likely to adopt protective measures if they do not recognize the severity of the hazards.

This gap is further reflected in the discrepancy between self-reported and observed practices. While some workers acknowledged the importance of personal protective equipment, observational findings revealed limited actual use of PPE. This inconsistency may be influenced by several factors, including social desirability bias in responses, lack of PPE availability, discomfort during use, weak enforcement of safety policies and insufficient understanding of occupational risks. These findings suggest that improving awareness alone may not be sufficient without addressing workplace conditions and enforcement mechanisms.

Environmental Factors and Exposure Enhancement

Environmental conditions in Makkah appear to play an important role in increasing occupational exposure. High ambient temperatures, which may reach up to 45°C, can accelerate gasoline evaporation and increase the concentration of VOCs in the air. In addition, the observed lack of effective ventilation in many gas stations may further contribute to the accumulation of harmful pollutants, particularly during periods of low air circulation.

Another important observation was the frequent practice of vehicle engine idling during refuelling, despite the presence of warning signs. This behaviour increases both fire risk and exposure to exhaust emissions. The persistence of such practices suggests insufficient enforcement of safety regulations and limited public awareness of safety protocols. Addressing these environmental and behavioural factors is essential for reducing overall occupational risk.

CONCLUSIONS

This study highlights a significant gap in occupational hazard awareness and safety practices among gas station workers in Makkah. Despite regular exposure to chemical and physical risks, most workers demonstrated limited understanding of workplace hazards, which was reflected in inadequate use of personal protective equipment, unsafe practices and a high frequency of occupational incidents.

The findings also indicate that a considerable proportion of workers have not received adequate safety training, which may contribute to poor risk perception and unsafe behaviours. The combination of long working hours, frequent exposure to fuel vapours and insufficient protective measures places workers at increased risk of both short-term symptoms and potential long-term health effects.

From a practical perspective, two key priorities emerge. First, employers must ensure that all workers receive structured and mandatory training on occupational hazards, safe handling procedures and proper use of protective equipment. Second, regulatory authorities should strengthen monitoring and enforcement of safety standards, including compliance with PPE use and operational safety measures such as engine shut-off during refuelling.

In addition, improving workplace conditions, particularly ventilation systems and addressing environmental factors such as high temperatures and fuel vapour accumulation are essential to reduce exposure risks. Enhancing public awareness, especially among vehicle users, is also important to support safer practices within gas station environments.

Overall, protecting the health and safety of gas station workers requires coordinated efforts from employers, regulatory bodies and the wider community. Ensuring safe working conditions is not only a regulatory responsibility but also a fundamental aspect of occupational health and human well-being.

Future Recommendations

Future studies should include larger and more representative samples across different regions of Saudi Arabia to improve generalizability. Incorporating objective exposure assessments, such as air quality monitoring and biological indicators, would provide a more accurate understanding of occupational risks. In addition, future research should examine organizational and system-level factors, including employer policies, supervision and enforcement of safety regulations, as well as evaluate the effectiveness of training programs in improving worker awareness and safety practices.

Implications for Practice

The findings highlight the need for immediate action at multiple levels. Employers should ensure mandatory safety training, consistent availability of personal protective equipment and strict enforcement of safety protocols. Regulatory authorities should strengthen inspection and compliance systems across gas stations, while public health agencies can support awareness initiatives targeting both workers and the general public. Improving workplace conditions and promoting safe behaviours are essential to reduce occupational risks and protect worker health.

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the sample size was relatively small and limited to workers in Makkah, which may restrict the generalizability of the results to other regions or settings. Second, the use of a convenience sampling approach may have introduced selection bias. Third, health symptoms were self-reported and were not clinically verified, which may affect their accuracy.

In addition, the study did not include objective measurements of environmental exposure, such as air quality monitoring or biological markers, limiting the ability to quantify actual exposure levels. The quantitative analysis was descriptive only, without inferential statistical testing, which restricts deeper interpretation of associations between variables. Furthermore, the observational component, while valuable, was not based on a standardized checklist and may be subject to observer bias. These limitations should be addressed in future research to strengthen the evidence base.

Ethical Statement

Ethical approval for the study was obtained from the Scientific Research Ethics Committee at Umm Al-Qura University (Approval No. HAPO-02-K-012-2021-03-646). Participants were informed about the purpose and procedures of the study and participation was entirely voluntary. Informed consent was obtained prior to data collection.

All responses were collected anonymously and confidentiality was maintained throughout the study. The observational component was non-intrusive and conducted in the natural work environment without interfering with routine activities, posing minimal risk to participants.

Acknowledgments

The author would like to thank all the gas station workers who participated in this study for their time and cooperation. Appreciation is also extended to those who facilitated access to the study sites.

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