

Artisanal petroleum refining and health security in Rivers State, Nigeria

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Abstract

This study investigated the ramifications of artisanal petroleum refining on public health security within the locales of Degema, Ogu-bolo, and Opobo local government areas. Its primary objective was to investigate the relationship between artisanal petroleum refining and health security in Rivers State. A cross-sectional survey research design was employed. Both primary and secondary data were used in the analysis of data. Primary data were sourced through a structured questionnaire. Secondary data were also drawn from scholarly literature sources, including internet materials and national publications. From the estimated population of 686,900, the sample size was determined using the sample size formula for proportion estimation which resulted in 384 respondents. Additionally, a total of 9 healthcare professionals within the study area were interviewed. A total of 295 respondents was covered for analysis, based on the response rate of the usable questionnaire received. A total of 202 (68.4%) respondents affirmed that they experience health challenges as a result of exposure to residues from illegal petroleum refining in the study areas. The data obtained were subjected to Pearson correlation and one-way analysis of variance using SPSS software to test the correlation. The test of correlation on the relationship between illegal petroleum refining (-.439) and health security (1) in Rivers State, indicated a moderate negative correlation, which is significant at 0.01 level (2-tailed). In order words, there is an inverse relationship between health security and illegal petroleum refining; which means that health security decreases as illegal petroleum refining increases. The incidence of illegal petroleum refining undoubtedly presents considerable hazards to public health security. This challenge can be mitigated by the assimilation of the knowledge and expertise of the illegal refiners into a comprehensive technology that the country can harness for starting up a national program of safe petroleum refining in Nigeria.

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1. Introduction

The increasing operations of artisanal petroleum refineries have intensified health challenges that transcend beyond the vicinities of where such operations are carried out. The term “artisanal petroleum refining” or “illegal

refining” pertains to the illicit practices of stealing crude oil and refining it through the utilization of indigenous resources, traditional knowledge, and skills, with minimal or no incorporation of contemporary technology [1]. This operation disregards health, the environment, and safety protocols, which results in disastrous outcomes. The effects of illegal petroleum refining on the environment and atmosphere have both direct and indirect consequences on human health and survival. This highlights the importance of investigating the reasons for such an operation and suggesting improved measures to curb this operation as an essential means of achieving health security [2]. Health security can be defined as the proactive and reactive measures needed to mitigate the risk and impact of severe public health events that harm people's health across geographical regions and international boundaries [3].

The incessant activities of artisanal petroleum refining with its attendant environmental damage, risk of inferno, conflict with law enforcement agents, and loss of lives among others have made it more compelling that the government in line with SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production) to show more concern about the consequences of illegal petroleum refining on the health security of people and their environment in which they live.

It is evident in the present global world that one of the major public health events that harm people's health is artisanal petroleum refining. This is so because petroleum is being sold from one country to another illegally which intensifies the operation of illegal refining of petroleum [4]. Although the existing body of literature extensively examines the impacts of artisanal petroleum refining on the environment and economy of communities, previous studies have provided a limited perspective on the implications of illegal petroleum refining on the health of people, particularly individuals residing in Degema, Ogu-bolo, and Opobo local government areas of Rivers State, Nigeria.

Communities and villages within Degema, Ogu-bolo, and Opobo local government areas (LGAs), where illegal petroleum refining is being carried out, are not just faced with climate and environmental hazards, but with severe health challenges. These communities and villages such as Bakana situated in Degema LGA, Agwe, located in Ogu-bolo LGA and Epelema in Opobo LGA among others, lack the measures needed to promote health security (Oyena and Sam, 2020). Evidently, while it can be argued that artisanal petroleum refining (IPR) takes a toll on the environment, economy, and ultimately human health, there remains an elusive understanding of how IPR can be transformed through the legislation and provision of safe and well-equipped environment with advanced technology for refining petroleum locally. With this, more industrious jobs are created, boosting the economy and making the achievement of health security a possible one [5].

Our argument is premised on the fact that, as a result of the excessive increase in the number of illegal petroleum refineries in Rivers State, health security cannot be achieved. This is because, there is a correlation between the two variables, in that, as illegal petroleum refining increases, the health security of the people decreases and as illegal petroleum refining decreases the health security of people are improved [6]. Given the correlation between the dependent (health security) and independent (illegal petroleum refining) variable, there is an increasing need to empower individuals who possess the skill of petroleum refining with the right equipment, safe environment, and well-advanced technology. By providing proper equipment and technology, the mitigation of risks associated with illegal petroleum refining can be achieved [4].

Based on the above discussion, this study examines the research question: what is the relationship between artisanal petroleum refining and health security in Rivers State?

The study adopts the resource curse theory to explain the experiences of people in Rivers State and extension Nigeria in terms of their welfare, development outcomes, and economic growth. This paper presents several significant contributions to the existing body of literature. First, we examined the legislation and provision of a safe and well-equipped environment with advanced technology for the refining of crude oil locally. With this, it provides more industrious jobs for the people, boosts the economy, and reduces health challenges [7].

