Journal of the Egyptian Society of Parasitology, Vol. 55, No. 1, April 2025
J. Egypt. Soc. Parasitol. (JESP), 55(1), 2025: 81 - 92
Online: 2090-2549

A COMMUNITY-CENTERED ASSESSMENT OF USING INSECTICIDE SPRAYS FOR MOSQUITO CONTROL AND ASSOCIATED FACTORS AMONG RESIDENTS IN DELTA STATE, NIGERIA

By

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Abstract

The community usage of insecticide sprays and associated factors among residents of Delta State, Nigeria, was measured. This cross-sectional study assessed 450 respondents, selected from 3 local government areas (LGAs) of Delta State through multi-stage cluster sampling. A pretested, structured, and open-ended questionnaire was adopted. The socio-demographics and economics of respondents, their knowledge, attitude, and insecticidal usage practice were assessed, as well as the insecticides type available in the area. About 48% of the pooled studied participants used different insecticide brands based on how effective (58%), safe (≈44%), comfortable (≈33%), affordable (≈26%), and available insecticides were ($p>0.05$).

Household preferred the insecticide brands was significantly dependent on the dwelling/ house types and locations ($p<0.05$). Most respondents used Raid insecticides every 1-2 days per week (18%). The education level, dwelling type, and financial status of participants were significant determinants of insecticidal application time ($p<0.05$). The insecticidal spraying level was below WHO's target of 80% coverage. Respondent's knowledge was moderate, but their attitude and practice were low. Adequate health care education on knowledge, attitude, and practice, as well as finance, should be considered in designing routine guidelines for the indoor residual spray (IRS). This could effectively help in managing insecticidal resistance.

Keywords: Attitude, Knowledge, IRS, Insecticide brands, Mosquito, Practice.

Introduction

Mosquito-Transmitted Diseases (MTDs), such as lymphatic filariasis (LF), malaria, and several arthropod-transmitted viruses, dramatically affect public health intervention and could be a hindrance to a nation's development worldwide (WHO, 2023). Malaria is a persistent medical condition affecting about 4 billion people globally, with approximalety 250 million mortality cases among 620,000 persons (WHO, 2023). Among other diseases, such as LF and arthropod-borne viruses, malaria in Africa accounted for 96% of disease in total, 95% of the global cases, and 96% of deaths, of which mortality in children was up to 80% (Cottis *et al,* 2023). The abundance and distribution of mosquitoes are due to the nature topographic of the place, which includes anthropogenic activities, insecticidal failure, housing conditions, farming activities and human factors (El-Tawdy *et al,* 2018). Globally, MTDs affect all ages, particularly pregnant women and children below 5 years in Sub-Saharan Africa, are more burdened (Anjorin *et al,* 2023).

Mosquitoes and associated diseases can be tackled by applying the feasible preventive programs involving intermittent therapy, insecticide use, and innovations including bednet and other impregnated materials, and larval control, dependent diagnosis, and regular surveillance (Oforka *et al,* 2023). The pyrethroid integrated control method was available amongst others chemical insecticides used (Ibrahim *et al,* 2023). However, the chemical intervention efficacy threating increased with climatic changes and vectorstors resistance to many chemical insecticides

(Ojianwuna *et al,* 2021). Alternative control interventions towards averting the issues of resistance are emerging in research and have been reported in Delta State, where mosquitoes are abundant (Ojianwuna and Enwemiwe, 2022). Several other alternative interventions involved a wide range of biological agents, environmental & larval control, and modern technologies, such as genetic mosquito's modification were used (Weng *et al,* 2024). In Delta State, Egedegbe *et al.* (2023) reported marked increase in mosquito-biting activities all over night. Also, efficiency of sampling methods was evaluated, and *Aedes* mosquitoes checked for yellow fever virus showed no mosquito infection, probably due to vaccination efforts implemented in there (Ojianwuna *et al,* 2024).

Insecticide Treated Nets (ITNs) are a widely accepted control strategy in many countries, especially in Sub-Saharan Africa (Haileselassie *et al,* 2023). Russell *et al.* (2015) reported that >99% of nets owned by Southeastern dwellers were ITNs, and 80% of the target population used them at night. LLIN usage was 70% in a state in Nigeria (Babalola *et al,* 2019). Some knowledge, attitudes, and practices (KAP) studies have reported the effectiveness of ITNs in Nigeria (Oforka *et al,* 2023). The socio-economic factors influencing the insecticidal use could be linked to the financial constraints, harmful adverse effects triggered by continuous insecticidal use, and other possible factors.

