



## Safety Concerns on the Use of Compressed Natural Gas (CNG) in the Nigerian Automobile Industry

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### Abstract

Compressed natural gas (CNG) offers Nigeria's automotive industry a cleaner and cost-effective alternative fuel. However, safety concerns has continued to hinder its full adaption since its launch in Nigeria in 2023 by the presidential initiative on compressed natural gas utilization. This study assessed the safety concerns associated with CNG-usage in the Nigerian automobile industry through the adaptation of a descriptive research design methodology involving surveys, policy reviews and international case studies. The study revealed that about 50.6 % of the respondent view CNG vehicles as safe from the sampled population with key concerns on explosion risks (48.1 %), capacity of technicians (40.3 %) and refueling infrastructure inadequacy (35.1 %). Furthermore, overlaps in regulatory agencies in the sectors such as the standard organization of Nigeria (SON), and Department of Petroleum Resources (DPR), coupled with low public awareness with about 26.0 % been unaware of safety standards exacerbated associated risks was revealed. The study highlighted the need for unified regulations, enhanced capacity of technicians through constant trainings, expanded infrastructure and sustained public awareness campaigns, implementing standards like ISO 11439 and establishing a CNG safety task force would ensure the safe adoption of CNG in the Nigerian automobile industry, boost public confidence and support Nigeria's transition to sustainable transportation.

**Keywords:** Compressed natural gas; safety; surveys; policy reviews; case studies; sustainable transportation.

### 1.0 Introduction

The need for sustainable transportation has risen significantly as countries face challenges such as environmental degradation, energy security, and economic instability [1]. In response to global initiatives aimed at lowering carbon emissions, enhancing fuel efficiency, and promoting energy diversification, alternative fuels such as compressed natural gas (CNG) has attracted considerable attention [2]. Compressed natural gas (CNG) is considered a clean and more economical fuel when compared to conventional fossil fuels like petrol and diesel [3]. The application of CNG in the transportation sector could lead to lower greenhouse gas emissions, decreased fuel costs, and better air quality [4]. Several nations of the world such as Iran, Pakistan, and Argentina have provided evidence of the potential benefits of adopting CNG by developing extensive infrastructure, creating favorable policy environments, and conducting public awareness initiatives [2, 5] on the use of CNG for automobile systems. The international experiences from these countries provides valuable insights on how developing countries such as Nigeria, can incorporate CNG into her energy transportation mix [2].

In Nigeria, the transportation sector depends heavily on the use of petrol and diesel both of which significantly contribute to greenhouse gas emissions and environmental pollution [6]. Recent studies indicated that Nigeria's transportation sector was responsible for nearly half of the country's carbon dioxide emissions from fuel combustion from 1971 to 2014 [6]. Additionally, Nigeria's reliance on imported refined petroleum products presents considerable financial burden on the national economy and exposes it to fluctuations in global oil prices [7]. To tackle these challenges, the Nigerian government introduced the presidential compressed natural gas initiative (P-CNGi) in 2023. The goal of this initiative was to migrate a significant proportion of the nation's transportation fleet from the use of petrol and diesel to CNG, thereby promoting energy security, environmental sustainability, and economic resilience [8]. The policy also aligns with international climate goals and Nigeria's efforts to diminish its carbon footprint [1, 9]. However, the transition to CNG technology in Nigeria brought with it concerns on safety related issues. These concerns included the dangers related to high-pressure storage cylinders, inadequate safety training for vehicle operators and technicians, absence of standardized conversion kits, and limited emergency response capabilities [3, 9, 10]. Without solid regulatory frameworks and public awareness initiatives, the program is prone to pushback and may create unintended safety risks [11].

The global transportation sector is experiencing a major transformation fueled by the pressing need to lower carbon emissions, confront climate change, and improve energy sustainability [1, 12]. A crucial strategy for achieving these objectives are the adoption of alternative fuels that are more eco-friendly and economically feasible than traditional fossil fuels [2]. Among these alternatives, compressed natural gas (CNG) stood out as a viable option due to its reduced emissions, widespread availability, and cost efficiency [3, 4, 13]. CNG has seen broad

adoption in several regions across the world including countries like India, Iran, Pakistan, and Argentina [2, 5], where government-led initiatives and supportive policies have facilitated widespread transition to vehicles powered by compressed natural gas. These success stories serve as valuable examples for developing nations striving to lessen dependence on imported petroleum products and alleviate urban air pollution [2, 3].

