Egyptian Journal of Occupational Medicine, 2025; 49 (3) : 103 - 120

ADVERSE HEALTH EFFECTS AMONG OIL EXPOSED WORKERS IN A GAS DERIVATIVES EXTRACTION PLANT: A COMPARATIVE CROSS-SECTIONAL STUDY

By

Gaafar K, Abozaid DA, El-Hossiney DM, and Abd Elaziz KM

Department of Community, Environmental and Occupational Medicine, Faculty of Medicine, Ain Shams University, Egypt

Corresponding author: *Abozaid DA.* ***Email:*** *Denaali@med.asu.edu.eg*

DOI: *10.21608/ejom.2025.402055.1377*

Submit date: *2025-07-08* ***Revise date:*** *2025-07-24* ***Accept date:*** *2025-07-24*

Authors' contributions: *All authors contributed equally in this work.*

Abstract

Introduction: Occupational exposure to highly volatile lipid-soluble hydrocarbons has been linked with numerous health hazards such as impairment of respiratory, cardiovascular, kidney and liver functions. **Aim of Work:** To identify possible health hazards of occupational exposure to liquefied natural gas and its related emissions among workers in oil sector industry in terms of respiratory, dermatological, hematological, liver and kidney function parameters. **Materials and Methods:** A comparative cross-sectional study was conducted in a gas derivatives extraction plants in Port Said, Egypt. Participants were divided into two groups: 311 oil exposed workers and 99 non-exposed comparative groups. Data collection was done by using a well-structured interview questionnaire including socio demographic characteristics, history of any present complaints, occupational and family histories, physical examination, spirometry, laboratory investigations (CBC, ESR, CRP, ALT, AST, Creatinine, BUN). **Results:** Respiratory symptoms such as morning cough (52.4% vs. 9.1%) and productive cough (30.5% vs. 13.1%) were more frequent among the exposed group with significant reduction in spirometry measurements (FVC/PVC: 95.2% vs. 101.4%, FEV1/FVC: 83.0% vs%, 8.7%, $p < 0.001$) suggesting early obstructive and restrictive changes. Dermatological symptoms were also higher among the exposed group, including eczema (33.4% vs. 15.2%) and rash (26.4% vs. 15.2%) ($p < 0.05$). Exposed workers showed significant hematological changes, including low WBC counts (7.26 vs. 9.08 ×10^9/L), high hemoglobin (14.87 vs. 13.69 g/dL), RBC (5.47 vs. 4.75 $\times 10^{12}$/L), ESR (13.69 vs. 2 mm/hr), and CRP (2.05 vs. 1.21 mg/L) ($p < 0.001$ for all). Liver enzymes (ALT: 37.8 vs. 29.1; AST: 41.4 vs. 28.2 U/L) and blood urea (42.6 vs. 26.7 mg/dL) were significantly elevated, indicating early renal and liver stress, while no significant difference was found in serum creatinine level ($p>0.05$). **Results:** Respiratory symptoms such as morning cough (52.4% vs. 9.1%) and productive cough (30.5% vs. 13.1%) were more frequent among the exposed group with significant reduction in spirometry measurements (FVC/PVC: 95.2% vs. 101.4%, FEV1/FVC: 83.0% vs%,8.7%, p <

0.001). Dermatological symptoms were also higher among the exposed group, including eczema (33.4% vs. 15.2%) and rash (26.4% vs. 15.2%) ($p < 0.05$). Exposed workers showed significant hematological changes, including low WBC counts (7.26 vs. 9.08 ×10^9/L), high hemoglobin (14.87 vs. 13.69 g/dL), RBC (5.47 vs. 4.75 $\times 10^{12}$/L), ESR (13.69 vs. 2 mm/hr), and CRP (2.05 vs. 1.21 mg/L) ($p < 0.001$ for all). Liver enzymes (ALT: 37.8 vs. 29.1; AST: 41.4 vs. 28.2 U/L) and blood urea (42.6 vs. 26.7 mg/dL) were significantly elevated. **Conclusion and Recommendations:** Occupational exposure to liquefied natural gas and its related emissions was associated with numerous adverse health effects, including respiratory, dermatological, hematological and biochemical changes suggestive of hepatic and renal stress. Effective occupational health and safety measures are warranted to protect those workers from long-term health effects.

Keywords: Petrochemicals, Liquefied natural gas, Spirometry, liver enzymes and Renal function.

Introduction

The petrochemical industry is growing rapidly and plays a critical role in modern economies. Today, petrochemicals are consumed by many industries such as the automotive industry, aviation manufacturing and power generation, increasing the risk of work-related injury and illness. These industrial chemicals are primarily derived from petroleum and natural gas through refining processes, though they can also originate from coal or renewable sources such as maize and sugarcane, however petroleum remains the dominant feedstock (Tripathy et al., 2017).

