

**ASSESSING THE HEALTH EFFECTS OF OCCUPATIONAL PETROL VAPOUR
EXPOSURE AMONG PETROL PUMP ATTENDANTS IN NIGERIA: A SYSTEMATIC
REVIEW**

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Word Count: 6,564

ABSTRACT

Background: *Petrol pump attendants experience repeated occupational exposure to petrol vapours containing benzene, toluene, ethylbenzene and xylene (BTEX), which have been associated with respiratory, neurological and haematological effects. However, existing evidence remains geographically dispersed and methodologically heterogeneous, limiting clear conclusions regarding the health consequences of occupational exposure.*

Objective: *This systematic review aimed to synthesise and critically appraise evidence on the health effects of occupational petrol vapour exposure among petrol pump attendants in Nigeria and comparable settings.*

Methods: *PubMed, Scopus, Web of Science and Google Scholar were searched for eligible studies. Studies examining occupational petrol vapour or BTEX exposure and relevant health outcomes among petrol station workers were included. Data were extracted systematically, methodological quality was assessed using Joanna Briggs Institute appraisal tools, and findings were synthesised narratively because of heterogeneity in study designs, exposure assessment and outcome measures.*

Results: *Of 1,274 identified records, 21 studies were included. Twelve studies were rated high quality, seven moderate quality and two low quality. Respiratory effects were most consistently reported, including reduced FEV₁, FVC and PEF and symptoms such as cough, wheezing and breathlessness. Headache, dizziness and fatigue were common neurological outcomes, while several studies reported haematological alterations. Evidence also identified inconsistent PPE use and limited occupational health surveillance.*

Conclusion: *Occupational petrol vapour exposure represents an important environmental and occupational health concern. However, predominantly cross-sectional evidence and inconsistent exposure and outcome measurement limit causal conclusions. Stronger exposure controls, surveillance and longitudinal research are required.*

Keywords: *Petrol vapour; BTEX; benzene; petrol pump attendants; occupational exposure; health effects; Nigeria; systematic review.*

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor for their guidance, constructive feedback and support throughout the completion of this dissertation. I am also grateful to the academic staff of the University for the knowledge and support provided during my studies. Finally, I would like to thank my family and friends for their encouragement and support throughout this research.

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LIST OF ABBREVIATIONS

Abbreviation	Full Meaning
ALT	Alanine Aminotransferase
AST	Aspartate Aminotransferase
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
FEV ₁	Forced Expiratory Volume in One Second
FVC	Forced Vital Capacity
IARC	International Agency for Research on Cancer
JB	Joanna Briggs Institute
MeSH	Medical Subject Headings
PEFR	Peak Expiratory Flow Rate
PPE	Personal Protective Equipment
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
tt-MA	trans,trans-Muconic Acid
VOCs	Volatile Organic Compounds
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Occupational exposure refers to contact with physical, chemical, biological, or environmental hazards encountered during the course of work that may adversely affect health over time (Betancur et al., 2024). Petrol vapour exposure remains a significant concern, particularly for petrol filling-station workers.. Petrol vapour is a complex mixture of volatile organic compounds (VOCs), including benzene, toluene, ethylbenzene, and xylene (BTEX), which are released during fuel storage, transportation, and dispensing activities. These compounds are recognised for their potential adverse effects on human health, particularly following prolonged exposure (Anigilaje, Nasir and Walton, 2024).

From an environmental health perspective, petrol vapour exposure is important because it affects both environmental quality and occupational wellbeing. Among the BTEX compounds, benzene is considered the most hazardous. The World Health Organization (WHO, 2022) classifies benzene as a human carcinogen, while the International Agency for Research on Cancer (IARC) categorises it as a Group 1 carcinogen due to its established association with haematological disorders and leukaemia. Exposure to BTEX compounds has also been linked to respiratory impairment, neurological symptoms, and blood abnormalities, making petrol vapour a significant public health concern (Saeedi, Malekmohammadi and Tajalli, 2024).

Petrol pump attendants are particularly vulnerable because of repeated exposure through inhalation and dermal contact. In Nigeria, where petrol remains a major source of transportation fuel, attendants often work extended shifts in environments characterised by limited ventilation and inconsistent use of personal protective equipment. Although occupational exposure to petrol vapour is recognised globally as a significant health concern, the extent of risk is influenced by contextual factors including workplace safety culture, regulatory enforcement, environmental monitoring, and access to protective equipment. Consequently, workers in developing countries may face disproportionately higher exposure risks than those in more regulated occupational environments. This highlights the need for greater attention to occupational health in Nigeria.

1.2 Problem Statement

Occupational exposure to petrol vapour remains an important environmental and occupational health concern among petrol pump attendants in Nigeria. Petrol station workers may experience repeated exposure to benzene, toluene, ethylbenzene and xylene (BTEX) during fuel dispensing, with exposure occurring through inhalation, dermal contact and, in some circumstances, poor workplace hygiene practices. Evidence reviewed by Anigilaje, Nasir and Walton (2024) indicates that some Nigerian petrol station workers undertake extended working hours of approximately 10 hours per day or more than 12 hours, potentially increasing cumulative exposure.

The scale of occupational health concerns is also reflected in reported symptoms and workplace practices. For example, 53.6% of petrol station attendants in Uyo reported headaches, while only 7.0% reported using personal protective equipment (PPE) and just 4.2% had ever undergone pre- or post-employment medical examination (Johnson and Etokidem, 2019). In another Nigerian study, petrol-fume inhalation and headaches were each reported by 22.4% of participants. PPE utilisation across Nigerian studies ranged from 7% to 89.4%, indicating considerable inconsistency in occupational protection (Adekunle, Alex and Adebayo, 2023).

These findings are concerning because benzene is a recognised human carcinogen and prolonged BTEX exposure has been associated with respiratory, neurological and systemic health effects (Saeedi, Malekmohammadi and Tajalli, 2024). Consequently, the continuing exposure of petrol pump attendants, combined with inconsistent protective practices and limited occupational health surveillance, represents a significant environmental health problem requiring systematic evaluation.

