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Risk of Faecal Contamination of Water Used by Food Vendors in Owerri Munipality, Imo State Nigeria

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Abstract:

Assessment of faecal contamination of water is a key factor in assessing the quality and safety of food. It also reveals the level of hygiene adopted by food handlers in the course of preparation and serving of such foods. This study assessed the risk of microbial contamination of water used by food vendors in Owerri munipality, Imo State Nigeria between January-December 2019 with an emphasis on total coliforms and the faecal coliforms/ faecal indicator bacteria (FIB) – *Escherichia coli* (*E. coli*) and thermotolerant coliforms (TTC). One hundred and thirty water samples collected across three vending types (street vendors, high level and low level restaurants) were evaluated for microbial contamination using standard methods. Data obtained was statistically analyzed with p-value set at 0.05 significance level. The result identified *Enterobacter* spp. and *Klebsiella* spp. The result showed that 48.46% (63) of the 130 water samples examined were contaminated with coliform bacteria, of which 20 (22.22%) samples had faecal coliform bacteria, representing 10.77% of the entire water samples examined. Of the 64 samples from water used for food preparation, 12.50% (8) had faecal coliform bacteria as against 9.09% (6) of 66 samples collected from water offered to customers for drinking. The result showed that 116 (89.23%) of the 130 water samples recorded no faecal coliform contamination, hence they were considered excellent based on the guidelines for determination of faecal contamination of water. Two samples had faecal coliform counts of 1-3 per 100 ml of water accounting for 1.54% of water samples, which is considered Satisfactory. The result revealed suspicious (4-9 per 100 ml) coliform count in 9 (6.92%) water samples, while three water samples (2.31%) had ≥10 count and are classified as unsatisfactory. The result revealed that 89.23% (116) of the examined water samples were of 'no risk' to the public, which was significantly higher than 8.46% (11) and 2.31% (3) recognized as being of low and intermediate risk respectively ($p < 0.05$). High and very high risk water samples were not encountered in the study. This trend in qualification of risk of water samples reflected in the two types of water usages, and the observed differences was however not statistically significant ($p > 0.05$).

Keywords: *risk, faecal contamination, coliform, food vendor, Owerri*

Introduction

Water is an important medium for the preparation and consumption of food by humans. It is an essential raw material in many street food vending activities. The quality of water used in producing and processing food determines the quality and safety of food. However, water quality and its impact on products and processes are commonly disregarded in food preparation and handling. Contaminated water when utilized for processing food, drinking or washing utensils, equipments and hands is a well-known vehicle

for the transmission of microbial diseases, among which are those caused by coliforms (Angulo *et al.*,1997). Estimates indicate that up to 485,000 diarrhoeal deaths yearly are linked to consumption of contaminated drinking water with the majority of these occurring in sub-Saharan Africa (WHO, 2019a; WHO, 2019b). Cholera, dysentery, diarrhoea, hepatitis, typhoid fever to mention but a few are diseases of public health importance linked to presence of pathogens in domestic water sources (WHO, 2019a).

Coliform bacteria are facultatively anaerobic, gram-negative, non-spore-forming rods that ferment lactose to produce acid and gas at 35±2°C within 24-48 hours. They are recognized as the normal flora of the intestinal tract of humans and animals. They belong to the family Enterobacteriaceae and largely include the genera *Enterobacter, Klebsiella, Citrobacter* and *Escherichia.* The presence of coliforms in water used for food preparation and drinking would therefore largely imply faecal contamination, eventuating in the risk of exposure to pathogens linked with gastrointestinal infections. The faecal indicator bacteria **(FIB)** – *Escherichia coli* (*E. coli*) or thermo-tolerant coliform **(TTC)** are the primary indicators of domestic water contamination with pathogenic micro-organisms. The WHO and Nigerian Standard for Drinking Water Quality guidelines stipulates that FIB should not be detectable in any 100 ml water sample intended for consumption (WHO, 1997; SON, 2015). On the other hand, the presence of total coliforms **(Tc)** in any 100 ml drinking water sample drawn from a supply system suggest treatment failure and possible contamination, since they are regarded as a veritable indicator of cleanliness and integrity in the drinking water distribution system (WHO, 2017).