Despite the increasing global and national interest in compressed natural gas (CNG) as a cleaner and more economical fuel alternative, Nigeria as a country still encounters several significant challenges to its safe and effective utilization in the automobile transportation sector. While the presidential compressed natural gas initiative (P-CNGi) was established in 2023 to aid the transition, the nation still lacks a comprehensive safety and regulatory framework for the storage, installation, maintenance, and operation of CNG-powered vehicles. Key issues involve the continuous use of inferior conversion kits, inadequate installation methods by unqualified technicians, and lack of awareness among drivers and first responders regarding the safe handling of CNG-powered vehicles [7, 13]. These challenges are further exacerbated by Nigeria's high atmospheric temperature and insufficient enforcement of safety inspections, which heighten the risk of accidents and foster public skepticism [6, 14]. Moreover, the regulatory framework is disjointed. Various agencies, including the Standards Organization of Nigeria (SON), Department of Petroleum Resources (DPR), and the National Automotive Design and Development Council (NADDC), have overlapping responsibilities, leading to poor coordination and ineffective enforcement of safety measures [11, 15]. In the absence of clear safety standards, technician certification, and organized public awareness initiatives, the CNG transition may pose unwanted safety risks to both users and the general public. Consequently, there is an urgent necessity to thoroughly assess the safety risks and institutional deficiencies in Nigeria's CNG deployment strategy, aiming to propose practical solutions that improve public confidence, safety, and long-term sustainability. Thus, there is need evaluate the current safety standards and practices governing the use of CNG in Nigeria, identify gaps in regulatory oversight, technical enforcement, and public awareness, examine real-world incidents or case studies involving CNG-related hazards in Nigeria and similar contexts and propose actionable policy recommendations that can enhance safety, boost adoption, and build public confidence in CNG technology.

In Nigeria, the transportation sector is essential to the economy but also significantly contributes to greenhouse gas emissions and air pollution [6, 16]. The sector relies almost entirely on petrol and diesel, most of which are imported at considerable expense [7, 17]. This dependency has not only strained the country's economy but also rendered it susceptible to global oil price fluctuations and supply disruptions [7]. A recent study [6] noted that from 1971 to 2014, Nigeria's transportation sector represented about 48 % of the nation's total CO<sub>2</sub> emissions from fossil fuel combustion. The Nigerian government confronted these challenges through the launch of the presidential compressed natural gas initiative (P-CNGi) in 2023 [8]. The initiative was aimed at promoting the use of CNG as an alternative fuel, especially in the automotive sector [8]. The policy forms part of a larger strategy to decrease dependence on fossil fuel, encourage the use of cleaner energy, and foster a more sustainable and varied energy economy [8, 11, 18]. Although the advantages of adopting CNG are broadly recognized, the safety aspects of CNG usage in Nigeria has not been thoroughly considered [11]. Unlike gasoline and diesel, CNG is kept under high pressure and necessitates specialized infrastructure, modifications to vehicles, and trained personnel for safe handling and maintenance [3, 9]. The lack of sufficient regulations, safety measures, and public education raises valid concerns regarding the preparedness of Nigeria's automotive sector for this transition [10-12, 19].

The adoption of compressed natural Gas (CNG) in Nigeria's automotive industry offers a considerable chance to decrease reliance on importation of refined automobile petroleum product, cut transportation expenses, and lessen environmental pollution [3, 4, 7]. However, this shift must be approached with caution to avoid unintentional safety risks and public skepticism [11, 14, 20]. The research is justified for several reasons. Firstly, it delivers a timely assessment of the safety challenges associated with increased usage of CNG in vehicles. As the presidential CNG initiative progresses, it is essential to gather empirical evidences that can inform safe practices. Secondly, the study fills a significant void in current policy discussions in that Nigeria does not have a definitive and enforceable national safety policy framework specifically for CNG transportation [9]. Furthermore, the research enhances academic understanding and facilitates dialogue among various stakeholders, such as policymakers, regulatory bodies, auto mechanics, and the general populace [7, 21]. It thus provides actionable recommendations that can help reconcile environmental goals with public safety issues [8, 11]. By identifying existing risks and proposing preventive measures, this study strengthens the long-term sustainability of CNG as a secure, eco-friendly, and widely accepted fuel option [3, 4, 22].