1.3 Research Gap

Although numerous studies have investigated the health effects of occupational petrol vapour exposure, the available evidence remains fragmented and methodologically diverse. Existing research has been conducted across different geographical contexts, including India, Ghana, South Africa, and Nigeria, with considerable variation in study design, exposure assessment methods, sample characteristics, and outcome measures. As a result, findings relating to respiratory, neurological, and haematological effects are often difficult to compare directly. Furthermore, relatively few studies have focused specifically on the Nigerian context, despite the country's extensive reliance on petrol and large population of filling station workers. While individual studies provide important insights into specific health outcomes, there remains limited synthesis of the evidence as a whole. Consequently, the overall strength, consistency, and applicability of current findings to occupational health practice and policy in Nigeria remain unclear. A systematic review is therefore necessary to critically evaluate and consolidate existing evidence, identify methodological limitations, and establish priorities for future environmental health research.

1.4 Aim and Objectives

Aim

To systematically synthesise and critically appraise existing evidence on the health effects of occupational petrol vapour exposure among petrol pump attendants in Nigeria and comparable settings.

Objectives

1. To identify and categorise reported short-term and long-term health outcomes associated with occupational petrol vapour exposure.
2. To examine patterns of exposure measurement and symptom reporting across included studies.
3. To critically evaluate the methodological quality and risk of bias within the existing evidence base.
4. To identify research gaps and implications for environmental health policy and occupational regulation.

1.5 Significance of the Study

This study is significant because it seeks to address an important environmental and occupational health issue affecting petrol pump attendants, a workforce that may be exposed to hazardous petrol vapours on a daily basis. By systematically synthesising evidence from existing studies, the review will contribute to knowledge by consolidating fragmented findings and providing a clearer understanding of the respiratory, neurological, and haematological effects associated with occupational petrol vapour exposure.

The study also has practical relevance for Environmental Health practitioners and occupational health professionals by supporting evidence-based risk assessment and workplace health interventions. Furthermore, the findings may assist policymakers and regulatory agencies in developing or strengthening occupational health policies, exposure monitoring strategies, and worker protection measures within the petrol retail sector. By synthesising evidence across multiple studies, this review may provide a more robust basis for occupational health interventions than individual studies alone. Additionally, identifying methodological weaknesses and research gaps within the existing literature may help guide future research priorities and improve the quality of evidence available for occupational health decision-making and regulatory planning.

CHAPTER TWO

LITERATURE REVIEW

2.1 Occupational Exposure to Petrol Vapour

Occupational Exposure Theory suggests that adverse health outcomes are influenced by the nature, frequency, duration and intensity of workplace exposure. Petrol pump attendants are repeatedly exposed to volatile organic compounds (VOCs), particularly benzene, toluene, ethylbenzene and xylene (BTEX), during fuel dispensing, tanker unloading, storage and spillages. These repeated occupational exposures have been associated with adverse health effects (Anigilaje, Nasir and Walton, 2024).

The Exposure Pathway Model explains how contaminants move from a source to an exposed receptor (McKone et al., 2000). For petrol attendants, inhalation is the principal exposure route because workers remain close to fuel pumps during dispensing, while dermal exposure may occur through fuel contact, handling nozzles or spillages (Anderson and Meade, 2014). Although individual exposures may be relatively brief, repeated daily exposure can increase cumulative occupational risk.

Exposure intensity is also shaped by working conditions. Petrol attendants in Nigeria may work 8–12-hour shifts for six or seven days weekly, increasing opportunities for repeated exposure (Chijioke, 2020). The Environmental Health Risk Assessment Framework emphasises that risk depends on both the hazardous properties of a substance and the magnitude and duration of exposure (Krewski, 2022). This is particularly relevant to benzene, a recognised human carcinogen, for which occupational exposure limits have been established internationally. Both the UK Health and Safety Executive (HSE) and the US Occupational Safety and Health Administration (OSHA) recommend an eight-hour workplace exposure limit of 1 ppm.

Occupational exposure is not uniform across settings because ventilation, dispensing technology, safety culture, PPE availability and regulatory enforcement influence exposure levels. Anigilaje, Nasir and Walton (2024) reported that BTEX concentrations around some Nigerian petrol stations exceeded recommended occupational thresholds. Therefore, evidence from highly regulated settings may not be directly transferable to Nigeria because differences in infrastructure and monitoring can produce different exposure profiles and risks.

2.2 Chemical Composition of Petrol Vapour and Toxicological Mechanisms

Petrol vapour contains volatile organic compounds, particularly benzene, toluene, ethylbenzene and xylene (BTEX), which are released during fuel dispensing, storage, transportation and evaporation (Anigilaje, Nasir and Walton, 2024). The Toxicological Dose–Response Theory proposes that the severity of adverse effects is influenced by exposure magnitude and duration, meaning that repeated exposure may produce cumulative biological effects over time (Tsatsakis et al., 2018).

Benzene receives particular attention because of its carcinogenicity. IARC (2018) classifies benzene as a Group 1 carcinogen, while WHO (2022) identifies it as an important public health concern. Following inhalation, benzene is metabolised into toxic compounds that can affect bone marrow and disrupt normal blood-cell production, contributing to haematological abnormalities and increased leukaemia risk (Saeedi, Malekmohammadi and Tajalli, 2024).

Although generally less carcinogenic than benzene, toluene, ethylbenzene and xylene remain occupational contaminants of concern. Toluene has been associated with neurological symptoms including headache, dizziness, fatigue and cognitive impairment, while ethylbenzene and xylene have been linked to respiratory and neurological effects (Saeedi, Malekmohammadi and Tajalli, 2024). Exposure occurs mainly through inhalation, although dermal absorption is also possible.

Evidence from Nigerian filling stations indicates elevated occupational BTEX concentrations during routine work activities (Anigilaje, Nasir and Walton, 2024). However, focusing predominantly on benzene may underestimate the broader toxicological burden. Cumulative exposure to multiple BTEX compounds may produce combined effects that remain insufficiently understood, supporting the need to consider mixed-chemical exposure rather than benzene in isolation.

2.3 Respiratory Health Effects

Respiratory impairment is one of the most frequently reported outcomes of occupational petrol-vapour exposure. The Environmental Exposure–Disease Model proposes that repeated exposure to airborne contaminants can produce pathological respiratory changes (Wallbanks et al., 2024). Petrol attendants experience repeated inhalation of BTEX during fuel dispensing, potentially

contributing to airway irritation, inflammation and impaired pulmonary function (Anigilaje, Nasir and Walton, 2024).

Pulmonary-function testing provides objective evidence of respiratory impairment, with FEV₁ and FVC widely used indicators of respiratory function (Ponce, Sharma and Sankari, 2023). Moghadam et al. (2019) found that petrol-exposed workers generally had lower FEV₁ and FVC than control groups, supporting an association between occupational exposure and impaired pulmonary function.