Street food vendors and restaurants have become an important aspect of the food distribution chain in several poor economies, including Nigeria. The sale and consumption of street foods are on the rise, and this trend will continue (WHO, 2006). The hygienic aspects of food vending operations are a major source of concern. Food safety is the guarantee that food prepared and consumed depending on the intended use will not harm the consumer. A majority of street meals are produced and served in unsanitary settings, with inadequate access to clean water, sanitary services, and waste disposal facilities (Rheinländer *et al.*, 2008). In addition, poor personal hygiene and improper storage among food handlers also accounts specifically for the contamination of water used for food vending purposes.

The conditions described above prevail in Owerri town, an upwardly mobile city in Imo state, South-eastern Nigeria, and are compounded by inadequate access to good pipe-borne water, poorly sited boreholes which litter the city and serves as a major source of water to many and poor drainage systems. This lack of social amenities and municipal utilities has, in no small measure impacted negatively to safety and hygiene of food vending activities in socality. It is on this backdrop that this research on the risk of faecal contamination of ater employed in food vending activities by food vendors in Owerri municipality is reported.

Materials and Methods

Design, Sample Size and Sampling Technique

The study employed a cross-sectional design. Using a simple random sampling technique, water from 55 consenting food vending sites in the municipality were sampled. Two (2) sample types, namely water used for food preparation and drinking water served to customers were collected. Cumulatively, 59 of the samples were from Street vendors, 34 from High-level restaurants, while 37 were from Low-level restaurant making a total sample size of one hundred and thirty (130: 64 food preparation and 66 drinking water samples). The minimum sample size required for the study was ascertained using the Cochran formula (Cochran, 1963).

Study Area

Owerri town of Imo State. Imo State, located in the South-East geopolitical zone of Nigeria, lies

within longitude 5°29'06"N and latitude 7°02'06"E occupying an area between the lower River Niger and the upper and middle Imo River (Government of Imo State, 2006). The Nigeria census in 2006 recorded 3.93 million (2.03 million males and 1.9 million females) as the population of Imo State and the populace is made up of the mainly Igbo ethnic group. The State has a population density of about 707.9 per square kilometer and occupies an area of 5289.49 square kilometers (Government of Imo State, 2006). The major sources of water in Owerri are sub-surface water (Nworie and Otamiri Rivers), and numerous private / commercial bore holes that litter the town.