This study therefore investigates these safety issues, emphasizing the identification of major hazards associated with CNG-powered vehicles in Nigeria while reviewing the current regulatory frameworks and evaluating their efficacy in ensuring safe implementation. The study further provides inputs into the safe and successful integration of CNG technology into Nigeria's transportation system.

## 2.0 Review of related studies

### 2.1 Emission and Fuel Expenses Reduction

Different studies have highlighted the ability of CNG to control emissions and reduce fuel expenses in Nigeria, resulting in substantial savings for drivers while enhancing air quality in urban areas [3, 4]. However, challenges related to safety, such as the dangers of high-pressure storage, inadequate infrastructure, fragmented regulations, insufficient training, low public knowledge, and weak emergency readiness, still pose substantial risks to its successful implementation [9-11]. Another research [6] analyzed CO<sub>2</sub> emissions in Nigeria's transport sector within the periods 1971-2014 using detailed review of fuel combustion data and transportation sector contributions. The study noted that the transport sector accounted for approximately 48% of CO<sub>2</sub> emissions from fuel combustion nationally. A major research shortcoming was heavy reliance on imported petrol/diesel, vulnerability to global oil prices, and lack of post-2014 updates. Recent events, such as the 2024 explosion in Edo and the 2025 accident in Ibadan, underscores the repercussions of these deficiencies, which are frequently linked to inferior conversions and inadequate monitoring [15, 16]. While international studies offer useful insights, research focused specifically on Nigeria remains scarce, typically emphasizing economic or technical dimensions instead of safety or human consequences [7, 17]. A study [18] reported the potential cost savings associated with the application of CNG systems but fail to address the challenges of implementing safety measures.

### 2.2 Inherent Technology and Economics of CNG Utilization in Nigeria

A recent study [17] examined the technology and economic aspects of using CNG as fuel for vehicles in Nigeria. Primary data from CNG stations comprising the use of interviews and secondary data from company reports were the means employed in the study. Initial recoverable cost of conversion were observed to be rapid, with the CNG technology applied enhancing the economic output as reported by the different respondents thereby boosting the economy. Furthermore, the issue of fuel scarcity and volatile prices in energy cost were key findings addressed in the study. Limited research on public perception and acceptance of CNG conversions were the identified research gaps in the study. A similar study [4] reported on the techno-economic analysis of CNG as alternative fuel for transport in Southwestern Nigeria. The assessment of fuel costs, emissions, and policy measures like incentives and subsidies was the central crux of the investigation. The study revealed that CNG reduces fuel costs by over ₦5,518 per 100 km when compared to petrol, providing economic relief and highlighted the need for tax incentives and regulatory frameworks. The identified research gap in the study was inability to address safety implementation challenges or human factors in adaptation. A report [11] evaluated regulatory frameworks for sustainable transport through CNG adoption in Nigeria. The study adopted mixed methods approach involving qualitative case studies and quantitative questionnaire involving several stakeholders. The key findings revealed strong government commitment, regulations, phased implementation showing that Nigeria's framework for CNG utilization has strengths but weaknesses in incentives and infrastructure. The identified research gap included limited incentives and inadequate infrastructure which hinders adoption needing context-specific insights for developing countries.