Within the oil and gas industry, particularly in liquefied natural gas (LNG) production, workers engage in intricate technical processes that encompass both hot and cold processing stages. These processes require highly specialized facilities and expose vulnerable workers to a range of hazardous chemical substances such as polycyclic aromatic hydrocarbons, volatile organic compounds and particulate matter, in addition to thermal, noise, and ergonomic stressors (Al-Yafei et al., 2022). Exposure to such agents has been associated with various adverse health outcomes, including respiratory dysfunction, neurobehavioral changes, reproductive toxicity, hematologic and hepatic abnormalities (Golara and Sadry 2015). Several epidemiological investigations have substantiated these health effects, Neghab et al., 2015 reported early liver and kidney dysfunction among workers at Shiraz petrol stations in Iran. Sirdah et al., 2013 also found significant alteration in hematologic and biochemical markers among workers handling liquefied petroleum gas in Gaza. Moreover, a recent study conducted in Adan observed a heightened prevalence of occupational asthma, skin allergy and hypertension among oil refinery workers with prolonged occupational exposure (Darwish et al., 2020).

In Egypt, few researches explored the health risks faced by petroleum station workers; a study conducted in Sohag Governorate reported significantly elevated red blood cell counts, along with increased liver enzyme and blood urea levels in exposed individuals (Elnabi et al., 2021). Another recent study showed significant cardiac and hematologic alterations, including elevated lipid profiles and renal biomarkers like kidney injury molecule-1 (KIM-1), particularly with longer oil exposure durations (Moneim et al., 2023). Despite this growing body of evidence, Egyptian studies on the cumulative health effects of liquified natural gas (LNG) exposure remains scarce, particularly among workers in gas derivatives and petroleum processing industries. Thus, the present study seeks to bridge this gap by systematically evaluating the health risks encountered by those workers in their career.

Aim of Work:

To identify possible health hazards of occupational exposure to liquefied natural gas and its related emissions among workers in oil sector industry in terms of respiratory, dermatological, hematological, liver and kidney function parameters.

Materials and Methods

Study design: It was a comparative cross-sectional study.

Place and duration of study: The study was conducted at one of the largest gas derivatives extraction plants in Port Said, Egypt. The facility is designed for deep extraction of natural gas liquids from mixed feed gas, processing approximately 1,350 million standard cubic feet per day. The plant produces valuable derivatives such as propane, liquefied petroleum gas, butane, and condensates. The study was done during the period from October 2023 to May 2025.

Study sample:

The total workforce at the gas derivatives extraction facility comprised 420 workers, all of whom were eligible to participate in the study as part of the routine annual medical examination program. **Inclusion**

criteria: Participants with at least two years of continuous employment at the plant. **Exclusion criteria**: Rotational staffs with intermittent exposure to oil, as well as those with pre-existing dermatological, respiratory, renal or hepatic diseases diagnosed prior to employment. Following the application of these criteria, the final study sample consisted of (410) participants. They were divided into two groups based on oil exposure.

The oil exposed group: included (311) workers from engineering and processing departments who were directly involved in the production and handling of liquefied natural gas (LNG) and associated emissions. **The non-exposed group**: comprised 99 employees working in administrative and support roles (e.g., human resources, accounting, housekeeping, and cafeteria), with no direct oil exposure.

Study methods:

I-A well-structured, validated **Interview questionnaire** was developed and adopted from prior studies (Darwish et al., 2020, Elnabi et al., 2021, and Moneim et al., 2023). It was written in English and composed of five sections to collect data on:

- Socio-demographic characteristics: age, marital status, education level, and smoking
- Job characteristics: department, years of experience, working hours, and PPD usage
- Medical history: Presence of any chronic comorbidities i.e. diabetes and hypertension
- Respiratory symptoms: Assessed using the standardized English version of the *British Medical Research Council Questionnaire (BMRQ),* a validated tool for occupational respiratory epidemiology used in many previous studies (Brogger et al., 2000).
- Dermatological symptoms: Assessed using the English short version of the *Nordic Occupational Skin Questionnaire (NOSQ-2002/SHORT)* (Susitaival et al., 2003), covering various skin symptoms such as eczema, itching rash and ulcer.

II- Clinical examination:

General examination was done to all participants, followed by focused chest and dermatological assessment to confirm diagnosis of cases.

III-Laboratory investigations:

Blood samples were collected to

assess hematological parameters, renal and hepatic functions. Each participant was assigned a unique code to link laboratory results with questionnaire data. Venous blood specimens (5 mL) were withdrawn from participants into K3-EDTA tubes and serum vacutainer tubes. CBC was performed within 2–4 hours of collection using an autoanalyzer (Coulter DXH 650) and included the following main parameters: total and differentiated white blood cell (WBC) count, red blood cell (RBC) count, hemoglobin (Hb) concentration, erythrocyte sedimentation rate (ESR) and C- reactive protein (CRP). Sera obtained by centrifugation at 3000 rpm for 15 min were used for determination of AST, ALT, creatinine and urea, using the commercially available Biosystems reagent kits.