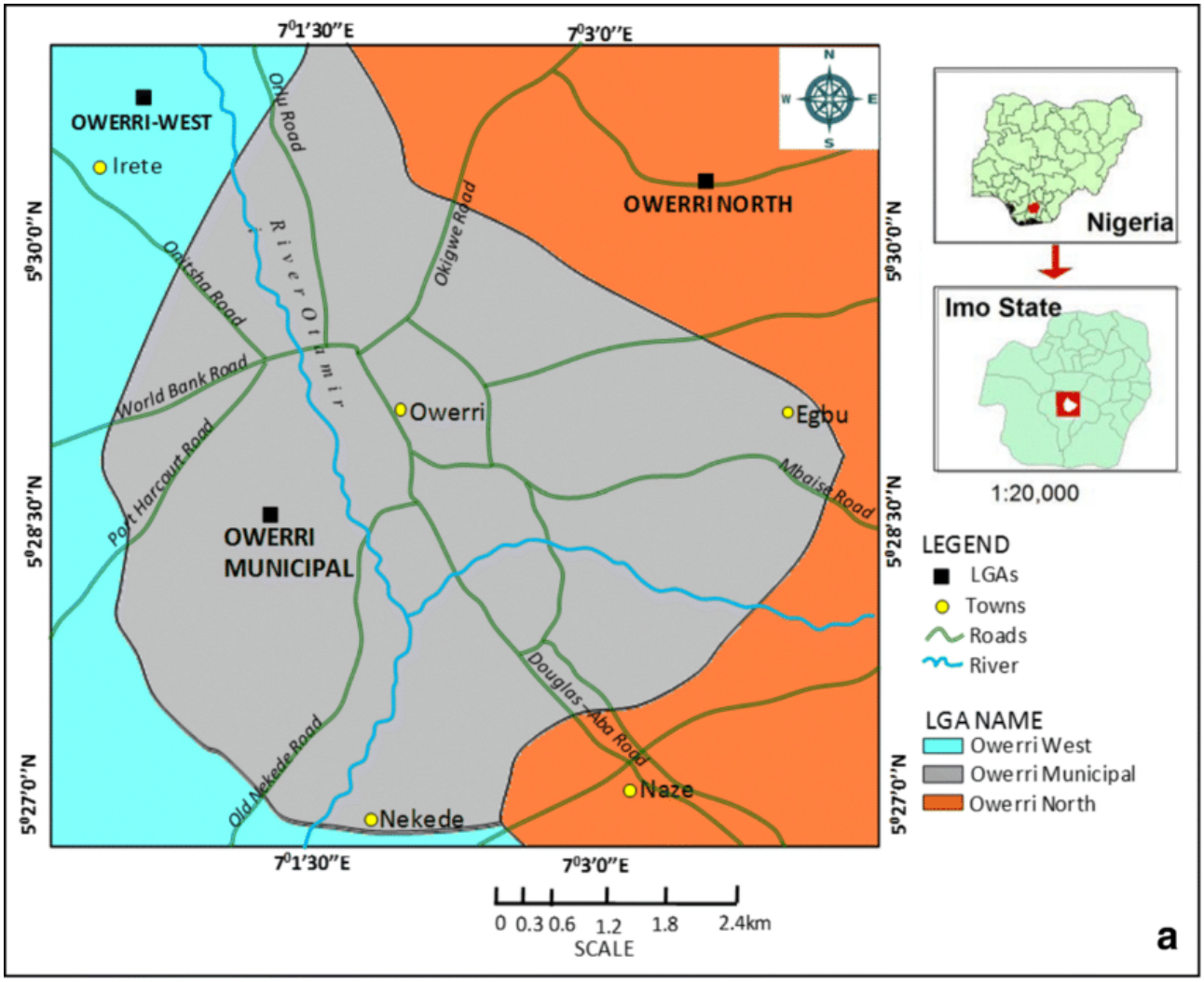

Figure 1. Map of Owerri city Imo State, Nigeria showing the study area
Source: Ibe et al., 2020

Ethical Considerations

Oral/written informed consent to take part in this study was obtained from food outlet managers prior to conducting the study in order to get permission to collect water samples, after adequate information about the objectives and the purpose of the study was provided by the trained research assistants. The confidentiality of the vendors was ensured all through the study. Vendors that declined to participate in the study or withdrew their consent were not penalized or denied benefits.

Study Population

Food vendors in big hotels, schools and hospital cafeterias, five-star restaurants, mid-end restaurants, fast-food outlets, food canteens, food kiosks, roadside food sellers and bukaterias make up the study population.

In this study, restaurants are classified according to food pricing, menu styling, and service;

- High-level restaurant's food price is high, the menu comprises a variety of food items; different meal packages are offered including a buffet system where a minimum of 30 food items is captured in the menu. Each table or customer is assigned a well-dressed uniformed steward to offer service. Major hotels, fast food restaurants, five-star restaurants were grouped as High-level restaurants.

- In low-level restaurants, fixed and limited items are cooked. Buffet facilities are not available; people come to eat regular meals and stewards are limited in number. Usually, the hygiene level is not strictly maintained as in high-level restaurants. Food canteens, Mid-end restaurants, School and hospital cafeterias were grouped as Low-level restaurants.

- Food vendors operating from makeshift and temporary roadside structures, food kiosks, bukaterias and roadside food sellers were profiled as Street food vendors.

Inclusion/Exclusion Criteria

The survey comprised restaurants and other stationary food vending units used for the preparation/sale of street foods, as well as their operators. Mobile food vending units such as pushcarts and their vendors were excluded from the study. Vendors who did not give consent to the study were excluded.

Methodology

Water Sample Collection

A total of 130 water samples (64 food preparation and 66 drinking water samples) were collected from 55 consenting food vending sites. Cumulatively, 59 of the samples were from Street vendors, 34 from High-level restaurants, while 37 were from Low-level restaurants. Water samples were collected based on standard protocols (APHA, 2017). Sample bottles were accurately identified with a reference number, date, time and site of collection as well as water usage type.