The available literature indicates that individuals engaged in the illegal practice of petroleum refining should be apprehended and their refineries destroyed [6]. However, this approach exacerbates the issue of health risks and fails to take into account the underlying motivations that drive individuals to participate in such activities. Hence, this study presents a detailed correlation between artisanal petroleum refining and health security in Rivers State. The subsequent sections of this paper are structured as follows: the forthcoming section provides an extensive literature review and theoretical framework. Following that, a comprehensive account of the research methodology and subsequent data analysis is provided. Afterward, the results and discussion of the findings are provided. The final sections of this paper provide the conclusion and recommendation as well as an overview of the limitations encountered throughout the study and suggest potential avenues for further research.

2. Literature review

This section presents a review of related concepts on illegal petroleum refining and health security. The concepts reviewed include Artisanal petroleum refining in the global community, Correlation between artisanal petroleum refining and health security between Nigeria and South Africa, Causes of increasing operations of artisanal crude oil refining, Health and environmental problems in Rivers State, Theoretical Framework - Resource curse theory and Environmental justice theory.

2.1. Artisanal petroleum refining in the global community

Artisanal petroleum refining can have significant implications on the global community, affecting various aspects such as the environment, public health, economy, security, and social well-being. The abundance of oil in a country can be advantageous and very beneficial, and it does not spontaneously lead to the oil curse. However, the existence of oil and the enormous inflow of oil profits, if not handled effectively by the host government, can depreciate a nation's economy, lead to health challenges, encourage corruption, and foster an environment that encourages violence [6].

Oil-producing nations frequently suffer from a degree of Dutch disease, which is mostly brought on by the host nation's ineffective handling of the enormous stream of dollar-valued oil income. Dutch disease is almost practically inevitable in nations where oil is the main export. The real exchange rate of the nation starts to rise as foreign money starts to come in to pay for the oil. Imports become less expensive while exports to the nation increase in value. As local prices for domestic output start to climb and exports decline, local manufacturing and agriculture suffer. Populations that are excluded from the oil boom suffer from this inflation [8]. Several developing oil-producing nations, including Algeria, Colombia, Ecuador, Nigeria (where oil production has negatively impacted existing cocoa, palm oil, and rubber industries), Trinidad, and Venezuela, have experienced a decline in their manufacturing and agricultural sectors due to Dutch disease. This phenomenon often leads to job losses and reduced economic opportunities in these sectors, particularly affecting vulnerable segments of society, despite the economic upturn driven by oil revenues [9].

The primary hub for the importation of illegally processed petroleum is located within the five Sahel nations of Burkina Faso, Chad, Mali, Mauritania, and Niger. It is estimated that these countries collectively consume approximately 90,500 barrels per day of motor petrol and distillate fuel oil (diesel), totaling over 33 million barrels annually, equivalent to more than five billion liters. Based on an average retail price of \$1 per liter, the combined annual market value of both legal and illicit fuel in this region exceeds \$5 billion. Despite Mauritania, Niger, and Chad being oil producers, only Chad and Niger possess the industrial capacity to refine crude oil into fuel. Nevertheless, these Sahelian nations heavily rely on illicit gasoline imports from neighboring countries, some of which are significant oil producers and fuel exporters in Africa [9].

Algeria, Nigeria, and Libya, members of the Organization of the Petroleum Exporting Countries (OPEC), share borders with Sahel countries except Burkina Faso. Crude oil cannot be directly utilized as fuel; it necessitates refining before it can power generators and vehicles. Both Nigeria and Libya lack substantial refining capacity

relative to their oil production capabilities, whereas Algeria possesses adequate refining infrastructure [4]. Despite their significant oil extraction capacities, Algeria, Libya, and Nigeria still depend on imports of refined petroleum products to meet domestic demand. These imports are heavily subsidized by all three nations, resulting in subsidized prices for gasoline and diesel at retail outlets.

Fuel trafficking into the Sahel is predominantly motivated by the competitive advantage of lower fuel prices in Algeria, Libya, and Nigeria, where a substantial portion of the trafficked fuel consists of official government-subsidized petroleum from these countries. While Nigeria experiences oil theft and artisanal refining, these activities primarily occur within the Niger Delta and extend into Cameroon, rather than serving as a major source of fuel trafficking into the Sahel [10]. There are apprehensions regarding the smuggling of Niger-generated fuel into northern Mali, alongside concerns about the trafficking of subsidized fuel within the region.

According to [11], the Sahel nations rely significantly on imports of refined fuel, including illegal shipments from Algeria, Libya, and Nigeria, despite having limited local production capacity. Illicit fuel flows into these countries vary in structure, influencing their respective markets. Some flows are well-organized and controlled by a few dominant entities involved in illegal import and export activities, while others are entirely informal, involving numerous independent operators responding to market demands. Profits generated depend on the volume of smuggled fuel, as well as the price and markup, with the latter increasing in accordance with the level of risk involved.

In Nigeria, Rivers State has become the hub for illegal petroleum refining, which exports illegally refined petroleum to neighboring countries. Rivers State is a significant region located in the Northern part of the Niger Delta. Most parts of this state are characterized by a riverine domain (wetland). These wetlands are vital to the survival of the local population, who rely on them for both food and income [8]. Rivers State, in Nigeria's Niger Delta, is a major oil hub. Black soot deposition in the environment has plagued the region for over five years due to the emergence of multiple illegal crude oil refineries in and around [12].