IV-Spirometry assessment:

The Spirometry test was completed using (Spir Ox PT - Meditech Spirometers) auto-calibrating device. Forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), and the ratio (FEV1/FVC), (FVC/PVC) standardized for age, gender, height, body surface area, and duration of exposure were assessed.

Consent

Participants' consent was also taken after explaining study objectives and assuring confidentiality of data.

Ethical Approval

Ethical approval was obtained from the Research Ethics Committee, Faculty of Medicine, Ain Shams University (Approval number; MS 610/2023). Institutional permission was received from the plant's medical and administrative departments.

Data Management

Each questionnaire was coded and linked to corresponding laboratory data using a unique identifier to ensure data privacy. Data was analyzed using SPSS software version 26. Quantitative variables were expressed as mean and standard deviation. Student's t-test and fisher exact test were used for comparison between groups, while qualitative variables were compared using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

Results:

Table 1: Personal and occupational characteristics of the studied workers.

Personal and characteristics	Oil exp. workers (No. = 311) Number %	Non-exp. workers (No. = 99) Number %	χ^2 test	P-value
Age (Mean ± SD)	42.23 ± 7.84	42.18 ± 7.38	0.5#	0.96
Gender (male)	311 100%	99 100%		
Marital status Married Single	 266 85.5% 45 14.5%	 85 85.9% 14 14.1%	2.3	0.165
Educational level High School Secondary School	 261 83.9% 50 16.1%	 50 50.5% 49 49.5%	45.7	**0.001***
Smoking (Yes)	31 10%	9 9.1%	0.006##	0.486
Occupational department Engineering and processing Security and QHSE Driver Cafeteria and housekeeping Admin, accounting, and HR	 288 92.5% 17 5.5% 6 1.9% 0 0% 0 0%	 0 0% 40 40.4% 8 8.1% 24 24.3% 27 27.4%	37.4	**0.001***
Work experience/ years (Mean ± SD)	16.20 ± 8.54	16.65 ± 7.60	0.46#	0.278
Daily work/ hours (Mean ± SD)	8.00 ± 0.00	9.62 ± 1.97	14.4#	**0.001***
PPE availability (Yes)	311 100%	4 4.0%	38.8	**0.001***
Wearing PPE frequently (yes)	287 92.3%	0 0.0%	41.0	**0.001***

#:t independent test ##: fisher exact test *: Statistically significant PPE: Personal Protective Equipment

Table 1 revealed that all participants were male. No statistical differences were found regarding age, marital status, smoking and years of work experience between both groups. The exposed group demonstrated significantly lower mean daily working hours compared to the non exposed group (8.00 vs. 9.62 hours, p = 0.001). Personal Protective Equipment (PPE) availability and usage were significantly higher among exposed groups.

Table 2. Distribution of respiratory symptoms and spirometry results among the studied workers.

Respiratory Symptoms	**Oil exp. workers (No. = 311) Number %**	**Non-exp. Workers (No.=99) Number %**	**χ^2 test**	**P-value**
Any respiratory symptoms in the past 6 m	163 52.4%	24 24.3%	14.268	**0.001***
Morning cough	163 52.4%	9 9.1%	16.856	**0.001***
Productive cough	95 30.5%	13 13.1%	13.581	**0.001***
Dry cough	68 21.9%	11 11.1%	9.876	**0.018***
Chronic cough (≥3 weeks)	71 22.8%	13 13.1%	9.154	**0.037***
Shortness of breath	32 10.3%	4 4.04%	2.894	0.056
Fatigue or pain while climbing stairs	31 10.0%	4 4.04%	2.356	0.066
Need to rest during walking	18 5.8%	4 4.04%	1.394	0.502
Wheezy chest	3 1%	1 1.01%	0.974	0.947
Symptoms worsen in work / improve in vacation	78 25.1%	9 9.1%	12.689	**0.001***
Spirometry Parameters	**Mean ± SD**	**Mean ± SD**	**t-test**	**P-value**
FVC/PVC (%)	95.19± 8.27	101.40± 5.67	12.34	**0.001***
FEV1/FVC (%)	83.02± 6.33	88.69 ± 2.99	10.58	**0.001***

SD: Standard Deviation, FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume in 1 second;

PVC: Predicted Vital Capacity *: Statistically significant

Table 2 revealed a significantly higher prevalence of respiratory symptoms among oil-exposed workers (52.4%) compared to non-exposed (24.3%) over the past six months ($p = 0.001$). Specific symptoms such as morning cough (52.4% vs. 9.1%), productive cough (30.5% vs. 13.1%), and dry cough (21.9% vs. 11.1%) were significantly prevalent among the exposed group (all $p = 0.001$). Also, chronic cough lasting three weeks or longer was significantly greater among the exposed group (22.8% vs. 13.1%; $p = 0.037$). Although shortness of breath and fatigue or pain while climbing stairs were more commonly reported among oil-exposed workers, these differences did not reach statistical significance ($p > 0.05$). About 25% of oil-exposed workers reported that their respiratory symptoms worsened during work and improved during vacation, compared to only 9.1% of the non-exposed group ($p = 0.001$). Regarding spirometry assessment, oil-exposed workers exhibited significantly lower mean FVC/PVC and FEV1/FVC ratios compared to control.