BTEX exposure may contribute to respiratory injury through oxidative stress and inflammatory responses (Zhou et al., 2025). However, the magnitude of reported pulmonary impairment varies between studies, potentially reflecting differences in exposure assessment, employment duration, workplace ventilation, smoking adjustment, sample size and environmental conditions.

Most available studies are cross-sectional, limiting causal inference. Therefore, although the evidence supports an association between occupational petrol-vapour exposure and respiratory dysfunction, longitudinal research is required to establish whether chronic exposure contributes to progressive disease. Nevertheless, the consistency of reported symptoms and pulmonary-function deficits indicates an important occupational respiratory-health concern.

2.4 Neurological Health Effects

Neurological symptoms are also reported among petrol-vapour-exposed workers. The Neurotoxicity Framework suggests that repeated VOC exposure may disrupt nervous-system functioning through effects on neural tissues and neurotransmitter activity (Yamada et al., 2025). Because petrol vapour contains benzene, toluene, ethylbenzene and xylene, prolonged occupational exposure may produce neurological symptoms.

Common neurological symptoms include headache, dizziness, fatigue and concentration difficulties. Thomas et al. (2020) identified headache as one of the most prevalent symptoms among petrol workers, while other occupational studies have reported dizziness and fatigue among exposed populations. These effects have been associated with inhaled hydrocarbons and prolonged exposure.

Toluene and xylene may contribute particularly to neurological symptoms because of their effects on cognitive and neurological functioning. Short-term exposure may produce headache and dizziness, while prolonged exposure has been associated with impaired concentration and reduced alertness (Saeedi, Malekmohammadi and Tajalli, 2024).

However, the neurological evidence requires caution because many studies rely on self-reported symptoms rather than objective neurological assessments. Recall and reporting bias, alongside stress, dehydration, fatigue and pre-existing conditions, may influence symptom reporting and make the independent contribution of petrol vapour difficult to establish.

Therefore, although the literature suggests an association between occupational petrol-vapour exposure and neurological symptoms, methodological limitations prevent firm conclusions. Future studies should incorporate objective neurocognitive assessments and biomonitoring to clarify the consequences of long-term exposure.

2.5 Haematological Effects

Haematological abnormalities are important occupational outcomes because of benzene's presence in petrol vapour. The Carcinogenesis Theory proposes that prolonged exposure to carcinogenic substances can produce cellular and genetic changes that increase malignancy risk (Koya and Ibrahim, 2026). Benzene is absorbed through inhalation and metabolised into toxic intermediates capable of affecting bone marrow and blood-cell production (Saeedi, Malekmohammadi and Tajalli, 2024).

Studies have reported alterations in WBC and RBC counts and haemoglobin concentrations among petrol-exposed workers, potentially indicating impaired haematological function (Getu, Shiferaw and Melku, 2020). Benzene metabolites can disrupt haematopoiesis and contribute to bone marrow suppression and abnormal blood-cell production (Saeedi, Malekmohammadi and Tajalli, 2024).

The Dose–Response Relationship suggests that haematological effects may vary according to benzene concentration and exposure duration. Workers with prolonged exposure have been reported to show greater haematological alterations than less-exposed populations (Rasheed, Rasheed and Saheed, 2026). Benzene exposure is also associated with haematological malignancies, particularly acute myeloid leukaemia (Saeedi, Malekmohammadi and Tajalli, 2024).

Despite strong biological plausibility, the evidence remains limited by the predominance of cross-sectional studies, which provide only a snapshot of exposure and health status (Moghadam et al., 2019). Consequently, causal inference and understanding of long-term disease progression remain limited. Prospective research is therefore required to clarify the relationship between occupational exposure and haematological outcomes.

2.6 Occupational Health and Safety Challenges in Nigeria

Effective protection requires occupational health and safety systems based on hazard identification, risk control, monitoring and continuous improvement. The Hierarchy of Controls prioritises elimination and engineering controls above administrative measures and PPE (Centers for Disease Control and Prevention, 2024). However, implementation remains challenging in developing-country contexts, including Nigeria (Sukare and Usman, 2026).

Occupational exposure may be exacerbated by inadequate PPE use, limited training and insufficient health surveillance. Monney et al. (2015) reported deficiencies in safety practices among filling-station workers, including inconsistent protective-equipment use, while Anigilaje, Nasir and Walton (2024) identified elevated BTEX concentrations in Nigerian filling stations, suggesting that existing controls may be insufficient.

Health surveillance and environmental monitoring are essential for occupational risk management, yet limited resources, weak enforcement and inadequate inspection capacity may reduce their effectiveness (Ayuba and Dadan-Garb, 2026). Consequently, workers may remain exposed without routine monitoring of exposure levels or health outcomes.

Importantly, the challenge may lie less in the absence of legislation than in implementation, monitoring and enforcement. Policy effectiveness depends on operational compliance rather than legislative existence alone. Strengthening regulatory oversight, workplace monitoring and adherence to safety protocols is therefore critical to reducing occupational exposure in Nigerian filling stations.

2.7 Theoretical Framework

The Environmental Health Risk Assessment Framework underpinning this study is grounded in the principles formalised by the National Research Council (NRC, 1983) in *Risk Assessment in the*

Federal Government: Managing the Process. The framework provides a structured approach to evaluating health risks from environmental hazards through four interconnected components: hazard identification, dose–response assessment, exposure assessment and risk characterisation (NRC, 1983).

The framework has subsequently informed environmental and public-health regulation. WHO (2022) applies systematic hazard, exposure and health-risk assessment to chemical hazards, while the US Environmental Protection Agency has developed a human-health risk assessment framework to support evidence-based decision-making (Fitzpatrick et al., 2017).

The framework is appropriate for this study because it connects the hazardous properties of petrol constituents with occupational exposure pathways and potential health outcomes. This is particularly relevant to benzene and other BTEX compounds, where relationships between hazard, exposure and health outcome are central to occupational environmental-health risk assessment.

The framework comprises four interrelated stages: hazard identification, dose–response assessment, exposure assessment, and risk characterisation.