According to [13] cited in [11], the activities of artisanal crude oil refining are prevalent in Rivers State and have deteriorated the air and water quality which has become unhealthy for human consumption, this has however negatively affected the health of the people. The Niger Delta region has witnessed the emergence of local technology for petroleum refining in response to the challenges of underdevelopment, poverty, and the escalating cost of refined petroleum products for domestic consumption in Nigeria, particularly in Rivers State [8].

According to [14] cited in [8] the equipment that is utilized for the functioning of illegal crude oil refining is locally crafted and acquired. These types of equipment include, but are not limited to; Pipes, tanks, drilling machines, drums, dried wood, Cotonou boats, firewood, crude oil, pumping machines, rubber hoses, and storage facilities, among many other things. According to [14], cited in [8], few people are needed to operate this illegal business efficiently and effectively in a convenient manner. Depending on the processing capacity that is selected or the entrepreneurial aptitude that is embraced, it requires a low capital outlay to get it started. Setting up the refinery is not complicated, and it makes good use of resources [5].

2.2. A comparative analysis between Nigeria and South Sudan on the correlation between artisanal petroleum refining and health security

South Sudan possesses abundant natural resources including forestry, pasturelands, wildlife, domestic animals, soils, water, oil, and minerals. However, the extraction and production of oil in the country contribute significantly to environmental degradation, impacting human health, animal populations, and plant life. Pollution in affected areas results from the mixing of hydrocarbons and organic substances with heavy metals. Local communities have raised concerns about environmental pollution and associated health risks stemming from petroleum waste disposal practices [7]. The study conducted by [15], shows the analysis of public health with the rise in the operations of unauthorized refining of oil. According to the study, 88.2% of the respondents indicated an increase in the distortion of newly born children and 93.8% reported that the death of infants was

increased. This has also been the case in Nigeria, where there are numerous cases of child-related defects among people living in areas where artisanal petroleum refining activities occur.

In the same trend, [7] in their study on Phytoremediation of crude oil contaminated soil using Sudanese plant species *Acacia sieberiana* Tausch, reflects the downturn trend of health security among the Sudanese, particularly among the Melut and Maban counties of the upper state of South Sudan. The study documented an increase in symptoms such as throat irritation, skin irritation, and rashes among the population, which correlated with elevated levels of polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) commonly found in crude oil.

2.3. Causes of increasing operations of artisanal crude oil refining

A lot of factors have led to the rise in the operations of artisanal crude oil refining in Rivers State and in the Niger Delta as a whole. According to [5], unemployment and poverty in the area are contributing factors to the rise in the activity of illegal crude oil refining. In Nigeria, as of the latest National Multidimensional Poverty Index for 2022, approximately 133 million people, constituting 63% of the population, experience multidimensional poverty. This contrasts with the 2018–19 national monetary poverty line, which indicates that 40.1% of Nigerians live below the poverty line. In the second quarter of 2023, the labor force participation rate among the working-age population remained robust at 80.4%. During the same period, the employment-to-population ratio stood at 77.1%.

In the second quarter of 2023, the combined rate of unemployment and underemployment due to insufficient work hours was 15.5% among the labor force (LU2). The unemployment rate in Q2 2023 stood at 4.2%, showing a slight increase of 0.1% from Q1 2023 (4.1%). Among young people aged 15-24 years, the unemployment rate in Q2 2023 was 7.2%, up from 6.9% in Q1. In urban areas during the same period, the unemployment rate rose to 5.9% from 5.4% in Q1. Additionally, 13.8% of young individuals were classified as NEET (Not in Employment, Education, or Training) in Q2 2023. (NEET Rate). (National Bureau of Statistics, 2023).

According to residents, artisanal crude oil refining has alleviated public suffering and employed a large number of women, men, and young people in Niger Delta villages, despite the region's rising unemployment and poverty rates. Products obtained by clandestine bunkering with crude oil are sometimes referred to as "kpofire." The individuals involved claimed to earn up to \$93,600 (₦70,668,000) annually. However, the cost of constructing an illegal crude oil bunkering site is just around \$4,700 (₦3,548,500) at a rate of \$755 to \$1.

Marginalization and neglect of the inhabitants of Rivers State as a major factor for the increasing presence of artisanal oil refineries in the area [16]. Many in the Niger Delta believe that the region's oil riches are being diverted to the more developed cities of Abuja and Lagos, despite the fact that those in the Niger Delta itself lack access to even the most fundamental of social services. There are some of the world's poorest people living in villages where oil is being explored in Rivers State. Their farmlands and rivers have been severely damaged, and they have no viable means of earning a living [17]. Most villages in Rivers State, which are already wracked by extreme poverty, typically have petroleum and gas conveying pipes running through them, which in most cases are not in good condition thus having leakages. This has however caused: loss of vegetation, destruction of mangrove and salt swamps, corrosive vapor from oil and gas handling dissipation and flaring, releasing residue into the environment and many more [13]. As a result, the youths of this region have resulted in taking what they consider theirs due to their dissatisfaction with the conditions in which they live. However, rather than providing a solution, the youths are further damaging the health and environment of the region by benefiting from their operation of illegal crude oil refineries [18].