Samples were conveyed to the laboratory within three hours of collection in a light-proof insulated cooler box containing ice packs. Analysis of water samples began immediately following sampling to avoid unpredictable changes in the microbial population (Gaudy 1998).

Sample Processing and Analysis

Using a membrane filtration method, 100mls of each water sample was filtered aseptically under partial vacuum through a properly disinfected filtration assembly on which a sterile 0.45µm pore size, 47mm diameter gridded membrane filter has been placed as described by APHA (2017). The membrane filter was aseptically plated as the case may be on an adequately prepared, sterilized, solidified and suitable culture media. Each sample was plated in triplicates.

All inoculated plates were labelled with sample reference number, site, date, time and incubated 24-48 hours. However, plates for enumeration of thermo-tolerant (faecal) coliform were incubated at 44.5^0 C while those for total coliforms were incubated for 35-37°C. At the end of the incubation periods, colonies were enumerated using an illuminated colony counter. Isolates were identified based on their colonial, morphological and biochemical properties following Bergey's Manual of Determinative Bacteriology (Holt et al., 1994).

Grading and Risk Assessment for Faecal Coliform Contamination of Water Samples

The water samples which recorded growth of coliforms were assessed and graded based on the WHO (1991) and WHO (2004) guidelines on water quality which stipulates criteria for faecal coliform contamination grading and risk assessment respectively.

The faecal contamination grading involves use of colony counts per 100ml of each water sample examined to categorize samples into Excellent (0), Satisfactory (1-3), Suspicious (4-9) and Unsatisfactory (≥10). Based on this grading, the faecal coliform load is quantitatively and qualitatively categorized to determine the risk level (No risk, low risk, intermediate risk, high risk or very high risk) the water poses to the consuming populace (WHO,2004).

A South African guideline on domestic water quality was further used to interpret the effect of this risk level on human health. Faecal Coliform counts of 0CFU/100ml has negligible risk of microbial infection; 0–10CFU/ml depicts slight risk of microbial infection with continuous exposure but negligible effects with occasional or short term exposure; 10 – 20CFU/100ml has a risk of infectious disease transmission with continuous exposure and slight risk with occasional exposure; while a count of >20CFU/ml has a significant and increasing risk of infectious disease transmission (DWAF,1996).

Data Analysis

The result is arranged in tables and presented in percentages.

Results

Coliforms identified by the study were *Enterobacter* spp. and *Klebsiella* spp. Table 1 reveals the distribution of the total and faecal coliform in water samples in the vending types. The result showed that 48.46% (63) of the 130 water samples examined were contaminated with coliform bacteria, of which 20 (22.22%) samples had faecal coliform bacteria, representing 10.77% of the entire water samples examined. Of the 64 samples from water used for food preparation, 12.50% (8) had faecal coliform bacteria as against 9.09% (6) of 66 samples collected from water offered to customers for drinking.

Street vendors recorded the highest prevalence of samples with faecal coliform (15.25%), followed by low level restaurants (10.81%), while the least was observed in samples from the high level restaurants (2.94%).

Table 1. Distribution of Total and Faecal Coliform in Water Samples from the Vending Types

	Number of samples (%)		
Vending Type	Total coliform	Faecal coliform	Proportion of Faecal coliform in total coliform
Street Vendor (S)			
Food Preparation N=30	14(46.67)	5(16.67)	5(35.71)
Drinking N=29	18(62.06)	4(13.79)	4(22.22)
Street Total N=59	32(54.24)	9(15.25)	9(28.13)
High level restaurant (R1)			
Food Preparation N=17	9(52.94)	1(5.88)	1(11.11)
Drinking N=17	4(23.53)	0(0.00)	0(0.00)
R1 Total N=34	13(38.24)	1(2.94)	1(7.69)
Low level restaurant (R11)			
Food Preparation N=17	9(52.94)	2(11.76)	2(22.22)
Drinking N=20	9 (45.00)	2(10.00)	2(22.22)
R11 Total N=37	18(48.65)	4(10.81)	4(22.22)
Food Preparation N=64	32(50.00)	8 (12.50)	8(25.00)
Drinking N=66	31(46.97)	6(9.09)	6(19.35)
Grand Total 130	63(48.46)	14(10.77)	14(22.22)

Note: S= Street food vendor; R1 = High level restaurants; R11 = Low level restaurants.