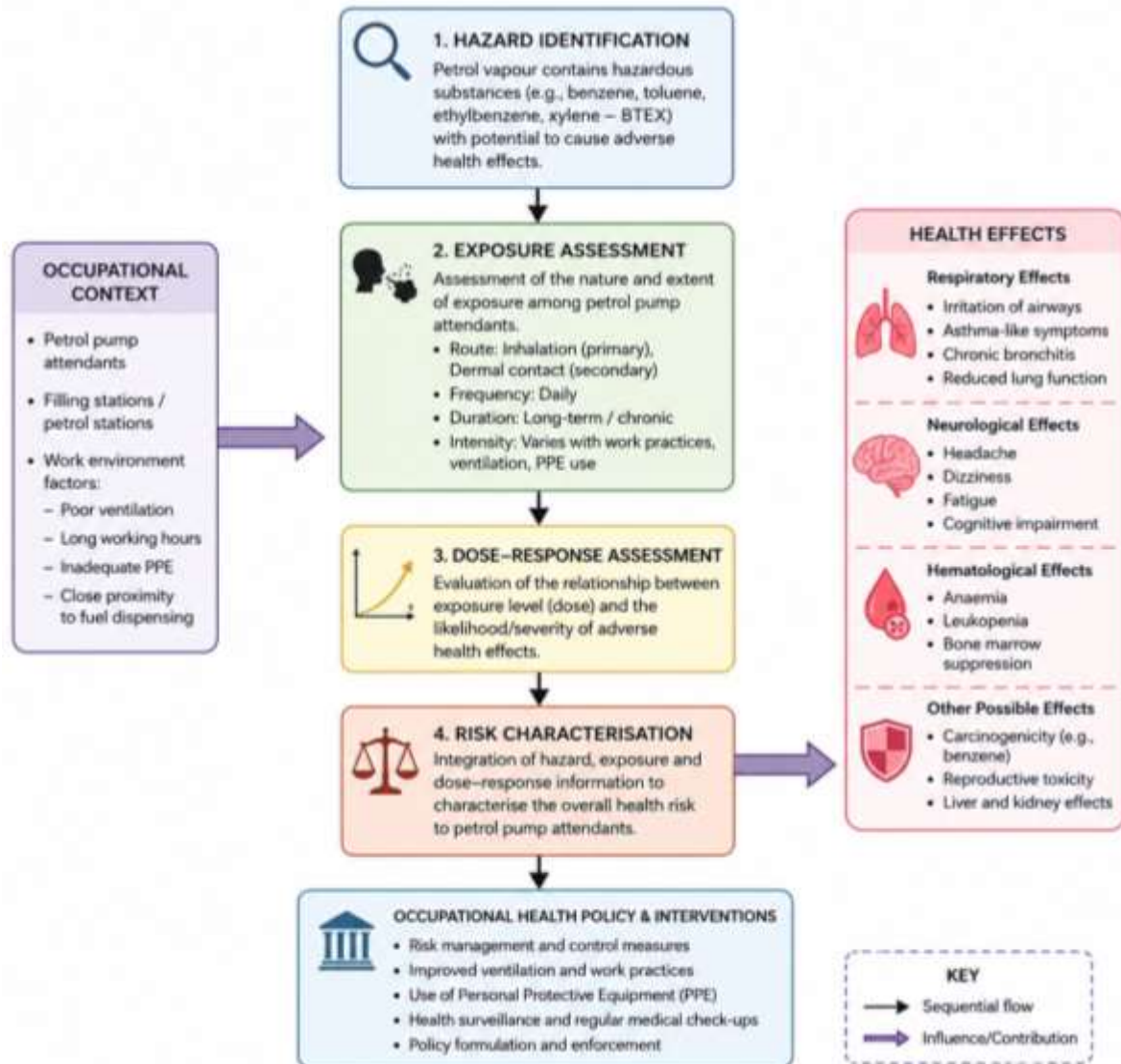


Figure 1: Theoretical Framework

2.8 Methodological Trends and Evidence Gaps

Existing research is methodologically diverse, with most studies using quantitative cross-sectional designs to examine associations between occupational exposure and health outcomes. Although these studies provide evidence of respiratory, neurological and haematological effects, their simultaneous measurement of exposure and outcomes limits causal inference (Moghadam et al., 2019). Evidence is concentrated in countries including India, Ghana, South Africa and Nigeria; however, Nigerian studies remain fragmented because of differences in study settings, exposure assessment and outcome measures. This heterogeneity limits direct comparison and makes it difficult to establish the consistency and magnitude of occupational risk (Anigilaje, Nasir and

Walton, 2024). Therefore, the key gap is not simply limited Nigerian research, but insufficient synthesis and comparability of existing evidence.

Table 1: Summary of Some Key Studies

Author	Country	Design	Sample	Key Finding	Limitation
Thomas et al. (2020)	India	Cross-sectional	Petrol workers	Increased respiratory morbidity	Self-reported symptoms
Obazee et al. (2023)	Nigeria	Cross-sectional	Petrol attendants	Reduced lung function	Limited sample size
Moghadam et al. (2019)	Multiple countries	Meta-analysis	Occupational studies	Pulmonary impairment associated with exposure	Heterogeneity of included studies
Monney et al. (2015)	Ghana	Cross-sectional	Filling station workers	Poor occupational safety practices	Single-country focus

Although current evidence suggests adverse respiratory, neurological and haematological effects, methodological heterogeneity limits definitive conclusions. Differences in study design, exposure assessment and outcome measurement reduce comparability, while reliance on cross-sectional research and limited objective exposure monitoring further constrain the evidence base. A systematic review is therefore necessary to evaluate the consistency, strength and limitations of existing evidence and identify priorities for future occupational health research

CHAPTER THREE

METHODOLOGY

3.1 Research Design

This study adopts a systematic review design to synthesise and critically appraise existing evidence on the health effects of occupational petrol vapour exposure among petrol pump attendants. A systematic review was selected because it provides a structured and transparent approach to identifying, evaluating, and synthesising findings from multiple studies addressing the same research question. Unlike traditional narrative reviews, systematic reviews follow predefined protocols that minimise selection bias and improve the reliability and reproducibility of findings (Brignardello-Petersen, Santesso and Guyatt, 2024). The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021).

3.2 Search Strategy

PubMed was selected because it provides extensive biomedical and occupational health literature, while Scopus and Web of Science offer broad multidisciplinary coverage and robust citation indexing. Google Scholar was used as a supplementary source to identify additional grey literature and studies not indexed in the primary databases.