According to [19], the scarcity and high price of fuel and kerosene throughout the Niger Delta is a contributing factor to the rise in the operation of artisanal oil refineries. The rising cost of petroleum is commonly thought to have stimulated the creation of local markets therefore creating a high demand for cheap supply of locally refined crude. The proponents of illegal oil refining have contended that their operations have fostered a flourishing economy in the Niger Delta region, owing to the establishment of a sophisticated supply chain [20].

2.4. Artisanal petroleum refining in scaling up health and environmental problems in rivers state

Artisanal or illegal crude oil refining has escalated health and environmental problems in Rivers State, particularly in the LGAs of Degema, Ogo-bolo, and Degema. The people in these areas have been plagued with increasing health challenges caused by frequent exposure to residues from the activities of artisanal refining of petroleum. The potential for artisanal crude oil refineries in Rivers State to pollute the area's air, water, land, and various forms of life has been identified as a significant threat [16].

There is no debate that it is a matter that should be of considerable worry due to reports of its association with a variety of fatal ailments including lung disorders, cancer, heart diseases, respiratory illnesses, and birth-related defects among other types of mortality [11]. As a direct result of the activities of illegal crude oil refineries in the area, the production of black soot has led to an increase in air pollution.

The implication of this illegal activity on the health of residents in Degema, Ogu-bolo, Opobo, and Rivers State, in general, has brought about a high mortality rate. Residents are faced with life-threatening sicknesses and diseases such as asthma, birth-related defects, breathing problems, chest pain, cough, heart disease, irritation of the eyes, lungs disorder and respiratory illness. Black soot that results from artisanal oil refining exposes human health to excessive and unavoidable degrees of air pollution, which in turn poses a huge health risk to the inhabitants of the areas in which it occurs [21]. There has been a rise in the occurrence of skin infection, cough, and asthma aggravation among the native population of Rivers State.

Research [21] explains that when these fine soot particles ($PM_{2.5}$) are inhaled, can go deep into bronchiolar tissue, where they can trigger oxidative stress, pulmonary inflammation, and even damage to the deoxyribonucleic acid (DNA) in cells. Long-term risks include arrhythmias and lung cancer, while short-term effects include irritation of the eyes, nose, and throat, chest tightness, wheezing, dyspnea, and acute exacerbation of asthma.

A study [22] was conducted to determine how illegal Nigerian crude oil refiners' operations had affected the surrounding neighborhoods as well as how it affected the health of people. The study used a quantitative research approach by surveying local stakeholders (including chiefs, youth, farmers, traders, fishermen/women, and inhabitants of affected villages) to discover how their livelihoods have been impacted by the nearby crude oil refineries. The research findings demonstrated that crude oil waste from nonstandard refining sites had a significant negative impact on farmlands and product yields of the host communities in which these illegal refiners operate.

Researchers [23] argue that the health of the people is in jeopardy as two of the major sources of life which are food and water are threatened by the spills of crude oil from illegal refineries. The farmland which the people depended on for food and occupation is being destroyed, thus leaving them with no food and no occupation. The result of the study also showed that since there are no alternatives to the source of water supply except the polluted river, the people are greatly affected, thus drinking polluted water and having health implications.

2.5. Theoretical framework

2.5.1. Resource curse theory

The resource curse theory, also known as the paradox of plenty, highlights how nations rich in natural resources often experience slower economic growth and development despite their abundance. This theory, coined by Auty in 1993, observes that countries endowed with substantial natural resources, like fossil fuels and minerals, tend to exhibit lower economic growth rates, reduced democratic governance, and poorer overall development outcomes compared to countries with fewer resources [24]. This phenomenon is observable in Rivers State, Nigeria, a region abundant in crude oil. Despite its resource wealth, Rivers State and Nigeria struggle with underdevelopment, slow economic growth, and inadequate welfare for their citizens. Over-reliance on oil exacerbates corruption risks. Funds derived from oil-related royalties and taxes are often misused through

corrupt practices in public procurement, benefiting select individuals and political elites instead of fostering public goods [1].

Due to the neglect in benefiting from oil wealth, Rivers State residents engage in illicit activities such as oil theft and pipeline vandalism to access crude oil for local refining and sale as a means of livelihood [25]. However, this illegal refining has resulted in increased health issues among the residents of Rivers State.

2.5.2. Environmental justice theory

The environmental justice theory serves as a bridge between the realms of nature and society, advocating for environmentalists to prioritize not only the preservation of wilderness and natural ecosystems but also the ecological health of human communities, particularly those that are economically disadvantaged, minority, or indigenous. This framework emphasizes the moral imperative of extending ethical considerations to nonhuman aspects of nature within the context of environmental justice concerns, thereby expanding the discourse of the environmental justice movement to encompass our ethical responsibilities toward the natural environment. This theory propounded by David Schlosberg, argues for the foundations of a more unified green movement, built on a set of common conceptions of justice [26].

This phenomenon is observable in Degema, Ogu-bolo, and Opobo LGAs, where the ecological health of human communities is not treated with justice, particularly poor, minority, and Indigenous communities, thus the green movement is being eroded. This theory is relevant in this study as it emphasizes the protection of nature for moral consideration promoting the capabilities needed for their functioning and flourishing.