Table 3. Distribution of dermatological symptoms and chronic comorbidities among the studied workers.

Dermatological symptoms	**Oil exp. workers. (No.= 311) Number %**	**Non-exp. workers (No. = 99) Number %**	**χ^2 test**	**P-value**
Any dermatological symptoms in the past 6 m	104 33.4%	15 15.2%	15.4	**0.001***
skin rash	82 26.4%	15 15.2%	9.5	**0.022***
Skin Eczema (overall prevalence)	104 33.4%	15 15.2%	15.4	**0.001***
Eczema on arms	67 64.4%	10 66.7%	0.9	0.865
Eczema on legs	37 35.6%	5 33.3%	0.95	0.865
Eczema worsens with contact with chemicals	85 81.7%	15 100%	2.7	0.124
Eczema improves during work vacations |	81 77.9%	10 66.7%	3.15	0.338

Dermatological symptoms related to work	120 38.6%	15 15.2%	16.5	**0.001***
Chronic comorbidities				
Hypertension	82 26.4%	28 28.3%	1.5	0.707
Diabetes Mellitus	141 45.3.%	23 23.2%	15.3	**0.001***

*: Statistically significant

Table 3 showed that the dermatological symptoms in the past six months were significantly higher among oil-exposed workers compared to non-exposed ones (33.4% vs. 15.2%, p =0.001). Among specific symptoms, skin rash and skin eczema were more significantly higher among the exposed group compared to the non-exposed (26.4% vs.15.2%, p = 0.022 and 33.4% vs. 15.2%, p =0.001 respectively). Within the eczema subgroup, the distribution of eczema on the arms and legs was similar between both groups, with no statistically significant differences. A significantly greater proportion of exposed workers reported that their dermatological symptoms were work-related (38.6% vs. 15.2%, p = 0.001). Regarding chronic comorbidities, 53.1% of oil-exposed workers reported having chronic illness compared to 37.4% of non-exposed workers (p = 0.006). Diabetes mellitus was significantly higher among the exposed workers, while hypertension was higher among the non-exposed group with no statistically significant difference (p>0.05).

Table 4. Comparison of selected hematological parameters among the studied workers.

Parameters	**Oil exposed workers. Mean ± SD**	**Non exposed workers Mean ± SD**	**t- test**	**P-value**
WBC (×10^9/L)	7.26 ± 2.23	9.08 ± 0.90	-12.2	**0.001***
Eosinophils (%)	4.44 ± 2.55	1.76 ± .81	10.2	**0.001***
Basophils (%)	0.32 ± .47	0.61 ± .652	-4.7	**0.002***
Neutrophils (%)	36.76 ± 11.79	31.13±7.29	4.5	**0.001***

ESR (mm/hr)	13.69 ± 8.04	2.75 ± 1.25	13.5	**0.001***
CRP (mg/L)	2.05 ± 1.78	1.21 ± .646	4.6	**0.001***
Hb (g/dL)	14.87 ± 1.74	13.69 ± 1.54	12.7	**0.001***
RBCs (×10^{12}/L)	5.47 ± 0.57	4.75 ± 0.52	5.35	**0.001***

* : Statistically significant at p<0.01 ESR: Erythrocyte Sedimentation Rate CRP:C-Reactive Protein

Table 3 showed a comparison of selected hematological parameters among both studied groups. Mean WBC count was significantly lower among the oil exposed group compared to non-exposed, with a highly significant p-value (p =0.001). Eosinophil and Neutrophil counts were significantly higher in the exposed group, while basophil counts were significantly lower. Inflammatory markers, including ESR and CRP, showed significant elevation among the exposed group. Additionally, oil exposed workers had significantly higher hemoglobin levels (Hb) and red blood cells (RBC) counts compared to the non-exposed group (p =0.001 for both).

Table 5. Comparison of kidney functions and liver enzymes activity among the studied workers.

Parameter	Oil exposed workers Mean ± SD	Non exposed Mean ± SD	t- test	P-value
Kidney functions				
Blood urea	42.60 ± 20.62	26.71 ± 5.021	7.59	**0.001****
Serum creatinine	1.15 ± .382	1.03 ± .382	1.12	0.332
Liver enzymes				
ALT	37.83 ± 11.22	29.07 ± 2.26	7.71	**0.001****
AST	41.41 ± 15.02	28.18 ± 2.59	8.71	**0.001****

SD = standard deviation; AST = Aspartate aminotransferase, ALT= Alanine aminotransferase

**: Highly statistically significant at p<0.01

Regarding renal function test and liver enzyme activity illustrated in table 5, blood urea level was significantly higher among the oil exposed group compared to the non-exposed (p = 0.001). While there is no statistically significant difference observed in serum creatinine levels between both groups (p = 0.332). Both ALT and AST levels were significantly elevated among the exposed group (p =0.001 for both), indicating altered liver enzyme profiles.