### 2.3 Stakeholders Evaluation, Apprehension and Analysis of CNG Prospects

A study reported on stakeholder analysis of automotive industry's CNG use in Nigeria [7]. The study employed Hermeneutics principles for stakeholder analysis, review of barriers and policy interventions measures. Their major findings showed that the barriers included uncoordinated implementation, need to align stakeholder interests and greater government involvement in standards and responsibilities. Slow uptake due to natural gas flaring and energy shortages and lack of comprehensive review of implementation approaches were some of the major research gaps identified. Another study [2] reported on the development of CNG as automotive fuel in Nigeria using lessons from other international markets as reference. This was achieved through the examination of natural gas vehicles (NGV) policies and strategies in seven diverse countries. Legislative mandates were reported to deepen penetration, thereby aligning with stakeholder's expectations ensuring that government support drives participation with uncoordinated approach as the main impediment in Nigeria. Barriers to market development, insufficient legal and regulatory frameworks and standards for vehicles/refueling were some of the identified research gaps that were not presented in the study. A study assessed CNG safety and pollution reduction in Delhi as a contextualized framework for hot climates [3]. The study investigated air quality changes in post-CNG implementation in transportation systems and observed that the use of CNG led to 10% reduction in particulate matter within a period of 2000-2010 with associated risks due to high-pressure storage tanks in hot climates. The study however failed to report on the dangers of high-pressure storage and leaks in confined areas with minimal focus on thermal safeguards in hot regions like Nigeria. A recent study reviewed regulatory gaps in CNG transportation safety framework in Nigeria [9]. Analysis of overlapping agency responsibilities (SON, DPR, NADDC) was observed in the study. Inconsistent framework lead to weak enforcement with no vehicle-specific safety measures implemented. Overlapping authorities were the major reasons for poor coordination with the absence of national database for monitoring conversions also a major gap identified. A study reported on the

examination of CNG conversion kits in Lagos workshops for standards compliance [19]. Survey of kits in the workshops were the means through which the investigations were conducted. The study reported that 60% of the kits did not comply with international standards resulting in high incidences of gas leakages. High likelihood of gas leakages from substandard kits due to limited enforcement of standards were some of the major shortfalls of the study which were not reported. Another study analyzed CNG safety challenges in developing nations with focus on gas leakages [20]. They reviewed weak safety cultures associated with pipeline and compressor issues using CNG. Their study showed that most developing nations using CNG as transportation fuels had systems infrastructure that were susceptible to gas leakages and malfunctions due primarily to funding constraints and shortage of the requisite expertise. The study failed to report on infrastructure vulnerabilities such as over-pressurization and data-deficiency in the case of Nigeria. Another study investigated safety issues from natural gas vehicles (NGV) accidents in Pakistan [21]. Analysis of accident data with focus on cylinder failures was the major thrust of the study. The key findings were that Type-I cylinders were more prone to explosions, poor refueling practices contributed to system failures and finally, the need for training and retraining of personnel for efficient operations were required. The study however did not report on mitigating extensive external corrosion in the cylinders used and failed to provide appropriate service life for the Type-I cylinders being used in Pakistan. A study [22] reported on public-private initiatives in the exploration of Kenya's CNG projects. The study reviewed several public-private-partnership (PPP) models for refueling CNG networks. They observed that PPP's broadened CNG networks and could serve as potential model for Nigeria given her vast natural gas resources. However, lack of funding and expertise could hinder its replication in Nigeria. Another study [14] investigated and assessed public skepticism towards CNG application in Nigeria through a survey using Lagos state as case study. 65% of respondents; mostly drivers' expressed concerns due to explosions of the cylinders largely propagated from the media and in-grained preferences for familiar fuels. Insufficient knowledge and education on CNG as an alternative fuel and heavy reliance on informal sources of information were the major causes of the identified apprehensions. Another study [23] evaluated CNG conversions by informal mechanics. The procedure reported on training and conversion practices by these untrained mechanics in the conversion of existing vehicles powered by petrol to CNG utilization. It was observed that about 80% conversions by these informal mechanics posed heightened failure risks. Essentially, the identified knowledge gap was associated with shortfall in the availability of trained technicians, as most of the approaches were based on trial-and-error methods. Another study [10] reported on Abuja CNG bus fire incident which was linked to defective CNG cylinder valves and Lagos refueling station CNG gas leakage using incident review on detection systems method. Fire injured passengers occurred as a result of that singular incident which heightened public concern on safety of CNG utilization. Defective valves in hot climates leads to safety concerns in CNG utilization due to inadequate thermal protection. It was further reported that in the case of the Lagos refueling station incidence, the leak caused temporary closure of the facility though there were no injuries but review of the scene of the accident revealed gas leakages due to cylinder ruptures. The incident showed that there were deficient automated systems and therefore the fuelling station had increased associated safety and risk concerns. A group of researchers [12] developed guidelines for CNG conversions in Nigeria. Policy document on standards and procedures were presented as part of the development objectives for the utilization of CNG fuelling alternative through preparing appropriate groundwork for inspections and technician qualifications. However, the policy lacked detailed instructions on intervals and qualifications. United Nations Environment Programme [1] provided a global overview of used vehicles' environmental impact due to emissions for fossil fuels. This was done through analysis of flows, scale, and regulations in one hundred and forty six importing countries. It was reported that used vehicles hinder climate efforts, contribute to pollution and accidents in low/middle-income countries. However, there were calls for harmonized minimum quality standards as country such as Nigeria lacked definitive CNG safety framework. A study [5] reported on the review of global CNG adoption success stories and lessons across different countries. It provided annual report on policies, infrastructure, and reductions strategies adopted and implemented across different countries with none presented for Nigeria which was of concern. The report showed that countries such as Argentina's training of technicians reduced CNG fatalities by 20% with over 1,900 fuelling stations supporting 1.5 million vehicles and with strong emphasis on public-private partnerships. Nigeria could replicate same scenario but the necessary incentives and approvals for fuelling stations development are presently lacking.