3. Research method

This study adopted a quantitative and qualitative research approach to investigate the relationship between artisanal petroleum refining and health security in Rivers State, Nigeria. The primary method of data collection was through a structured survey administered to a randomly selected sample of the population as well as interviews with 9 health care professionals, 3 health care professionals each from the LGAs were interviewed. A cross-sectional survey design was chosen for this study to capture a comprehensive overview of the relationship between illegal petroleum refining and health security at a specific point in time. This method allows for efficient data collection from a diverse population within a short timeframe, providing a broad overview of how these variables correlate across different groups or regions. The study focuses on residents of Rivers State, Nigeria, where illegal petroleum refining is prevalent. The estimated population size is approximately 686,900 individuals, encompassing various communities and villages across the selected LGAs. The current estimated population of Ogu-bolo LGA is 108,300. Opobo LGA's population is currently estimated to be 219,800 and that of Degema LGA is currently estimated to be 358,800 (National Population Commission, 2023). Three local government areas (LGAs) Degema, Ogu-bolo, and Opobo were purposively selected based on their reported incidence of illegal petroleum refining activities. Within each selected LGA, villages were identified and grouped into clusters based on geographical proximity and administrative divisions. Using a random number generator, a predetermined number of clusters were randomly selected from each LGA. This method ensured that every cluster had an equal chance of being included in the study. The villages included were Agwe and Ndoni from Ogu-bolo LGA, Bakana, Bille, Bukuma, and Ogurama from Degema LGA, and Epele and Minima from Opobo LGA. The sample size of 384 participants was determined using the sample size formula for proportion estimation:

$$\frac{\frac{Z^2 \times P (1 - P)}{e^2}}{1 + \left(\frac{Z^2 \times P (1 - P)}{e^2 N} \right)}$$

Where; N = Population size = 686,900

Z = Z score = 1.96

E = Margin of error (Confidence level) = 95%

P = Standard of deviation = 0.5

$$\begin{aligned}
 \text{Sample size} &= \frac{\frac{1.96^2 \times 0.5(1-0.5)}{0.05^2}}{1 + \left(\frac{1.96^2 \times 0.5(1-0.5)}{0.05^2 \times 686,900} \right)} \\
 &= \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} \\
 &= \frac{3.8416 \times 0.25}{0.0025} \\
 &= \frac{0.9604}{0.0025} \\
 &= 384.16 \\
 &1 + \left(\frac{1.96^2 \times 0.5(1-0.5)}{0.05^2 \times 686,900} \right) \\
 &= 1 + \frac{3.8416 \times 0.25}{0.0025 \times 686,900} \\
 &= 1 + \frac{0.9604}{1,717.25} \\
 &= 1 + 0.00055927 \\
 &= 1.00055927 \\
 &= \frac{384.16}{1.00055927} = 384
 \end{aligned}$$

This study employed correlational analysis to investigate the relationship between the dependent variable, "health security," and the independent variable, "illegal petroleum refining." The data obtained were subjected to Pearson correlation and one-way analysis of variance using SPSS software to test the correlation. The test of correlation on the relationship between illegal petroleum refining (-.439) and health security (1) in Rivers State, indicated a moderate negative correlation, which is significant at 0.01 level (2-tailed). In order words, there is an inverse relationship between health security and illegal petroleum refining; which means that health security decreases as illegal petroleum refining increases. The correlational analysis is suitable for examining the extent and direction of association between variables without implying causation, making it appropriate for exploring relationships between variables that may influence health security.

3.1. Data analysis

3.1.1. Response rate of questionnaire administered

Table 1 presents the tabulated frequencies of responses received from the surveyed population in response to the questionnaire.

S/N	Degema LGA	Ogu-bolo LGA	Opobo LGA
1.	157(53.2)	46(15.6)	92(31.2)

In order to infer responses from the study population, a total of 384 questionnaires were systematically distributed. A total of 295 usable questionnaires were collected. The data indicates that the response rate was 76.8%, as evidenced by the total number of usable questionnaires retrieved. According to Yousef (2020), a response rate of 50% or higher is regarded as commendable. Thus, the response rate of 76.8% obtained in the study can be deemed appropriate. Following the fieldwork of the study, it was found that the number of distributed questionnaires in Degema LGA was 200, while in Ogu-bolo and Opobo, the numbers were 61 and 123, respectively. The analysis of the quantitative data obtained from the questionnaire was conducted using both SPSS version 21 and Microsoft Excel.

4. Result and discussion of findings

Data presents the socio-demographic parameters of the study participants. The first theme surveyed the participants' demographic profiles. The second theme was to examine the correlation between illegal petroleum refining and health security in Rivers State. The third theme was to analyze the effects of the operations of illegal crude oil refining on the health of residents in Rivers State.

4.1. Demographic characteristics of respondents

Table 2: Socio-demographic parameters of the study participants

S/N	Variables	Attributes	Frequency	Percentage (%)
1.	Gender	Male	125	42.4
		Female	170	57.6
		Total	295	
2.	Age	18-29	177	60.0
			66	22.4
			19	6.4
			20	6.7
			13	4.4
3.	Highest Educational Qualification	SSCE	8	2.7
		OND/HND	13	4.4
		B.Sc.	175	59.3
		M.Sc.	96	32.5
		PhD	3	1.0

Table 1 presents the demographic characteristics of the study participants. The aforementioned comprises the demographic information of the participants, encompassing their age, gender, and educational attainment. It reveals that 125 individuals, constituting 42.3% of the total sample, were male. Conversely, the female demographic constitutes 57.6% of the total populace, comprising a total of 170 individuals. Based on the data, the study exhibited a higher proportion of female participants in comparison to male participants.