Discussion

Workers in the oil and gas industry are routinely exposed to hazardous substances that have been linked to a wide range of acute and chronic health effects, particularly affecting the respiratory, dermatological, hepatic, and renal systems. The current study aimed to assess the potential health hazards of occupational exposure to liquefied natural gas and its related emissions among workers in a Gas Derivatives Extraction plant in Egypt. The mean age was almost the same in both exposed and non-exposed groups with no significant difference between them (42.23 vs. 42.18, P>0.05), (Table 1). This supported the effectiveness of the comparable process done as age was considered to be potential confounding variables in evaluating exposure-related health impacts. The exposed group demonstrated significantly lower mean daily working hours compared to the non-exposed group (8.00 vs. 9.62 hours, p = 0.001) (Table 1). This is due to the facility's policy aimed at minimizing occupational exposure by limiting the working hours of exposed employees. Personal Protective Equipment (PPE) availability and usage were significantly higher among exposed groups (Table 1) reflecting occupational safety protocols measures in the oil sector. In addition, exposed workers were exclusively employed in high-risk operational areas such as engineering and processing, while the non-exposed group was largely employed in administrative and support roles (e.g., housekeeping, cafeteria, HR, and accounting).

The studied oil exposed participants exhibited significantly higher incidences of respiratory and dermatological symptoms, elevated inflammatory markers, altered hematological profiles, and disruptions in hepatic and renal parameters.

Study results revealed a significantly higher prevalence of respiratory symptoms, including morning cough, productive cough, dry cough, and chronic cough among oil-exposed workers (Table 2). This finding can be attributed to prolonged inhalation of petrochemical emissions, including volatile organic compounds (VOCs) and particulate matter, which are known to irritate the respiratory tract, trigger inflammation, and contribute to the development of chronic bronchitis-like symptoms. This was comparable with other studies involving hydrocarbons-exposed populations. A study was done among 80 subjects employed in the coking unit of an oil refinery in Italy showed higher percentages of cough (33.7%), and runny nose (36.2%) among exposed individuals (Minov et al., 2010). Also, Anigilaje et al., 2024 and Alves et al., 2017 reported an increased prevalence of chronic bronchitis, rhinitis and reduced pulmonary function in petrol station workers. Furthermore, Kaur-Sidhu et al., 2019, reported increased prevalence of respiratory symptoms including phlegm (25.7%) and cough (54%) among rural women exposed to liquefied petroleum gas and solid biomass fuel emissions.

Also dyspnea and exertion symptoms were more prevalent among exposed studied participants compared to non-exposed, however the differences did not reach statistical significance ($p>0.05$) .Nonetheless, the clinical relevance of these symptoms should not be ignored, particularly given that over a quarter of the oil-exposed workers (25.1%) reported symptom exacerbation during work and relief during vacations (Table 2). This pattern supported the hypothesis of occupational causality and aligned with the findings detected by Darwish et al.,2020 who reported that 10% of Egyptian petroleum refinery workers were suffering from fatigue, nasal irritation and breathing difficulties during the working hours and noted resolution during periods of exposure cessation.

The spirometry results found in the present work further supported the clinical findings, both FEV1/FVC and FVC/PVC ratios were significantly lower among the exposed group, indicating a possible early obstructive or restrictive ventilatory defect (Table 2). Although mean values remained within the normal range, the downward trend in lung function parameters suggests subclinical impairment that may progress with prolonged exposure. Paralleling with the results of Ismail et al., 2023 who reported reduced lung function among Nigerian liquefied petroleum gas workers. In addition, reduction in spirometry values was recorded by Gam et al., 2018, among workers with high potential exposure to burning oil.

There was a significantly higher prevalence of dermatological symptoms among the studied oil-exposed workers compared to non-exposed, specifically skin rash (26.4% vs. 15.2%) and eczema (33.4% vs. 15.2%) as illustrated in Table 3. Crude oil and many of its components have been shown to irritate the skin, disrupt its barrier and activate innate immune response, resulting in the release of proinflammatory cytokines and localized inflammation (Milam et al., 2020). This finding aligned with Darwish et al., 2020 who stated that 26.9% of oil refinery workers experienced skin symptoms due to repeated dermal contact with irritants like oil derivatives and detergents. Similarly, a recent study investigated skin conditions associated with dermal exposure to oil spill chemicals among Deepwater Horizon disaster cleanup workers, reported increased prevalence ratios for dermatitis and eczema among them (Chen et al., 2025). In addition, Jabbar and Ali, 2020 observed similar dermatological symptoms among petrol station workers in Basra city, Iraq. Interestingly, our finding showed that 81.7% of exposed workers reported eczema worsening with chemical exposure and 77.9% found improvement during work vacation, which suggests the occupational nature of these conditions (Table 3).