### 3.0 Methodology

The methodology adopted in this research integrated both **primary and secondary data collection methods** to gain a holistic understanding of safety risks, regulatory frameworks, and public awareness related to CNG adoption. The methodology employed survey technique to provide information from the different respondents based on demographic profile, CNG usage and familiarity, factors influencing CNG adoption, safety perception and concerns associated with CNG-powered vehicle utilization, safety protocols and education levels of CNG operators, regulatory awareness of respondents and government implementations of such measures and possible

suggestions for improvements. The population sample for the study was 1077 respondents obtained within a period of eight months.

### 3.1 Research design

The study adopted a descriptive research design to investigate safety concerns surrounding CNG usage in Nigeria's transportation system. A descriptive design was suitable because it enabled the researcher to systematically gather information on the current state of CNG safety, evaluate existing regulatory measures, and assess the level of public and stakeholder awareness. This design allowed for both qualitative and quantitative data to be collected and analyzed to identify patterns, trends, and areas for improvement.

### 3.2 Data collection methods

Data for the study were gathered from both primary and secondary sources which included surveys, academic and industry reports and policy and regulatory document reviews. Structured questionnaires were distributed to private vehicle owners, public and commercial transport operators. The survey was used to explore participants' knowledge and awareness of CNG safety measures, their experiences with CNG utilization in vehicles, and nay perceived associated risks or incidents. The questionnaires consisted of both closed-ended and open-ended questions to allow for quantitative and qualitative responses.

### 3.3. Techniques for data analysis

The data collected were analyzed using quantitative data technique analysis approaches. These analyses assisted in identifying common safety concerns, levels of awareness, and patterns in user experiences with CNG.

### 3.4 Ethical Considerations

Individual respondents in this research were informed of the purpose of the research, and their written consent was obtained. A consent form was printed for the different respondents, and they were informed that their responses were strictly for academic purposes. Thus, to ensure ethical integrity in this research, informed consent, confidentiality, and voluntary participation were the parameters employed. Thus, the methodology adopted in this study combined quantitative and qualitative approaches to explore the safety landscape of CNG usage in Nigeria's automotive sector. By integrating stakeholder insights, regulatory reviews, and public perceptions, the study sought to contribute to the formulation of more effective and safer CNG policies and practices.

