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The health risks associated with long-term fuel exposure on Saudi Arabian workers: Prevention strategies and best practices

Idriss Bakar M. Al-Barnawi *

Safety and Health Supervisor in Medical Services program, Yanbu, KSA.

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Abstract

Clinically, petroleum products contain harmful chemicals. The health impacts of fuel pollution have become a real environmental problem in Saudi Arabia, which largely rely on the petroleum industries. The aim of this review paper is to highlight the health risk associated with long-term exposure to fuel pollutions on the workers of Saudi Arabia, and to elaborate the prevention and protection strategies for safety practices. The review showed how the workers in Saudi Arabia (as a leading oil producer country) exposed to fuel during their work in its volatile form (volatile organic compound; VOC). This air pollution can cause adverse effect on their health (e.g., hematological disorders) as was reported in many places within Saudi Arabia. The review also reflected the needs for evaluation parameters to assess the level of exposure to these contaminants. Also, recent evidence was introduced about acute and long-term exposure to VOCs was introduced. The systemic health implications, included respiratory, immunological, hematological, dermatological, renal, reproductive, and central nervous system pathologies. The review also discusses the protection and safety strategy to promote the health status of the worker and also hammering on the personal protection devices.

Keywords: Health Risk; Fuel; Exposure; Saudi Arabia; Workers; Prevention Strategy

1. Introduction

With time, the health impacts of environmental pollution have become a grave global concern. The ever-rising urban population and increased industrialization lead to rising energy demands, lowering the quality of life. For instance, nations like Saudi Arabia, which largely rely on the petroleum industry, have witnessed a steady rise in health issues associated with long-term fuel exposure. Hassan *et al.* (2015) infers that employees in this sphere working in refueling stations, transportation, and refineries experience the adverse effects of harmful organic compounds, such as BTEX (benzene, toluene, and xylene). Ekpenyong and Asuquo (2017) state that acute and long-term exposure to gasoline compounds results in various systemic health effects, including respiratory, reproductive, dermatological, renal, hematological, and central nervous system pathologies. While national, regional, and international laws have significantly improved occupational health practices, Saudi Arabia faces critical issues caused and aggravated by the scale of petroleum operations, its ecological conditions, and the prevailing regulatory frameworks that require a multifaceted approach to enhance industrial safety and alleviate worker health outcomes.

1.1. Occupational Fuel Exposure

Saudi Arabia is among the leading oil producers nationally. While this extensive industry offers thousands of residents and immigrants stable employment opportunities and a promise of improved living standards, long-term exposure to volatile organic compounds (VOCs) causes adverse health effects. Since these workers interact with high concentrations of harmful toxins, such as benzene, xylene, ethylbenzene, and toluene, consistently, they often suffer similar and life-threatening conditions as outlined by various researchers. For instance, a case study on fuel attendants in Jeddah by

* Corresponding author: Idriss Bakar M. Al-Barnawi.

Hassan *et al*. (2015) confirmed high levels of air pollutants, with specific emphasis on VOCs, in their work environment. After thorough research, the authors established that the prevailing levels of Benzene, a well-documented carcinogenic, far exceeded the safety levels prescribed by international health organizations. Hassan *et al*. (2015) suggest a link between prolonged exposure to these contaminants to acute symptoms like headaches and dizziness. Long-term exposure that exceeds the recommended occupational limits causes long-term health issues, such as hematological disorders. These scholars' evidence significant health risks to Saudi Arabian employees working in the nation's expansive yet hazardous petroleum sector.

Further investigations have repetitively confirmed high exposure to VOC among Saudi Arabian workers and negative health implications. For instance, Heidari *et al*. (2024) assessed the situation across various petrol stations and noted inadequate ventilation solutions in most refueling stations, aggravating this problematic issue. These scholars underscore the absence of monitoring mechanisms, which are a blatant oversight of existing regulatory frameworks. On the one hand, all actors (employees, employers, and private and public agencies) know that petroleum products contain harmful chemicals. Heidari *et al*. (2024) explain that most fuel stations lack evaluation parameters to assess the level of exposure to these contaminants. On the other hand, Saudi Arabia experiences harsh climatic and geographic conditions characterized by extremely high temperatures for long periods. Inadequate ventilation systems in VOC-concentrated areas, such as refineries and gas stations, particularly in high temperatures, expose workers and residents to adverse health conditions. In another study, Khalafalla *et al*. (2023) confirmed high levels of BTEX at fueling stations in Eastern Saudi Arabia. In their findings, the authors infer that these alarming benzene levels harm employees in the petroleum sector and pose adverse ecological risks to the neighboring communities. Khalafalla *et al*. (2023) note that while legislators and international actors have recommended exhaustive occupational safety protocols, implementation often falls short, leaving employees and residents vulnerable to negative health issues. These findings highlight the significance of regulatory enforcement of practical mitigation strategies to improve air quality and foster adherence to existing safety standards.