Medical Subject Headings (MeSH), free-text keywords and Boolean operators (AND, OR) were combined to maximise retrieval of relevant studies. Keywords will include petrol vapour, gasoline vapour, benzene exposure, BTEX, petrol pump attendants, filling station workers, occupational exposure, and health effects. Studies published between 2016 and 2026 were included to ensure the review reflects contemporary occupational health evidence. Reference lists of eligible articles were manually searched to identify additional relevant studies that may not have been captured through database searches.

Table 2: Search Strategy Used for Literature Search

Database	Search Terms	Boolean Operators / Search String
PubMed	Petrol vapour, gasoline vapour, petrol pump attendants, filling station workers, benzene exposure, BTEX, occupational exposure, health effects	("petrol vapour" OR "gasoline vapour" OR benzene OR BTEX) AND ("petrol pump attendants" OR "filling station workers") AND ("occupational exposure") AND ("health effects" OR respiratory OR neurological OR haematological)
Scopus	Petrol vapour, BTEX, petrol attendants, occupational exposure, health outcomes	("petrol vapour" OR BTEX) AND ("petrol pump attendants" OR "filling station workers") AND ("health effects")
Web of Science	Petrol vapour, gasoline vapour, benzene exposure, occupational health	("petrol vapour" OR "gasoline vapour") AND ("occupational exposure") AND ("health effects")
Google Scholar	Petrol vapour exposure, filling station workers, benzene toxicity, occupational health	"petrol vapour" AND "filling station workers" AND "health effects"

3.3 Eligibility Criteria

Studies will be selected according to predefined inclusion and exclusion criteria.

Inclusion criteria include:

1. Peer-reviewed articles published in English.
2. Studies investigating occupational exposure to petrol vapour or BTEX compounds.
3. Studies involving petrol pump attendants or filling station workers.
4. Studies reporting respiratory, neurological, or haematological health outcomes.
5. Studies conducted in Nigeria or comparable low- and middle-income countries.

Exclusion criteria include:

1. Studies focusing solely on environmental pollution without occupational health outcomes.
2. Animal or laboratory studies.
3. Conference abstracts, editorials, and non-peer-reviewed publications.
4. Studies lacking sufficient methodological information or full-text availability.

3.4 Study Selection

The retrieved records were screened in two stages. First, titles and abstracts were assessed against the predefined eligibility criteria. Duplicate records were removed before screening, after which the remaining records were assessed for relevance. Full-text reports were then retrieved and assessed against the inclusion and exclusion criteria. The study selection process was documented using a PRISMA 2020 flow diagram, providing a transparent account of records identified, screened, excluded and included in the final review (Page et al., 2021).

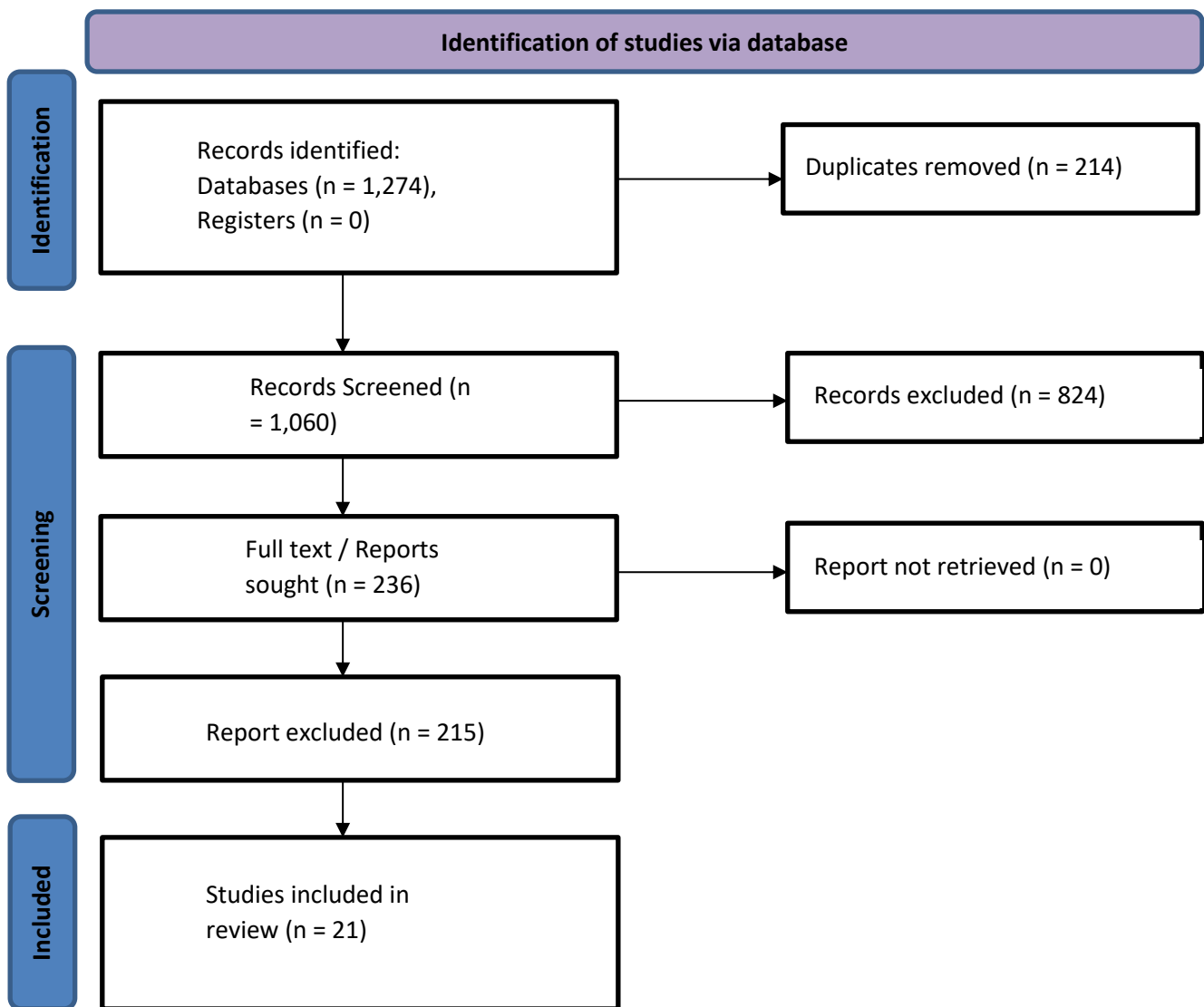


Figure 2 PRISMA Flow Diagram

3.5 Data Extraction

Data from the eligible studies were extracted using a standardised data extraction form. Information extracted included author, publication year, country, study design, sample characteristics, exposure assessment methods, reported health outcomes and key findings. This structured approach facilitated comparison of evidence across studies and supported consistent data management.