## 4.0 Results and discussion

The survey garnered responses from 1077 individuals between January 4<sup>th</sup> and August 15<sup>th</sup>, 2025, utilizing a structured questionnaire on Google forms. The participants comprised vehicle owners, commercial transport operators, government employees, technicians and mechanics, and others, with a concentration majorly on urban areas such as Abuja (35.1%; 378 respondents), Lagos (11.7%; 126 respondents), Port Harcourt (1.3%; 14 respondents), and various other locations (52.0%; 560 respondents). The results are categorized by main themes corresponding to the research aim and objectives, encompassing CNG usage, awareness, safety perceptions, concerns, regulatory knowledge, and suggestions.

### 4.1 Demographic profile

Table 1 presents the results of the demographic distribution of respondents utilized in the study. Based on the data from Table 1, majority of the respondents were male while the dominant age brackets were 31-40 and 41-50 years of age. The analysis revealed a curious implication for the study as more of the youth age bracket seems to be uninterested in use and safety issues related to CNG deployment as alternative green fuel for automobile systems. Furthermore, the dominant occupation of most of the respondents were private vehicle owners and government officials which could be attributed to education level and interest than other respondents.

Table 1: Demographic distribution of respondents utilized in the study

Parameter Utilized	Respondents
<b>Gender</b>	
Male: (54.5 %)	587
Female: (45.5 %)	490
<b>Age Group</b>	
21-30: (16.9 %)	182
31-40: (31.2 %)	336
41-50: (29.9 %)	322

Parameter Utilized	Respondents
> 50: (21.1 %)	227
<b>Occupation</b>	
Private Vehicle Owners (29.9 %)	322
Government Officials (20.8 %)	224
Commercial Transport Operators (5.2 %)	56
Technicians and mechanics (2.6 %)	28
Others (41.6 %)	448

Table 2 presents the findings associated with study conducted on CNG usage and familiarity amongst the different respondents in the selected locations. The table showed that the usage and familiarity of CNG in the country is quite low based on the respondents' answers. This could be attributed to the relatively new nature of the use of CNG in vehicular systems in Nigeria which has only been heightened due to recent rise in cost of transportation fuel particular premium motor spirit (PMS) otherwise called petrol. The relatively recent adaptation of the use of CNG in transportation has thus elicited increased interest but has been hampered due to safety issues which have been reported across different parts of the country. Furthermore, the cost associated with the conversion of petrol-powered vehicles to CNG-powered vehicles has also affected its usage and familiarity amongst the different respondents in addition to lack of technical expertise and non-availability of refueling facilities as multiple locations within the same locations.

Table 2: Analysis of CNG usage and familiarity by different respondents

Parameter Utilized	Respondents
<b>Current Use of CNG Vehicles</b>	
Usage: (11.7 %)	126
Non-usage: (88.3 %)	951
<b>Familiarity with CNG Technology</b>	
Familiarity: (33.8 %)	364
Non-familiarity: (66.2 %)	713
<b>Knowledge and Source of CNG Usage</b>	
Social media: (20.8 %)	224
Government initiatives: (15.6 %)	168
Print and electronic news outlets: (10.4 %)	112
Other sources: (22.1 %)	238

Table 3 presents the inherent factors considered by the different respondents in adopting the use of CNG as an alternative source of fuelling their vehicles.

Table 3: Factors influencing CNG adoption by the different respondents

Factors considered	Respondent
Reduction in fuel expenses (59.7 %)	643
Environmental benefits (27.3 %)	294
Government policy (10.4 %)	112
Availability and accessibility to CNG conversion kits (2.6 %)	28

Most respondents viewed reduction in fuel expenses as the major factor that would influence their choice of CNG adoption as transportation fuel. They noted the environmental benefits in terms of cleaner environment due to the use of CNG but were of the opinion that government policies has failed to encourage its adoption as an alternate fuel for transportation. They further observed the non-availability and accessibility to CNG conversion kits as another major constraint to its adaptation in real-world utilization as several respondents noted that the conversion kits were difficult to obtain and original conversion kits were basically out of the reach of the ordinary Nigerian due to its exorbitant price and availability.

The safety perception and concerns of the different respondents were hinged on several factors which influenced their final decisions and these have been collated and presented in Table 4.