1.2. Health Impacts of Acute and Prolonged Exposure

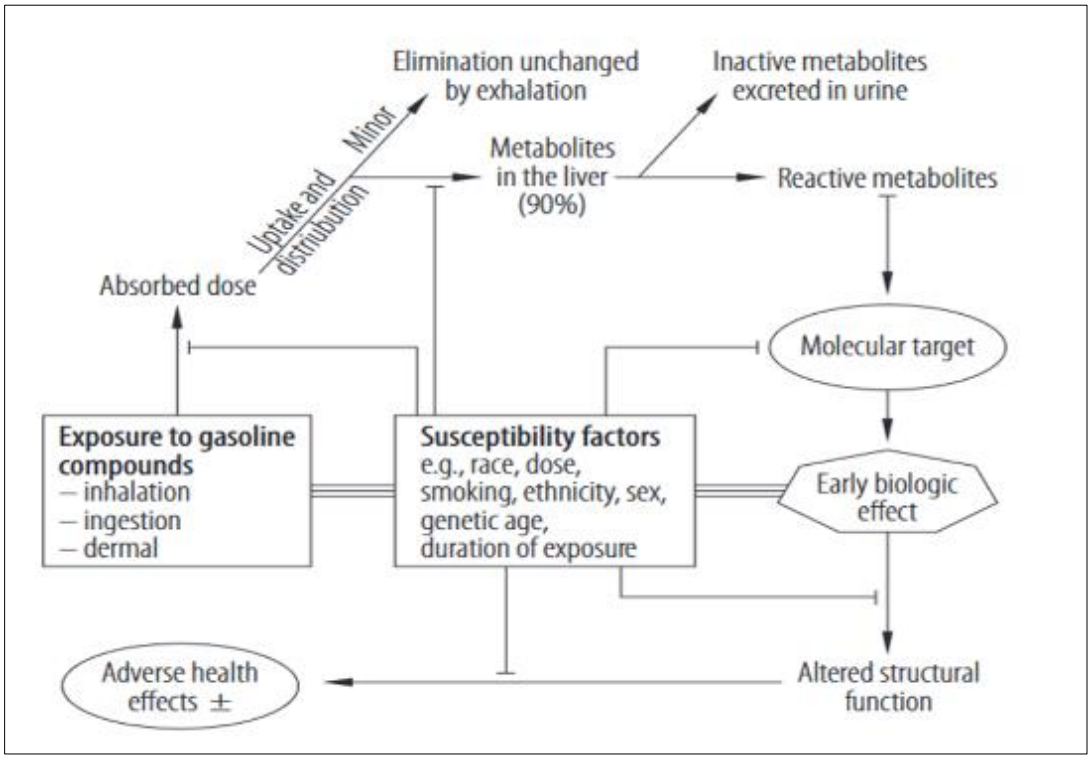

Figure 1 An Illustration of the Toxicokinetic Pathway of VOCs for Exposed Workers Sourced from: Ekpenyong and Asuquo (2017)

Gasoline or petroleum products contain multiple hydrocarbons and additives, leading to complex toxicokinetic or metabolic pathways. Ekpenyong and Asuquo (2017) note that gasoline is either ingested or inhaled before being absorbed, up-taken, and distributed in one's body. While the body process eliminates a small percentage through metabolites in urine, a high concentration of VOCs undergoes further toxicokinetic processes, including oxidative tissue

damage and generation of reactive oxygen, causing multi-system toxicity. Ekpenyong and Asuquo (2017) infer that the toxicokinetic properties (Figure 1) of various VOCs largely depend on individual susceptibility determinants, such as race, ethnicity, age, duration, genetics, and exposure concentration. Recent advances in biological assays evidence that acute and long-term exposure to VOCs results in systemic health implications, including respiratory, immunological, hematological, dermatological, renal, reproductive, and central nervous system pathologies. Workers in the expansive Saudi Arabian petroleum industry face considerable health hazards because of the elevated exposure levels exacerbated by poor climate and geographical conditions and inadequate compliance with safety standards.

1.3. Hematological Pathologies

Prolonged exposure to benzene compounds is an established cause of hematological disorders. Ekpenyong and Asuquo (2017) contend that workers in the petroleum industry suffer from bone marrow suppression, leading to adverse health outcomes, such as anemia and thrombocytopenia. Khalafalla *et al*. (2023) and Ekpenyong and Asuquo (2017) concur that benzene leads to various hematological malignancies like acute myeloid leukemia. Saudi Arabian employees in the petroleum sector are prone to severe hemotoxic effects since the above studies confirm that they work in deplorable conditions where benzene concentrations exceed occupational safety limits (WHO, 2019).

1.4. Respiratory Issues

VOC inhalation results in acute and chronic respiratory pathologies. On the one hand, employees in this industry report various pulmonary problems like coughing, wheezing, and shortness of breath after short-term exposure. On the other hand, prolonged exposure leads to chronic obstructive pulmonary disease and other inter-linked health complications. An investigation by Hassan *et al.* (2015) at Jeddah-based refueling stations confirms a correlation between exposure to VOC and a heightened prevalence of respiratory issues. Kamarehie *et al*. (2024) and Ali *et al*. (2024), reflected the same problem in Iran and Ethiopia, respectively.