There was a significant effect of oil exposure on hematological parameters among the studied exposed workers. The total WBC count significantly decreased compared to non-exposed group (Table 4), this could be due to bone marrow suppression or altered immune function linked to prolonged hydrocarbon exposure. Similar results were reported by Qafisheh et al., 2021from Sudan, while Emenike et al 2015from Edo state, Nigeria, found significant elevation in WBC count among exposed individuals, Etura et al., 2022 from Calabar Metropolis, Nigeria, reported no significant changes. These discrepancies in results highlighted the complexity of interpreting the immune-toxic effects of petroleum exposure, suggesting that other factors such as individual susceptibility and exposure duration could alter the results. Furthermore, the significant elevation in Eosinophil, Neutrophil, ESR and CRP levels among the exposed groups indicated a chronic inflammatory response due to oil exposure. Likely, Jabbar and Ali, 2020, reported increased inflammatory markers and altered leukocyte profiles among petroleum workers.

There was a significant elevation in hemoglobin concentration and red blood cells among the studied exposed group (Table 4). This unexpected finding might represent a compensatory response to subclinical hypoxia, possibly due to long-term inhalation of volatile hydrocarbon affecting pulmonary function. Similar findings were reported by Salem et al., 2022 on individuals exposed to carbon-rich compounds, where increased erythropoiesis was proposed as an adaptive mechanism. Getu et al., 2020 also, reported significant increase in the mean Hb level in petrol filling Ethiopian workers. However, Badejo et al.,2025 found that individuals exposed to petroleum products in Abuja, Nigeria, had significantly lower RBC count and Hg values, and higher prevalence of anemia. While, in Ibadan, another city in Nigeria, Akintomiwa et al. 2005 reported no significant difference in the RBCs counts. These discrepancies in the literature might be attributed to variations in sample sizes, doses and length of exposure to oil products.

There was a significant elevation in ALT and AST levels among the studied exposed workers compared to non-exposed (Table 5) suggesting early hepatocellular injury, this increase could be due to hepatic metabolism of hydrocarbons and the resultant generation of reactive metabolites. Similar findings were earlier reported by Isamil et al., 2023 and Sirdah et al., 2013. Furthermore, Hu et al,.2010 found that long-term exposure to coke oven emissions increased the risk of liver dysfunction. However. Obodo et al.,2020 reported no significant changes in liver function among petrol workers. As regards kidney functions, present findings showed significant elevation in blood urea levels among the studied exposed workers indicating early signs of renal stress or impaired renal clearance. Inductions of oxidative stress, immune system dysfunction, and inflammation have been implicated in the pathogenesis of hydrocarbon induced renal function impairment (Azeez et al., 2013). While serum creatinine levels did not differ significantly, this may be due to its limited sensitivity as a standalone marker for detecting early nephrotoxicity. Similar findings were reported by Elnabi et al., 2021 from Egypt, while Awadalla et al., 2017 fro Sudan found significantly higher creatinine values among oil exposed workers.

The higher prevalence of diabetes mellitus among the studied exposed workers (45.3% vs. 23.2%) (Table 3) was surprising and supported a growing body of evidence linking long-term hydrocarbon exposure to endocrine disruptions, as some volatile organic compounds have been identified as endocrine disruptors, potentially interfering with insulin signaling pathways and glucose metabolism (Lee et al., 2017). Similarly, Jardel et al., 2022 reported an increased risk of diabetes among oil spills cleanup workers. While current results found no significant difference in hypertension prevalence between both groups, Lee et al., 2020 stated that oil spill exposed workers were at increased risk for longer-term cardiovascular outcomes including hypertension, palpitations, and self-reported myocardial infarction.

Conclusion

Workers exposed to liquefied natural gas and its related emissions in the present study were at risk of several adverse health outcomes including respiratory, dermatological, hematological and biochemical changes suggesting early hepatic and renal stress.

Recommendations

The study findings emphasize the urgent need for targeted occupational health interventions, including regular medical surveillance for early detection of adverse health effects. Periodic environmental monitoring is also recommended to quantify exposure level and guide control measures. Lastly, workers educational programs should be implemented to promote proper use of personal protective equipment and encourage early symptom reporting

Study limitations

The cross-sectional design limits the ability to establish causality. The absence of objective environmental exposure assessment and incomplete adjustment for confounders (e.g. smoking, comorbidities) may impact the validity of associations. Longitudinal studies are warranted to confirm these findings and evaluate long-term outcomes, including carcinogenic and neurobehavioral effects.

Conflict of Interest

None declared.

Funding

No funding was received for this study.

Acknowledgment

The authors would like to thank all participants and staff of the petrochemical company for their

cooperation and support during the study.