Table 4: Safety perception and concerns associated with CNG-powered vehicle utilization

Safety issues	Respondent
Explosion (48.1 %)	518

Safety issues	Respondent
Inadequate and untrained technicians (40.3 %)	434
Insufficient and poorly equipped refueling stations (35.1 %)	378
Limited access to conversion kits (31.2 %)	336
Lack of emergency response systems (31.2 %)	336

The survey revealed that several participants view CNG vehicles as unsafe, while expressing skepticism, indicating substantial public unease. The primary safety apprehensions of explosions (48.1%), insufficiently trained technicians (40.3%), and insufficient refueling stations (35.1%) presented in Table 4 reflected similar conclusions in certain literature. As an example, [3] reported on the dangers associated with high-pressure CNG storage in hot regions like Nigeria, where temperatures frequently exceed 35 °C, which can compromise cylinders lacking adequate thermal safeguards. This was equally reported in another study [6]. 23.4% of participants who have seen or encountered CNG-related incidents, such as the explosion in Edo State in 2024 [15], highlighted the palpable consequences of these dangers. The perception that safety protocols at refueling stations are lacking (35.1 %), as indicated in Table 4 corresponded with the study [10] reported on a leak at a Lagos refueling station in 2023 attributed to deficient leak detection systems. The scarcity of refueling stations (fewer than 20 across the country) reported by [24] heightens risks, as drivers may travel considerable distances, potentially leading to cylinder over-pressurization. These results corroborate and aligns with the objective of the study, underscoring shortcomings in existing safety regulations and infrastructure.

Table 5 presents the different analyses conducted on opinions expressed by the different respondents regarding safety protocols and the education level of CNG deployment, usage, and safety. The analysis showed average parametric understanding from the different indicators and participants, which calls for great concern.

Table 5: Assessment on safety protocols and education

Parameter assessed	Respondent
<b>Assessment of safety measures at refueling stations</b>	
Adequate safety measures (31.2 %)	336
Inadequate safety measures (68.8 %)	741
<b>Training of CNG Technicians</b>	
Well-trained Technicians (29.9 %)	322
Not well-trained Technicians (70.1 %)	755
<b>Source of Conversion Kits</b>	
Authorized dealers (31.2 %)	336
Direct importation by individuals (7.8 %)	84
Unauthorized or black marketers (61.1 %)	658

Uncertainty about the origin of conversion kits, along with reports of local black market kits (61.1 %), supports the study by [25] based on observation that 70% of CNG-converted vehicles in Lagos lack certification, heightening the risk of incidents like the 2025 Ibadan collision [16]. Public awareness also remains insufficient, with only 74.0% knowledgeable about safety standards, even though 46.8% have some familiarity with CNG technology (Table 5). The dependence on informal channels such as social media (20.8%) and personal contacts (10.4%) for information indicated a lack of organized awareness initiatives, echoing the study by [16] on remarks about public skepticism stemming from insufficient education. These results address heightened and reinforces the objectives of the study by identifying regulatory disarray and low awareness as obstacles to the safe adoption of CNG.

In analyzing the related issues of safety and usage of CNG systems in the Nigerian automobile industry, regulatory awareness as well as deliberate government policies are needed to cascade and accentuate the growth of the policy as well as improve upon the usage and safety of the operators. The various respondents reflected the lack of these policies which are presented in Table 6.

Table 6: Regulatory awareness and government efforts

Parameter employed	Respondent
<b>Support for Technician Certification</b>	
Requirement for government certification (74.0 %)	797
Government certification not required (26.0 %)	28
<b>Awareness on safety standards</b>	
Public awareness on safety standards (74.0 %)	797
Non-awareness on safety standards (26.0 %)	28

Parameter employed	Respondent
<b>Responsible agencies</b>	
Federal road safety corps (FRSC) (55.8 %)	601
Ministry of transportation (31.2 %)	336
Standards organization of Nigeria (SON) (18.2 %)	196
Department of Petroleum Resources (DPR) (5.2 %)	56
Others (not certain) (7.8 %)	84
<b>Government efforts</b>	
CNG vehicular safety awareness is adequate (36.4 %)	392
CNG vehicular safety awareness is not adequate (63.7 %)	686

The survey indicated a disjointed regulatory framework, with 74.0% of participants advocating for government certification of technicians, while expressing uncertainty regarding the quality of technician training. This is consistent with a study reported by [9], where they observed overlapping responsibilities amongst standard organization of Nigeria (SON), Department of Petroleum Resources (DPR), and national automotive design and development council (NADDC), resulting in inconsistent enforcement and a weak policy framework.