1.5. Reproductive and Immunological Problems

Prolonged exposure to petroleum chemicals may impair one's reproductive organs (Adly and Saleh, 2021). Khalade *et al*. (2010) posit that benzene and toluene compounds interfere with the body's hormonal balance, lowering one's fertility, altering or hindering normal growth patterns, and adversely affecting pregnancy outcomes. While empirical evidence of this health concern is limited among Saudi Arabian workers, research by Khalade *et al*. (2010) confirms the link between high VOC exposure and increased risk for reproductive health. Moreover, chronic exposure to these toxins leads to immunosuppression, making petroleum industry workers more susceptible to infections. Khalafalla *et al*. (2023) contend that prolonged exposure to benzene lowers the body's blood cell counts, hindering their capacity to withstand and fight infections. Chronic exposure to petroleum toxins causes reproductive and immunological pathologies, necessitating urgent and comprehensive redress.

1.6. Renal, Dermatological, and Central Nervous System Issues

Specific petroleum-related compounds, such as toluene, are nephrotoxic. Prolonged occupational exposure to these toxins leads to kidney damage because of lessened renal function. With time, it increases one's susceptibility to kidney-related conditions. Khalade *et al*. (2010) hint that employees exposed to fuel fumes over long periods need routine renal function evaluation to detect and encounter toxicity. Additionally, direct skin contact with petroleum hydrocarbons irritates one's skin causing dermatitis and chemic burns (in rare and severe occurrences). Khalafalla *et al*. (2023) contend that workers who handle fuel without sufficient protective gear and equipment risk contracting severe dermatological conditions. Furthermore, workers exposed to VOCs over long periods complain of neurological symptoms, such as headaches, dizziness, and impaired cognitive capabilities. Chronic exposure could adversely affect one's central nervous system characterized by neurobehavioral and memory problems. This discussion confirms that Saudi Arabian employees in the petroleum sector are susceptible to multilayered health issues because of insufficient occupational safety standards and high levels of prolonged exposure to VOCs.

1.7. Mitigation Strategies and Best Practices for Improved Occupational Health and Safety

Evidence from various scholarly sources confirms that workers in Saudi Arabia's fuel-related industries experience chronic exposure to VOCs, such as benzene, toluene, ethylbenzene, and xylene. Private and public actors must design, implement, and reinforce strategies to mitigate exposure, foster workplace safety, and improve health outcomes through aggressive awareness and routine monitoring.

1.8. Personal Protective Equipment

The Saudi administration must popularize the uptake of personal protective equipment (PPE) among employers and employees. For example, workers in the fuel-related sector need certified respirators with enhanced organic vapor cartridges to minimize VOC inhalation. Organizations should provide staff members with protective clothing, like impermeable overall, boots, and gloves to protect their skin from adverse dermal conditions occasioned by unregulated exposure. Moreover, workers in this industry require adequate eye protection solutions, such as face shields, to protect them from irritation caused by vapor contact.

1.9. Health Monitoring

The Saudi Arabian fuel sector should improve its workplace policies to foster occupational safety. For instance, they should introduce functional worker rotation with specific shifts and incorporate training initiatives to increase employee awareness while heightening compliance. Private and public actors must introduce routine medical surveillance programs, such as hematological tests, skin analysis, and lung function evaluations, to detect adverse health effects early and promote effective interventions. Moreover, they should include biomarkers to assess different metabolites, fostering risk assessment and management (Muda *et al*., 2023). The Saudi administration should implement far-reaching environmental regulations, such as fuel reformulation, to enhance fuel purification and reduce VOC vapor. Finally, stakeholders must invest in advanced research and development efforts to explore alternative and renewable energies that will reduce reliance on fossil fuels, solving this issue exhaustively.

2. Conclusion

The above discourse demonstrates that prolonged occupational exposure to VOCs, such as benzene, toluene, ethylbenzene, and xylene, exposes workers to multiple health hazards. The Saudi Arabian fuel industry suffers from inadequate safety measures compounded by geographic and climatic factors, such as high temperatures. The public and private sectors must unite to address these challenges as they predispose employees to hematological, reproductive, dermatological, renal, and respiratory pathologies. Solving this multilayered complication requires a multi-sectoral and multi-stakeholder approach by reengineering the built environment, implementing administrative changes, and investing in research and development efforts. By enforcing these imperatives, Saudi Arabia could enhance workplace safety for petroleum industry employees, lessening the prevalence of associated health risks while improving their quality of life.

Recommendation

The Saudi Arabian petroleum sector must remodel its built environment to minimize employee exposure to VOC. For instance, companies in this landscape must modernize the ventilation systems to capture and remove fuel vapor at the source. These institutions should install functional detection systems to evaluate air quality, enabling prompt interventions to resolve exposure issues.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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