The breakdown of the samples studied on the basis of the guidelines for grading faecal contamination of water is given in Table 2. The result showed that 116 (89.23%) of the 130 water

samples recorded no faecal coliform contamination, hence they were considered excellent based on the guidelines for determination of faecal contamination of water. Two samples had faecal coliform counts of 1-3 per 100 ml of water accounting for 1.54% of water samples, which is considered Satisfactory. The result revealed suspicious (4-9 per 100 ml) coliform count in 9 (6.92%) water samples, while three water samples (2.31%) had ≥10 count and are classified as unsatisfactory.

Among the vending types, suspicious water samples were observed in water from street vendors, 5(8.47%) and low level restaurants, 4(2.70%), while only 3(5.08%) street vendors water samples were unsatisfactory.

Table 2. The Distribution of the Samples Studied Based on the Guidelines for Grading Faecal Contamination of Water

Faecal contamination Class/ Grade					
S/N	Water usage	Presumptive count per100mL (%)			
		Excellent	Satisfactory	Suspicious	Unsatisfactory
		0	1-3	4-10	>10
S	Food preparation N=30	25	0	3	2
	Drinking N=29	25	1	2	1
	Street Total N=59	50 (84.74)	1(1.69)	5(8.47)	3(5.08)
R1	Food preparation N=17	16	1	0	0
	Drinking N=17	17	0	0	0
	R1Total N=34	33(97.06)	1(2.94)	0 (0.00)	0(0.00)
R11	Food preparation N=17	15	0	2	0
	Drinking N=20	18	0	2	0
	R11 Total N=37	33(89.19)	0(0.00)	4(10.81)	0(0.00)
	Food preparation Total N=64	56(87.5)	1(1.56)	5(7.81)	2(3.13)
	Drinking Total N=66	60(90.90)	1(1.52)	4(6.25)	1(1.52)
	Grand Total N=130	116 (89.23)	2(1.54)	9(6.92)	3(2.31)

Note: S= Street food vendors; R1 = High level restaurants; R11 = Low level restaurants.

Table 3 illustrates the risk assessment of the level of faecal coliform contamination of water samples across the vending types. The result revealed that 89.23% (116) of the examined water samples were of 'no risk' to the public, which was significantly higher than 8.46% (11) and 2.31% (3) recognized as being of low and intermediate risk respectively ($p < 0.05$). High and very high risk water samples were not encountered in the study.

This trend in qualification of risk of water samples reflected in the two types of water usages, and the observed differences was not statistically significant ($p > 0.05$). The water samples used for food preparation has slightly lower prevalence for samples of 'No risk' (87.50% vs 87.88%) to customers, but higher prevalence of samples with low (9.38% vs 7.58%) and intermediate risk (3.13% vs 1.52%) than samples from drinking water.

The assessment of the risk posed by water samples based on vending types showed that the water samples also followed the general trend of risk (no risk>low risk>intermediate risk). High level restaurants reported more water samples with 'No risk' (97.06%) to the public, followed by low level restaurants (89.19%); no 'Intermediate risk' sample was observed in the restaurants. The street vending sites recorded more risk samples (15.25% i.e 100 - 84.75%), besides, being the only vending type with samples (3 samples of 11,13,18 CFU per 100ml) that are of intermediate risk to vendors and their customers. Statistical analysis could not show relationship between the vending types and the category of risk of water used.

Table 3. Risk Assessment of Level of Faecal Coliform Contamination of Water Samples Across the Vending Types