3.6 Quality Appraisal

The methodological quality of the included studies was assessed using the appropriate Joanna Briggs Institute (JBI) critical appraisal tools. The appraisal considered study design, participant selection, exposure measurement, outcome assessment and potential sources of bias. The JBI tools were used to assess the methodological credibility and risk of bias of the included studies (Joanna Briggs Institute, 2020).

3.7 Data Synthesis

Given the variation in study design, exposure assessment and outcome measures, the findings were synthesised using a narrative synthesis approach. The results were organised into key themes, including respiratory, neurological and haematological health effects, to facilitate comparison across studies.

3.8 Ethical Considerations

As the study used publicly available published literature and did not involve human participants or personal data, formal ethical approval was not required. Nevertheless, all sources were accurately referenced, and the review was conducted in accordance with principles of academic integrity and good research practice.

CHAPTER FOUR

FINDINGS

4.1 Introduction

This chapter presents the findings of the systematic review examining the health effects of occupational petrol vapour exposure among petrol pump attendants. The findings are organised around study characteristics, methodological quality, and four principal outcome areas: respiratory, neurological, haematological, and occupational health findings.

4.2 Study Selection Results

The review identified 1,274 records, of which 214 duplicates were removed, leaving 1,060 records for screening. Following title and abstract screening, 824 records were excluded, and 236 full-text articles were assessed. A further 215 articles were excluded, resulting in 21 studies being included in the final qualitative synthesis. The selection process is presented in the PRISMA flow diagram.

4.3 Characteristics and Methodological Quality

The 21 studies were conducted predominantly in Nigeria, alongside Ghana, India, Iran, Thailand, Brazil and other settings. Most used cross-sectional designs, while smaller numbers used case-control, biomonitoring, environmental exposure and review designs. Sample sizes ranged from approximately 36 to more than 1,700 participants. Exposure was assessed using workplace BTEX monitoring, air sampling, urinary biomarkers, employment duration and questionnaires, while outcomes included spirometry, neurological symptoms, haematological indices and occupational safety practices.

JBİ appraisal classified 12 studies (57.1%) as high quality, seven (33.3%) as moderate quality and two (9.5%) as low quality, providing an overall evidence base of acceptable methodological quality.

4.4 Respiratory Findings

Respiratory outcomes were among the most frequently reported findings. Studies identified impaired pulmonary function, including reductions in FEV₁, FVC and other spirometric measures,

among exposed workers. Obazee et al. (2023) reported significant reductions in pulmonary-function parameters among gasoline attendants, while Moghadam et al. (2019) found generally lower FEV₁ and FVC among petrol-exposed workers. Respiratory symptoms included chronic cough, throat and nasal irritation, shortness of breath and chest discomfort, with complaints more frequently reported among workers with longer occupational exposure.

4.5 Neurological Findings

Neurological findings were reported less frequently than respiratory outcomes. Headache, dizziness, fatigue, nausea and general weakness were the most commonly reported symptoms. Tudararo-Aherobo and Oritsema (2025) reported frequent headaches among petrol attendants, while Anigilaje et al. (2024) similarly identified headache as a common occupational complaint. Biological monitoring also confirmed occupational benzene absorption through elevated urinary trans,trans-muconic acid among exposed workers (Chaiklieng et al., 2019).

4.6 Haematological and Occupational Health Findings

The included studies reported alterations in several haematological parameters. Chijioke (2020) found increased methaemoglobin and reduced packed cell volume among exposed attendants, while Sajid Jabbar and Ali (2020) reported changes in haemoglobin, red blood-cell parameters and liver enzymes. Other studies identified biochemical and oxidative-stress changes.

Occupational health findings showed inconsistent PPE use, limited medical surveillance, inadequate training and continued exposure to BTEX. Kuranchie et al. (2019) demonstrated measurable BTEX exposure among Ghanaian pump attendants, while Chaiklieng et al. (2019) confirmed benzene exposure through urinary biomarkers. Nigerian studies similarly reported variable implementation of workplace safety measures.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter critically discusses the findings of the systematic review on the health effects of occupational petrol vapour exposure among petrol pump attendants. The findings are interpreted in relation to existing empirical literature, the Environmental Health Risk Assessment Framework and the methodological quality of the available evidence. Particular attention is given to respiratory, neurological and haematological outcomes, as well as occupational health and safety conditions. The chapter also considers areas of agreement and divergence between studies and examines implications for environmental health practice, occupational regulation and future research.

5.2 Overview of Principal Findings

The systematic review identified 21 studies examining occupational petrol vapour exposure among petrol pump attendants and related fuel-station workers. The evidence was predominantly derived from observational research, particularly cross-sectional studies, with Nigeria representing the largest geographical component of the evidence base. The methodological quality assessment classified 12 studies as high quality, seven as moderate quality and two as low quality, indicating that although the evidence base contained a substantial proportion of methodologically robust studies, limitations remained across the included literature.

Across the evidence base, respiratory effects were the most consistently reported outcomes. These included reductions in forced expiratory volume in one second (FEV₁), forced vital capacity (FVC) and peak expiratory flow rate (PEFR), together with symptoms such as cough, wheezing and breathlessness (Thomas et al., 2020; Moghadam et al., 2019). Neurological complaints, particularly headache, dizziness and fatigue, were also frequently reported, while several studies identified alterations in haematological parameters (Anigilaje, Nasir and Walton, 2024). The evidence also demonstrated continued occupational exposure alongside inconsistent implementation of personal protective equipment (PPE), health surveillance and workplace safety measures.

5.3 Discussion of Respiratory Findings

The respiratory findings represent the strongest and most consistent pattern identified in this review. Several included studies reported poorer pulmonary function among petrol pump attendants, particularly reductions in FEV₁, FVC and PEFR, while others identified increased reporting of cough, wheezing, chest tightness and breathlessness. This consistency is important because the evidence was not restricted to subjective symptoms; objective pulmonary-function measurements were also reported. Consequently, the convergence of physiological and symptom-based outcomes provides stronger support for an association between occupational petrol-vapour exposure and respiratory impairment than either type of evidence alone.