Age Distribution: The study participants' age groups were classified as follows: The age group of 18-29 constituted the majority of the sample population, with 177 individuals, representing 60.0% of the total. On the other side, 66 people fell into the age range of 30 to 39, making up 22.4% of the entire population. 19 participants, comprising 6.4% of the total sample, were categorized within the age range of 40-49 years. The age group of 50-59 years was represented by a number of 20 participants, representing 6.7% of the total sample. 13 individuals, accounting for 4.4 % of the total sample, were categorized as being aged 60 years or above.

Educational Qualification Distribution: Among the people who took part in the study, there were a total of 8 people who had a Senior Secondary Certificate Examination (SSCE) as their highest degree of educational attainment. This percentage represented 2.7 % of the sample. 13 participants, accounting for 4.4 % of the sample, indicated that their highest level of educational attainment was an OND/HND (Ordinary National Diploma/Higher National Diploma). A B.Sc. (Bachelor of Science) was the highest educational qualification held by 175 persons, accounting for 59.3% of the total. Within the sample, 32.5% of individuals, totaling 96, had achieved M.Sc. (Master of Science) as their highest level of educational attainment.

Finally, three people, representing 1.0 % of the total, held a Doctor of Philosophy (Ph.D.) as their highest level of education. The presented data depicts the distribution of research participants across different levels of educational attainment. The results indicate that a significant proportion of the sample (59.3%) held a Bachelor of Science degree, with the second largest group (32.5%) possessing a Master of Science degree.

4.2. Correlation test on the relationship between artisanal petroleum refining and health security in Rivers State

The correlation analysis in Table 2 indicates a moderate negative correlation between health security and artisanal petroleum refining in Rivers State. This means that there is an inverse relationship between these two variables. When artisanal petroleum refining increases in the region, the analysis suggests that health security tends to decrease. This implies that, as the incidence of artisanal petroleum refining operations rises, it has a detrimental effect on the overall health security situation in Rivers State. This negative impact could manifest in various ways, such as increased environmental pollution, health risks associated with exposure to toxic substances released during refining processes, and potential accidents or incidents related to these illicit activities.

Table 3. Correlation test between illegal petroleum refining and health security

		Health security	Artisanal petroleum refining
Health Security	Pearson Correlation	1	-.439**
	Sig. (2-tailed)		.000
	N	295	295
Illegal Petroleum Refining	Pearson Correlation	-.439**	1
	Sig. (2-tailed)	.000	
	N	295	295

**Correlation is significant at the 0.01 level (2-tailed).

On the other hand, when artisanal petroleum refining decreases, the analysis suggests that health security tends to improve. This implies that as efforts are made to reduce or control artisanal petroleum refining activities, the overall health security situation in Rivers State shows signs of improvement. This could be due to reduced pollution levels, lower health risks for the population, and enhanced safety measures implemented to prevent accidents or incidents related to artisanal refining. The correlation analysis indicates a relationship between these two variables.

Nine health care practitioners, three each from Degema, Ogu-bolo, and OPobo, reported that the sicknesses and diseases the indigenes experience, which have been listed in Table 4 include: asthma, birth-related defects, breathing problems, catarrh, chest pain, cough, heart disease, irritation of the eyes and nose, lungs disorder, nasal disorder, nausea, respiratory illness, skin irritation and sore throat, are as a result to the operations of artisanal crude oil refining. The health care practitioners and the locals argued that these fatal diseases were not common among them before the increase in the operations of artisanal petroleum refining and thus their health was mostly in good condition, they argued further that if there was probably an ailment it was usually stomach pains, headaches, constipation, and malaria, which was always treated with local herbs.

However, with the increase in the operation of artisanal petroleum refining, complicated health conditions which are incurable by their local herbs have continued to be on the rise resulting in a decrease in the health security of the people. The lack of standard hospitals in their communities to treat these diseases has led to a high mortality rate among the people. Furthermore, relocating to regions where hospitals meet established standards, the cost of medical expenses proves prohibitive, requiring individuals to cope with these health conditions with limited financial resources.

4.3. Operations of artisanal petroleum refining on the health of residents in Rivers State

Based on a 4-point scale organized into categories; very often, often, not often, and never, the study respondents gave their responses on how often they are exposed to residues from illegal petroleum refining. Out of the study participants 295, a total of 210 individuals, representing 71.1% of the sample, indicated ‘very often’ being exposed to the residues from artisanal petroleum refining. A total of 50 respondents, comprising 16.9 % of the sample, signified that they are being exposed to residues from illegal petroleum refining often. A total of 22 (7.4%) respondents signified that they are not exposed to these residues often, while 13 (4.4%) stated that they have never been exposed.