Colony forming unit per 100 mL						
		0	1-10	11-100	101-1000	1000+
		No risk	Low risk	Intermediate risk	High risk	Very high risk
S	Food preparation N=30	25	3	2	0	0
	Drinking N=29	25	3	1	0	0
	Street Total N=59 (%)	50 (84.74)	6(10.17)	3(5.08)	0(0.0)	0(0.0)
R1	Food preparation N=17	16	1	0	0	0
	Drinking N=17	17	0	0	0	0
	R1 Total N=34(%)	33(97.06)	1(2.94)	0(0.00)	0(0.0)	0(0.0)
R11	Food preparation N=17	15	2	0	0	0
	Drinking N=20	18	2	0	0	0
	R11 Total N=37(%)	33(89.19)	4(10.81)	0(0.00)	0(0.0)	0(0.0)
	Food preparation Total N=64(%)	56(87.50	6(9.38)	2(3.13)	0(0.0)	0(0.0)
	Drinking Total N=66(%)	60(90.90)	5(7.58)	1(1.52)	0(0.0)	0(0.0)
	Grand Total N=130(%)	116 (89.23)	11(8.46)	3(2.31)	0(0.0)	0(0.0)
KEY: S=Street food vendors; R1= High level restaurants; R11= Low level restaurants.						

Discussion

The quality of water for drinking and other domestic uses is an influential environmental determinant of health therefore access to water of portable quality is paramount. This however may not always be feasible and practical due to poor availability of social amenities and municipal utilities in Owerri municipal. Food handlers are thus prompted to fetch water from unprotected water sources thereby predisposing consumers to water-borne infections. Coliforms isolated in this study belonged to the genera *Enterobacter* and *Klebsiella*. Similar organisms have been reported in previous studies on water in Nigeria and outside Nigeria (Okonko et al., 2008; Prasanna and Reddy, 2009; Olaoye and Onilude, 2009; Oladipo et al., 2009; Oyedeji et al., 2010; Iwuala et al., 2018). Iwuala et al. (2018) reported the presence of *Enterobacter* spp, *Klebsiella* spp., *Escherichia* coli, in addition to *Salmonella* spp and *Proteus mirabilis* in drinking water sources in Okigwe, Orlu and Owerri zones of Imo state. This also aligns with the findings of Oladipo et al. (2009) in their work titled microbiological assessment of vended drinking water in Ogbomosho Osun State Nigeria where they isolated *Enterobacter aerogenes*.

Coliforms count is a hygienic indicator and high coliform counts generally indicates unsanitary condition or poor hygiene practices. Analysis of the reports in this study showed that the total coliform and faecal coliform counts recorded were higher than the permissible level. However, the coliform counts (total and faecal) was found not to be significantly influenced by the water usage type nor the type of vending practised. The implication therefore is that foods and water sold within Owerri municipality are generally "unsafe". The prevalence of positive faecal coliform contamination in all the water samples under consideration in this study was 10.2%; with high level restaurants having a lower occurrence of faecal coliform contamination compared to the other vending types [street vendors (15.5%) > low level restaurants (10.8%)> high level restaurants (2.9%)]. From the foregoing, one is tempted to infer that

hygiene levels is closely associated with the vending type. Notwithstanding, food vendors across the vending types did not live up to expectations. It therefore becomes pertinent that concerted efforts in terms of robust sensitization campaigns, trainings, workshops and government regulations should be channelled to all food vendors. Under the same observation, the municipal town authority must conduct periodic ascertainment of water quality in food outlets as a strategy to improve the microbial quality.

Based on WHO (1991 and 2004) guidelines for determination of faecal coliform contamination grade and risk assessment of water respectively, 89.23% of the water samples studied had no faecal coliform contamination hence posing no foreseeable risk to the populace. Of note is the fact that this number was majorly contributed to by high level restaurants. These observations however do not rule out the potential for water-borne disease outbreak in Owerri municipal from the few faecally contaminated samples. The mere presence of faecal coliforms at concentrations considered as being of intermediate risk even without the concomitant presence of well known entero-pathogens could be a cause of much morbidity among the populace.

Conclusion

The potential risks of poor water quality used by food vendors as revealed by this study cannot be underscored. These are key safety issues that have increased the likelihood of outbreaks of water- and food-borne diseases originating from many of these food vending outlets. To forestall these risks, routine intensive result-oriented inspections of food vendors and food vending sites should be rekindled with penalties instituted for defaulters. Government involvement might include reactivating the public water supply with complementary functional water treatment as well as trainings on food hygiene and safety for food vendors as part of yearly documentation and licensing to practise. There is a need for similar studies to be conducted in other satellite towns in Imo state to provide a holistic view that will impact positively in government planning and policy making.

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