These findings are consistent with the broader evidence synthesised by Moghadam et al. (2019), whose systematic review and meta-analysis identified significant reductions in several pulmonary-function parameters among workers occupationally exposed to petrol. Their findings indicated reductions in measures including FVC and FEV₁, while duration of occupational exposure was also associated with poorer pulmonary function. This strengthens the possibility that repeated occupational exposure may contribute to respiratory impairment. Similarly, Thomas et al. (2020) reported respiratory morbidity among petrol pump workers, including respiratory symptoms associated with occupational exposure.

The consistency between the present review and previous research is important; however, it should not automatically be interpreted as evidence of causation. Most studies included in the review used cross-sectional designs, meaning that exposure and health outcomes were generally measured at a single point in time. This limits the ability to establish temporality. Consequently, it cannot always be determined whether occupational petrol exposure preceded the development of respiratory impairment. This limitation is particularly important where workers' previous occupational or medical histories were inadequately controlled.

Potential confounding factors may also explain some of the variation between studies. Smoking status, age, previous occupational exposure, ambient air pollution and other workplace exposures can independently affect lung function. Differences in the extent to which these variables were measured and controlled may therefore influence the magnitude of reported associations. This is consistent with the methodological concerns identified within the broader literature, where

differences in study populations and exposure assessment have contributed to heterogeneous findings (Moghadam et al., 2019).

Another important issue is the variation in exposure assessment. Some studies relied primarily on occupational duration or employment status as indicators of exposure, whereas others incorporated environmental measurements or biological monitoring. These approaches are not equivalent. Employment as a petrol attendant does not necessarily indicate the same exposure intensity across workplaces because ventilation, fuel-dispensing technology, station design, traffic density, shift duration and workplace practices may differ considerably. Anigilaje, Nasir and Walton (2024) similarly identified substantial variation in occupational conditions and BTEX exposure across Nigerian petrol stations.

The respiratory evidence should therefore be interpreted as demonstrating a credible and relatively consistent association, rather than definitive causation. The convergence of objective pulmonary-function impairment, respiratory symptoms and evidence of occupational exposure strengthens confidence in the association. Nevertheless, methodological heterogeneity, potential confounding and the predominance of cross-sectional research limit the ability to determine the precise magnitude of risk attributable specifically to petrol vapour exposure.

5.4 Discussion of Neurological Findings

Neurological symptoms were reported less consistently than respiratory outcomes, with headache, dizziness, fatigue, nausea and general weakness representing the principal complaints. The recurrence of these symptoms across occupational settings suggests that neurological complaints may form part of the health burden experienced by petrol pump attendants exposed to petrol vapours (Anigilaje, Nasir and Walton, 2024).

The findings are biologically plausible because petrol vapour contains volatile organic compounds, including benzene, toluene, ethylbenzene and xylene, which can enter the body predominantly through inhalation. Saeedi, Malekmohammadi and Tajalli (2024) identified inhalation as an important route of BTEX exposure and discussed the potential systemic health consequences associated with these compounds.

Nevertheless, the neurological evidence requires greater caution than the respiratory findings. A major limitation is the reliance on self-reported symptoms. Headache, fatigue and dizziness are

non-specific outcomes that may arise from numerous occupational and environmental factors, including heat exposure, dehydration, prolonged standing, inadequate rest, psychological stress and poor workplace ventilation. Therefore, the presence of these symptoms cannot independently establish neurotoxicity caused by petrol vapour.

This limitation is particularly relevant in the Nigerian context, where petrol attendants may work extended shifts under demanding environmental conditions. Although some studies reported more recurrent symptoms among workers with longer occupational exposure, this does not necessarily establish a dose-response relationship because exposure duration may also be associated with other occupational conditions.

Biological monitoring provides an important complementary perspective. Chaiklieng et al. (2019) reported elevated urinary trans,trans-muconic acid (tt-MA) among petrol station workers, providing evidence of occupational benzene absorption. However, evidence of chemical absorption does not, in itself, demonstrate neurological injury. Overall, the neurological findings therefore provide suggestive evidence of possible neurotoxic effects, but stronger conclusions would require longitudinal studies incorporating objective neurological assessments and quantified exposure measurements.

5.5 Discussion of Haematological Findings

The haematological findings provide an important dimension of the health risk because benzene is a particularly significant constituent of petrol vapour and has established systemic toxicity. The included studies reported alterations in methaemoglobin, packed cell volume, haemoglobin and red blood cell-related parameters, although the findings were not entirely consistent.

For example, Christian (2022) reported increased methaemoglobin concentrations and reduced packed cell volume among petrol attendants compared with unexposed controls. Similarly, Sajid Jabbar and Ali (2020) identified significant differences in several haematological indices and reported elevated liver enzymes among exposed workers. These findings suggest that occupational petrol exposure may be associated with measurable physiological changes extending beyond the respiratory system.

The biological plausibility of these findings is strengthened by toxicological evidence identifying benzene as an important component of BTEX exposure because of its potential systemic and

haematopoietic effects; consequently, its established toxicity provides a plausible mechanism through which repeated occupational exposure could contribute to alterations in blood parameters (Saeedi, Malekmohammadi and Tajalli, 2024). However, the inconsistency between studies is important. Anigilaje, Nasir and Walton (2024) reported evidence of lower haemoglobin, packed cell volume and red blood cell counts among petrol station workers in several Nigerian studies, but also identified studies where selected haematological parameters did not differ significantly between exposed and unexposed groups. One study also reported elevated white blood cell counts. This variation indicates that a uniform haematological response cannot be assumed across all occupationally exposed workers.

Several factors could account for these differences. Exposure concentration and duration may vary substantially between petrol stations, while nutritional status, age, sex, smoking, concurrent chemical exposure and underlying health conditions may also influence haematological parameters. In addition, differences in laboratory methods and outcome definitions can reduce comparability between studies.

The evidence should therefore distinguish between biological plausibility and epidemiological certainty. The toxicological evidence provides a credible mechanism for benzene-related haematological effects, but the predominantly cross-sectional occupational studies cannot consistently establish temporality or demonstrate a clear dose-response relationship. Consequently, the findings support concern regarding potential systemic effects but do not justify concluding that all observed haematological abnormalities were caused by petrol vapour exposure.

Longitudinal studies incorporating repeated exposure measurements and biological monitoring would therefore provide stronger evidence. Such research could determine whether changes in haematological parameters develop progressively with occupational exposure and whether these changes reverse following exposure reduction.