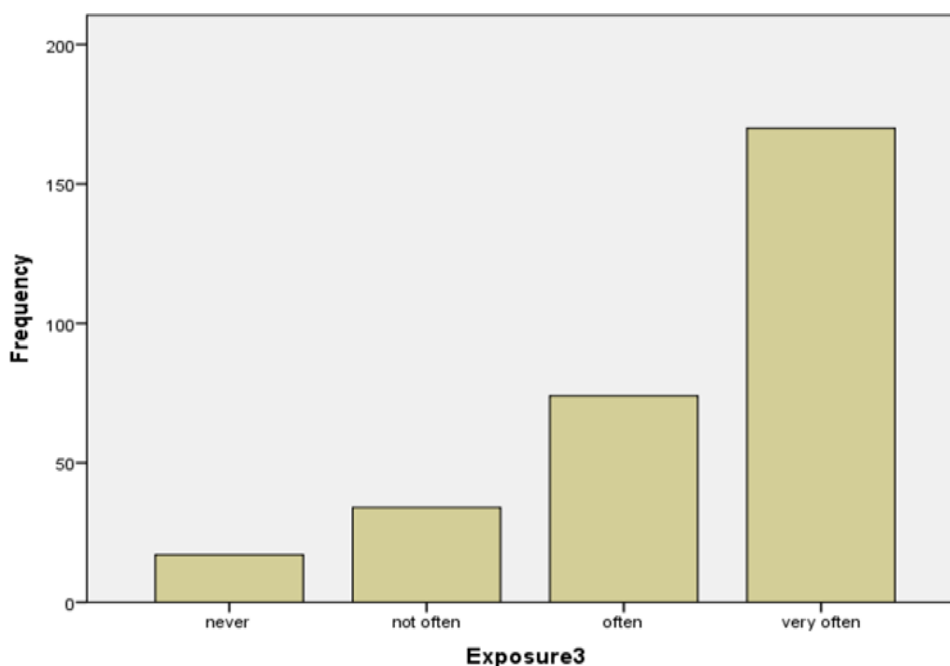


Figure 1. Bar chart showing the response distribution on the question ‘How often are you exposed to residues from illegal crude oil refining?’

The findings of the study show that the majority of the people from Degema, Ogu-bolo, and Opobo LGAs are frequently exposed to residues from illegal petroleum refining. The people believe that this exposure has impacted their health negatively and has caused them to experience health challenges more than ever before.

Regarding health challenges, 202 respondents, making up 68.4 % of the total, claimed to experience health challenges as a result of the operations of artisanal petroleum refining. 80 respondents, representing 27.1% of the total, stated that they do not experience any health challenges, while 13 individuals, accounting for 4.4% of the total, indicated unawareness of whether they have health challenges or not.

Table 4. Specific health challenges experienced by the respondents

S/N	Health Challenges	Frequency	Percentage (%)
1.	Asthma	25	8.4
2.	Birth related defects	18	6.1
3.	Breathing problem	14	4.7
4.	Catarrh	2	0.6
5.	Chest pain	16	5.4
6.	Cough	69	23.3

S/N	Health Challenges	Frequency	Percentage (%)
7.	Heart disease	7	2.3
8.	Irritation of the eyes	7	2.3
9.	Irritation of the nose	9	3.0
10.	Lungs disorder	10	3.3
11.	Nasal disorder	3	1.0
12.	Nausea	3	1.0
13.	Respiratory illness	11	3.7
14.	Skin irritation	5	1.6
15.	Sore throat	3	1.0

Table 4 above shows the responses on specific health challenges faced by the respondents as a result of artisanal crude oil refining. It is evident from the findings that the operations of illegal petroleum refining have continued to have a negative effect on the health of the residents. The most frequently mentioned health concern was cough, with 69 respondents (23.3%) reporting experiencing this health issue. The operation of illegal petroleum refining frequently entails the production of petroleum commodities in impoverished and unregulated facilities, which may discharge hazardous substances into the surrounding ecosystem. The substances encompass a range of volatile organic compounds (VOCs), including but not limited to benzene, toluene, and xylene, in addition to sulfur compounds and particulate matter [11]. When individuals are exposed to these toxic residues, either through inhalation or direct contact, it can irritate the respiratory system and lead to respiratory symptoms such as coughing. The presence of toxic compounds has the potential to irritate the mucous membranes that line the respiratory tract, including the nasal cavity, the throat, and the lungs. This irritation can lead to irritation and the triggering of a cough reflex [27].

The people believe that the sicknesses and diseases they experience are due to the operations of illegal crude oil refining which have been listed in Table 4 to include; Asthma, Birth related defects, breathing problems, catarrh, chest pain, cough, Heart disease, Irritation of the eyes, Irritation of the nose, lungs disorder, Nasal disorder, Nausea, Respiratory illness, skin irritation and sore throat. The environment is consistently contaminated by crude oil spills in water, land, and air, posing health risks to humans, fish, and other aquatic organisms. This pollution has severely impacted local fishing industries and rendered agricultural land unsuitable for cultivation. Residents also expressed concern over illegal crude oil refining contributing to acid rain, which corrodes building roofs and contaminates rainwater, a primary source of drinking water during the rainy season [28]. They attribute various respiratory ailments such as asthma, birth defects, lung diseases, skin irritations, and heart conditions to the consumption of water contaminated by crude oil. Illegal bunkering has exacerbated hardship and significantly harmed human, plant, and animal life in their vicinity [29].