References

1. Akintomiwa A, Ojo B, and Sofola O (2005): Effect of chronic exposure to petroleum products on some hematological and biochemical parameters. NQJHM; 15 (2):77–82.
2. Akpan E, Moffat I, and Abara U (2021): Analytical data on respiratory symptoms and pulmonary impairments due to exposure to non-combusted liquefied petroleum gas. Data Brief; 36:107106. DOI: 10.1016/j.dib.2021.107106
3. Alves LP, Vieira DS, Nunes LS, Cruz LP and Cruz P (2017): Relationship between Symptoms, Use of PPE and Habits Related to Occupational Exposure to BTEX Compounds in Workers of Gas Stations in Bahia, Brazil. J Environ Prot; 8 (5). DOI: 10.4236/jep.2017.85042
4. Al-Yafei H, Al Nouss A, Aseel S, Kucukvar M, Onat NC et al. (2022): How sustainable is the natural gas supply chain liquefied? An integrated life cycle sustainability assessment model. Energy Convers Manag; 15: 100246. DOI: 10.1016/j.ecmx.2022.100246
5. Anigilaje EA, Nasir ZE and Walton C (2024): Exposure to benzene, toluene, ethylbenzene, and xylene (BTEX) at Nigeria's petrol stations: a review of current status, challenges and future directions. Front Public Health; 25 (12): 129.
6. Awadalla A, Ahmed N, and Yagoob A (2017): The effects of Petroleum Products on Renal Function among Petroleum Workers Stations in EL-Obied City. EJPMR; 4(10): 395-9.
7. Azeez OM, Akhigbe RE and Anigbogu CN (2013). Oxidative status in rat kidney exposed to petroleum hydrocarbons. J Nat Sci Biol Med; 4(1):149-54. DOI: 10.4103/0976-9668.107280. PMID: 23633852; PMCID: PMC3633267.
8. Badejo DA, Dele-Ochei PE, Akhaumere EO, Odionyenma UC, Oyakhire F et al. (2025): Hematological profile of workers occupationally and environmentally exposed to petroleum products in Abuja. Environ Health;17(3): 213–2
9. Benson C, Dimopoulos C, Argyropoulos D, and Boustras G (2021): Assessing the common occupational health hazards and their health risks among oil and gas workers. Safety Science; 4 (1):140. DOI: 10.1016/j.ssci.2021.105284
10. Brogger JC, Bakke PS and Gulsvik A (2000): Comparison of respiratory symptoms questionnaires. Int J Tuberc Lung Dis; 4(1): 83-90.
11. Chaiklieng S (2021): Risk assessment of workers' exposure to BTEX and hazardous area classification at gasoline station. PloS One: 16(4). DOI: 10.1371/journal.pone.0249913
12. Chen D, Lawrence KG, Stewart PA, Gorman Ng, Stenzel MR et al. (2025): Skin conditions associated with dermal exposure to oil spill chemicals among Deepwater Horizon disaster response and cleanup workers. Ecotoxicol Environ Saf; 294:1180
13. Chen D, Lawrence KJ, Pratt GC, Stenzel M, Stewart PA et al. (2022): Fine Particulate Matter and Lung Function among Burning-Exposed Deepwater Horizon Oil Spill Workers Environ. Health Perspect; 130 (2). DOI:10.1289/EHP8930
14. Darwish M, Zayet H, Alhaj M, and Elghazally S (2020): Health Hazards and some Correlates among oil refinery Workers. Egypt J Occup Med; 43(3); 761-76.
15. Elnabi M, Mohamed S, Abo-El Wafa H, Khalaf H, and Allam W (2021): Assessment of hematological parameters, liver and kidney functions among fuel station workers in Sohag governorate, Egypt. Ain Shams J Forensic Med Clin Toxicol; 37(2): 57-66.
16. Emelike OF, Okhuakhua OJ, Momodu MM, Ogunsuyi OE, and Ezimah ACU (2015): Some Hematological Parameters of Petrol Attendants and Automobile Mechanics in Ekpoma, Edo State, Nigeria. Sch J Appl Med Sci; 3: 1400-3.
17. Etura JE, Onwukwe OD, Asemota EA, Akpan UO and Emeribe AO (2022): Some Hematological Parameters of Fuel Pump