5.6 Discussion of Occupational Health and Safety Findings

The review identified important weaknesses in occupational health protection, particularly inconsistent PPE use, limited health surveillance, inadequate training and continued exposure to petrol vapours. These findings are consistent with the Nigerian evidence reviewed by Anigilaje,

Nasir and Walton (2024), which identified considerable variation in occupational health and safety practices across petrol stations.

An important distinction therefore emerges between awareness of occupational hazards and effective risk control. Workers may recognise that petrol vapour presents a health hazard without having sufficient organisational support, equipment or regulatory enforcement to reduce exposure. Consequently, improving worker awareness alone is unlikely to eliminate occupational exposure.

The findings can be further interpreted through the Hierarchy of Controls. PPE represents the least effective level of control and should not be considered an adequate substitute for engineering and administrative measures. Where workers remain continuously exposed to petrol vapours, greater emphasis should be placed on engineering controls such as effective ventilation, vapour-recovery systems and safer fuel-dispensing technologies. Administrative measures, including appropriate working schedules, training, health surveillance and exposure monitoring, should complement these controls.

This is particularly important because the review identified measurable BTEX exposure during routine fuel-dispensing activities (Anigilaje, Nasir and Walton, 2024). The persistence of exposure despite awareness of occupational hazards suggests that the problem extends beyond individual worker behaviour to organisational and regulatory implementation.

Evidence from Ghana also supports this interpretation. Monney et al. (2015) identified occupational health and safety challenges within fuel-service stations, demonstrating that weaknesses in workplace protection are not unique to Nigeria and may reflect broader challenges within lower-resource occupational environments. However, evidence from Ghana should not be assumed to represent Nigeria directly because regulatory systems, workplace organisation and enforcement capacity may differ.

5.7 Interpretation Through the Environmental Health Risk Assessment Framework

The findings can be interpreted through the Environmental Health Risk Assessment Framework, which is grounded in the risk-assessment principles established by the National Research Council (NRC, 1983). The framework incorporates hazard identification, exposure assessment, dose-response assessment and risk characterisation.

The principal hazards identified in this review were petrol vapour and its BTEX constituents, particularly benzene. Exposure assessment was supported by environmental and biological evidence demonstrating occupational exposure and benzene absorption among petrol station workers (Chaiklieng et al., 2019; Anigilaje, Nasir and Walton, 2024). The respiratory, neurological and haematological outcomes identified in the review provide evidence relevant to risk characterisation. However, limitations in exposure measurement and the predominance of cross-sectional research weaken conclusions regarding dose-response relationships. Therefore, the framework supports recognition of a credible occupational health risk, while simultaneously demonstrating the limitations of the current evidence in establishing the precise magnitude of that risk.

5.8 Strengths and Limitations of the Evidence

A major strength of the evidence base is the consistency of respiratory findings across studies using both subjective symptoms and objective pulmonary-function measurements. The inclusion of biological monitoring and haematological assessments also strengthens the evidence by providing measurable indicators of exposure and physiological response. Furthermore, 12 of the 21 included studies were classified as high quality, representing 57.1% of the evidence base. Nevertheless, nine studies were classified as moderate or low quality. The predominance of cross-sectional designs, differences in exposure assessment, inconsistent outcome measures and reliance on self-reported neurological symptoms reduce causal certainty. These limitations mean that the evidence provides substantial support for an association between occupational petrol-vapour exposure and adverse health outcomes, but does not establish a definitive causal relationship for every outcome.

5.9 Implications for Environmental Health Practice and Policy

The findings support a precautionary approach to occupational petrol-vapour exposure in Nigeria. Environmental health practice should prioritise workplace exposure assessment, improved ventilation and vapour-control measures, appropriate PPE, worker training and periodic occupational health surveillance. The evidence also indicates that effective occupational health protection depends not only on the existence of regulatory requirements but on their implementation and enforcement (Anigilaje, Nasir and Walton, 2024).

The findings have particular relevance for environmental health professionals because petrol station exposure represents an intersection between chemical hazard, workplace conditions and regulatory protection. Consequently, interventions should address the source and pathway of exposure rather than relying predominantly on individual worker behaviour. Engineering controls should therefore be prioritised, with administrative controls and PPE used as complementary measures.

5.10 Chapter Summary

This chapter critically interpreted the systematic review findings and identified consistent evidence of adverse respiratory effects alongside suggestive neurological and haematological effects among petrol pump attendants. However, methodological heterogeneity, potential confounding and the predominance of cross-sectional research limit causal certainty. The findings nevertheless support stronger exposure controls, occupational health surveillance and regulatory enforcement within petrol-station environments.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This systematic review examined the health effects of occupational petrol vapour exposure among petrol pump attendants in Nigeria and comparable settings. Evidence from 21 included studies indicated adverse respiratory, neurological and haematological outcomes associated with occupational exposure. Respiratory effects were most consistently reported, including reduced FEV₁, FVC and PEFR and symptoms such as cough, wheezing and breathlessness (Moghadam et al., 2019; Thomas et al., 2020). Headache, dizziness and fatigue were also frequently reported, alongside alterations in haematological and biochemical parameters (Anigilaje, Nasir and Walton, 2024; Saeedi, Malekmohammadi and Tajalli, 2024). However, the predominance of cross-sectional studies, variation in exposure assessment, and differences in outcome measurement limit definitive conclusions regarding causality.

6.2 Recommendations

Based on the findings, petrol stations should strengthen BTEX exposure monitoring, improve ventilation and vapour-control systems, and prioritise engineering controls over reliance on PPE alone. Employers should provide appropriate PPE, practical safety training and regular occupational health surveillance, including relevant respiratory and haematological assessments. Nigerian regulatory authorities should strengthen inspection, enforcement and monitoring of occupational safety requirements. Evidence generated through future high-quality research should also inform the formulation, implementation and evaluation of occupational and environmental health policies. Policymakers should further examine effective petrol-station occupational health approaches used in other jurisdictions and adapt transferable measures to the Nigerian context. Future Nigerian research should adopt longitudinal designs using larger samples, personal exposure monitoring and biological biomarkers to establish clearer exposure-response relationships.

6.3 Final Statement

Overall, petrol pump attendants remain an occupational group requiring stronger preventive protection from petrol vapour exposure. Integrated exposure monitoring, engineering controls, health surveillance, worker protection and effective regulatory enforcement are warranted to reduce occupational health risks.

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