Table 7 presents the suggestions and recommendations for improvements provided by the different respondents based on identified parameters.

Table 7: Suggestions and recommendations for improvements

Parameters	Respondent
Increased public awareness and education (28.8 %)	310
More training for technicians (25.2 %)	271
Expansion of CNG refueling stations (20.42 %)	220
Stricter safety regulations and certifications (7.36 %)	79
Subsidizing conversion costs (10.74 %)	116
Improved emergency response system (7.48 %)	81

A notable 28.8% of survey participants reported incidents related to CNG, which corresponded to local examples such as the 2022 bus fire in Abuja and the 2024 explosion in Edo, both linked to inadequate conversions [10, 15]. On a global scale, comparable events in Pakistan in 2019 and Egypt in 2023 were caused by the use of unapproved kits and insufficient training [19, 26]. These similarities indicated that Nigeria shares challenges seen elsewhere, necessitating context-specific approaches such as implementing ISO 11439 standards for cylinders and UNECE Regulation 110 for vehicle safety, as enunciated in different literature. This further buttresses the objectives of the study by emphasizing the importance of having stringent standards to avert such incidents.

### Implications for policy and practice

Based on the survey analysis, greater awareness (310 respondents), technician education (271 respondents), and an increase in refueling stations (220 respondents) are in line with the study objective and provide concrete suggestions. The observed high percentage of respondents willing to advocate for CNG vehicles shows that there is potential for their acceptance if safety issues are resolved, leveraging a similar procedure adopted by India in its achievements through public-private collaborations and workforce training [3]. The lesser percentage who feel the government is insufficiently active reflected a sense of distrust, highlighting the need for clear communication and sharing success stories, such as the Abuja pilot program in 2024 involving the conversion of thirty (30) CNG army vehicles [24]. The demand for more rigorous regulations and certifications (79 respondents) underscores the need for a specialized CNG safety task force, as proposed by [9]. Providing subsidies for conversion expenses (116 respondents) could help overcome financial obstacles, while advancements in emergency response systems (81 respondents) are consistent with Argentina's approach of compulsory CNG training for first responders, which led to a 20% reduction in fatalities [5]. These insights imply that Nigeria could learn from successful global strategies while tackling local issues such as high temperatures and untrained technicians.

### 5.0 Conclusion

This study assessed existing safety protocols, identifying gaps in regulations and awareness, analyzing actual CNG-related incidents, and suggesting policy improvements. The study further provided valuable insights into public perceptions, safety obstacles, and weaknesses in regulations with suggestions to promote the safe and sustainable integration of CNG in Nigeria's automotive industry. Additionally, the study revealed that while CNG offers significant environmental and economic benefits for Nigeria's automobile industry, safety concerns pose substantial barriers to its adoption. The high-pressure nature of CNG storage facility, coupled with Nigeria's hot

climatic condition, increases risks of explosions and leaks, as evidenced by several local incidents and public concerns. The study noted regulatory fragmentation among SON, DPR, and NADDC, combined with inadequate technician training and limited refueling infrastructure, undermines safety standards. Also, low public awareness, driven by reliance on informal information sources, further fuels skepticism, with low safety indicator parameters for CNG vehicles which made the adoption unsafe. Despite these challenges, the potential for CNG adoption remains strong, and several respondents were willing to recommend CNG vehicles. Nigeria's vast natural gas reserves and the economic benefits of lower fuel costs provides a compelling case for CNG as a sustainable alternative to petrol and diesel. Without addressing safety, regulatory, and awareness gaps, CNG utilization risks public mistrust and potential hazards. Thus, there is an urgent need for coordinated policies, robust safety standards, and public engagement to ensure CNG's safe integration into Nigeria's transportation system.

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