4.4. A way forward

The research findings indicate that achieving health security in Rivers State hinges on curtailing or eliminating artisanal petroleum operations. The Nigerian government has enacted various policies and initiatives focused on harnessing the knowledge and skills of its populace to foster employment and economic growth, exemplified by efforts in industrialization and economic diversification.

Harnessing the skills of local individuals proficient in petroleum refining through the establishment of adequately equipped refineries and enhancing their capabilities will significantly lead to employment opportunities and foster economic growth. This approach promises mutual benefits for both citizens and the Nigerian government, representing a win-win strategy. By implementing well-established refineries with a focus

on safety protocols, the leakage of residues can be mitigated, thereby reducing health risks associated with petroleum refining and advancing health security in the area.

Furthermore, instead of exporting Nigeria's crude oil for external refining at considerable expense, the government should capitalize on the indigenous skills and knowledge base to establish domestic refining capacity. This initiative stands to bolster Nigeria's economy, diminish unemployment—recognized as a pivotal driver of illicit petroleum activities—and alleviate poverty. Research indicates that domestically refined petroleum products from these purportedly illegal sites often exhibit superior quality and safety compared to imported equivalents, suggesting a compelling case for governmental consideration. Thus, leveraging local expertise contributes to human capital enhancement, heightened health security, expanded employment avenues, and national economic development.

This research also advocates for the policy change implemented by the former governor of Rivers State, Minister Nyesom Ezenwo Wike. The policy of eradicating and destroying illegal sites for refining petroleum by the Joint Task Force should be stopped, as it further destroys the environment, causes more dangers to health, increases pollution, and destroys farmland [30]. Coupled with the fact that illegal refineries are cheap and easy to set up, it only becomes a repeated process of destroying and setting back up for operation. Rather, implementing training programs and harnessing locals' skills will eliminate health risks associated with illegal petroleum refining.

The findings of this research underscore the critical necessity for adequately equipped healthcare facilities and medical services in Degema, Ogu-bolo, and Opobo LGAs. Policymakers and the Rivers State Government should allocate resources towards constructing hospitals and deploying healthcare professionals to these regions. This proactive approach aims to provide treatment for individuals already afflicted by illnesses stemming from these activities, thereby enhancing health security and reducing mortality rates.

5. Conclusion and recommendations

To conclude, illegally refining petroleum presents considerable hazards to public health security, affecting not only those engaged in the unlawful practice but also the inhabitants of nearby refining locations. Empirical investigations and scholarly inquiries have illuminated the environmental implications of illegal refining, encompassing atmospheric and aquatic contamination, soil deterioration, and ecological harm. Illegal petroleum refining emits harmful pollutants that possess the potential to cause adverse health effects, including but not limited to respiratory ailments, skin disorders, and cancer.

Based on the established relationship between illegal petroleum refining and health security, it is recommended that illegal petroleum refining calls for a multifaceted strategy that includes law enforcement, regulatory controls, community involvement, and public health initiatives. Together, these organizations can lessen the practice of illegal petroleum refining, help build a safer and more comfortable atmosphere, and improve health security. Also, by harnessing the knowledge and expertise of the locals, the Nigerian Government can create employment opportunities, thus reducing unemployment rates and improving the overall economy. Moreover, refining crude oil locally can promote a safer environment by implementing stringent quality control measures and reducing the risk associated with transporting crude oil over long distances. This approach can help prevent accidents, oil spills, and other environmental hazards, ensuring the protection of local ecosystems and communities.

6. Limitations and further studies

This research is not free from limitations. The study focuses majorly on Degema, Opobo, and Ogu-bolo local government areas in Rivers State, leaving other LGAs where illegal petroleum refining occurs. The study also focuses on the impact of illegal petroleum refining on health security and does not focus on other areas such as its impact on the economy of the State, the multinational petroleum companies, and its impact on climate change. Lastly, the study focuses only on Rivers State.

The following suggestions for future studies are drawn from the limitations of the study. Further studies can focus on other LGAs in Rivers State where illegal petroleum refining is being carried out. The impact of illegal petroleum refining on other areas can be observed in future studies. Also, other states where illegal petroleum refining is being practiced can inform the basis of further studies.

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Declaration of competing interest

The authors do not have any conflicting interests.

Author contributions

Background to the study, G. U. Osimen, and I. E. Pokubo; Conceptualization, A. M. Oladoyin, and G. U. Osimen; Methodology, A. M. Oladoyin, and I. E. Pokubo; Software, G. U. Osimen; Validation, A. M. Oladoyin, and G. U. Osimen.; Formal Analysis, I. E. Pokubo, and G. U. Osimen; investigation, A. M. Oladoyin and I. E. Pokubo.; data curation, G. U. Osimen; Writing - original draft preparation, A. M. Oladoyin; writing - review and editing, I. E. Pokubo and G. U. Osimen; Visualization, A. M. Oladoyin, and G. U. Osimen; Supervision, A. M. Oladoyin; Project Administration, I. E. Pokubo. All authors have read and agreed to the published version of the manuscript.

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