Attendants in Calabar Metropolis. Afr J Lab Haematol Transfus Sci; 1(1): 54-61.
18. Golara M and Sadry SS (2015). Employees' occupational diseases: Reference to oil and gas companies. Ind J Fundam Appl Life Sci; 5(S1): 4317–22.
19. Gam KB, Kwok RK, Engel LS, Curry MD, Stewart PA et al. (2018): Lung Function in Oil Spill Response Workers 1–3 years After the Deepwater Horizon Disaster. Epidemiology; 29 (3):315-22.
20. Getu S, Shiferaw E, and Melku M (2020): Assessment of hematological parameters of petrol filling workers at petrol stations in Gondar town, Northwest Ethiopia: a comparative cross-sectional study. Environ Health Prev Med; 25(1):44. DOI:10.1186/s12199-020-00886
21. Hu Y, Chen B, Qian J, Jin L, Jin T et al. (2010): Occupational coke oven emissions exposure and risk of abnormal liver function: modifications of body mass index and hepatitis virus infection. Occup Environ Med; 67(3): 159–65.
22. Ismail AU, Ibrahim SA, Gambo MD, Muhammad RF, Badamasi MM et al. (2023): Impact of differential occupational LPG exposure on cardiopulmonary indices, liver function and oxidative stress in Northwestern city of Nigeria. Sci Total Environ; 862: 16088. DOI: 10.1016/j.scitotenv.2022.160881
23. Jabbar SA and Ali ET (2020): Impact of Petroleum Exposure on Some Hematological Indices, Interleukin-6, and Inflammatory Markers of Workers at Petroleum Stations in Basra City. J Environ Public Health; 7693891. DOI:10.1155/2020/7693891
24. Jardel HV, Engel LS, Lawrence KG, Stewart PA, Stenzel MR et al. (2022): The association between oil spill cleanup-related total hydrocarbon exposure and diabetes. Environ Res; 212(Pt E):113591. DOI: 10.1016/j.envres.2022.113591
25. Kaur-Sidhu M, Ravindra K, Mor S, John S, and Aggarwal AN (2019). Respiratory Health Status of Rural Women Exposed to Liquefied Petroleum Gas and Solid Biomass Fuel Emissions. Air Soil Water Res; 12. DOI:10.1177/1178622119874314
26. Lee S, Hong S, Liu X, Kim C, Jung D et al. (2017): Endocrine disrupting potential of PAHs and their alkylated analogues associated with oil spills. Environ Sci Process Impacts ; 19(9):1117–25.
27. Lee M, Park MS, and Cheong HK (2020): An association between oil spill clean-up work and cardiovascular disease. Ecotoxicol Environ Saf;194: 110284
28. Milam EC, Nassau S, Banta E, Fonacier L, and Cohen DE (2020): Occupational Contact Dermatitis: An Update. J Allergy Clin Immunol Pract;8(10):3283-93.
29. Minov J, Bislimovska J, Vasilevska K, Trajceva L, Risteska-Kuc S, et al. (2010): Respiratory and nasal symptoms, immunological changes and lung function among petroleum refinery workers. Med Lav;101(5):364-74.
30. Moneim WA, Hady RA, George S, and Hafiz W (2023): The Potential Biochemical and Clinical Hazards in some Petroleum Station Workers. Zagazig J Forensic Med Toxicol; 21(1): 92-109. DOI: 10.21608/zjfm.2022.156840.1122
31. Neghab M, Hosseinzadeh K, and Hassanzadeh J (2015): Early Liver and Kidney Dysfunction Associated with Occupational Exposure to Sub-Threshold Limit Value Levels of Benzene, Toluene, and Xylenes in Unleaded Petrol. Saf Health Work; 6(4):312-16.
32. Qafisheh N, Mohamed OH, Elhassan A, Ibrahim A, and Hamdan M (2021): Effects of the occupational exposure on health status among petroleum station workers, Khartoum State, Sudan. Toxicol Rep; 8:171-6. DOI: 10.1016/j.toxrep.2020.12.025.
33. Obodo BN, Iyevhobu KO, Idara IU, Okobi TJ, Abayomi SA et al. (2020): Effects of duration of exposure on biochemical and hematological profile in liquefied petroleum gas (LPG) plant workers. Int J Res Publ; 58(1):1-8.

DOI:10.47119/IJRP100581820201352

34. Rushton L, Schnatter AR, Tang G, and Glass DC (2014): Acute myeloid and chronic lymphoid leukemias and exposure to low-level benzene among petroleum workers. Br J Cancer; 110:783–7. DOI: 10.1038/bjc.2013.780.
35. Salem GM, Shaboun S, Algamodei YM, Almalyan MF, Althwadi EM et al. (2022): Effect of occupational exposure on hematological and biochemical parameters in workers at oil and gas companies. Mediterr J Pharm Sci; 2(1):95-102. DOI:10.5281/zenodo.6399948.
36. Sirdah MM, Al Laham NA, and El Madhoun RA (2013): Possible health effects of liquefied petroleum gas on workers at filling and distribution stations of Gaza governorates. East Mediterr Health J; 19(3):289-94.
37. Susitaival P, Flyvholm MA, Meding B, Kanerva Let al. (2003): Nordic Occupational Skin Questionnaire (NOSQ-2002): a new tool for surveying occupational skin diseases and exposure. Contact Dermatitis; 49(2): 70-76. DOI:10.1111/j.0105-1873.2003. 00159
38. Tripathy DB, Yadav A and Mishra A (2017): Applications of petrochemicals: A mini review. Recent Adv Petrochem Sci; 2 (4). DOI: 10.19080/rapsci.2017.02.555594