Apart from bed nets, insecticide sprays manufactured in Nigeria and other countries are used. The effectiveness of planned indoor residual spray in Ethiopia, with over 35% of sprayed walls was altered by household dwellers (Ibrahim *et al,* 2023). Changes in socio-demography, vector behavior and biology, infectivity rate (Thomsen *et al,* 2017), KAP of individuals towards malaria vector control affected mosquito access to blood meal, infection rate, choice of disease treatment options, control, and preventive measures (Rek *et al,* 2020). Although studies assessed KAP of residents to malaria control in Nigeria (Omotayo *et al,* 2021), they didn't explore holistically insecticide usages among residents or surveyed insectcides used and the constituents of insecticides as predictable drivers of resistance in area if intensity of insecticide usage is measured.

So, an assessment of the utilization of insecticide sprays and associated factors among house-holds was done in three municipalities in Southern Nigeria (Isoko South, Sapele, & Ndokwa West, Delta State), where Nigeria Malaria Elimination Programme (NMEP) already deployed insecticide-treated bed-nets. The relationship between the insecticide spray acceptance and the education level, dwelling types, and other socio-demographic and economic factors were determined among residents in Delta State, Nigeria.

Materials and Methods

Study area and design: Delta State is comprised of 25 LGAs in three senatorial districts. One LGA with the highest malaria record was selected from senatorial district by using the Delta State unpublished malaria surveillance data. This cross-sectional survey was conducted in three local government areas (LGAs), including Sapele, Ndokwa West, and Isoko South, of Delta State, between September and November, 2021. The LGAs were divided using the grid sampling method, and four communities were selected. The study participants from these communities were randomly selected systematic sampling.

Sampling Strategy: 450 study participants consented to participate, and each was given a semi-structured and pre-tested questionnaire adopted (Omotayo *et al,* 2021). The sample size was calculated by using formula given by Anyaele and Enwemiwe (2021), z statistics for 95% level of confidence was 1.96, precision (d) was given at 5%, and the insecticide proportion usage by respondents was set at 50% since there were no similar studies conducted on the area.

After detailed calculation, 384 participants were finally selected. Consent was sought from each available household head and any

adult available and willing to participate. Four villages were selected from each LGA mapped out. To ensure spread of sampling, each community had between 37 and 38 households to make up the 150 participants in each LGA. For each household, only one consenting adult (≥18 years old) was selected for interview. The research randomizer app guided the house selection to avoid selection bias (Urbaniak and Plous, 2021).

Inclusion and exclusion criteria: Household heads or individuals above 18 years who consented to participate in the study were included. The study excluded individuals who did not consent to participate in the study after a detailed explanation and individuals with health-related and communication impairments.

Data Collection: Three entomologists and one health personnel from each location were recruited and trained to assist in the selection of study participants and carry out interviews. Questionnaires were administered by trained field personnel in English and further explained in the local language for a better understanding. Survey questionnaire was piloted before use to ensure comprehensibility, clarity, and appropriateness. After each interview, a ten-minute briefing on the malaria causes, its transmission, prevention, and intervention methods were done to the household in English or Vernacular. This briefing was approved and aided by the community leaders who assisted in communicating in the local language of the LGAs visited for community awareness.

A questionnaire and key informants (KIs) were chosen as the data collection methods to ensure comprehensive data collection methods. KIs comprised four groups of participants: adult men, adult women, young boys, and young girls (≥18 years). One individual from each group was selected from each community to make up the KIs for the LGA.

A total of 20KIs were selected from each LGA. The focus determined the preference for malaria control methods, the underlying reasons for using the available control measures, and whether the local plant materials were used as alternative treatment. The insecticide brands available for purchase and use in Delta State were equally surveyed. The chemical composition, the chemical ingredients concentration, spray time recommended by producers, and diffusion time were recorded.

Ethical Statement: The Ethics Review Committee, Faculty of Science, Delta State University, Abraka, Nigeria (REL/FOS/2023/12) approved the study protocol.

Statistical analysis: Data were checked for completeness, and entered into IBM SPSS version 23 (IBM Corp., Armonk). Data were tabulated, pie charts, and bar charts. Chi-square test determined the interrelationship among education level, LGAs, and dwelling type. The relationship between selected factors and insecticide usage was determined by using inferential statistics. Likewise, relationship between acceptance and non-acceptance of insecticides and demographics and socioeconomics was determined. Lastly, the relationship between insecticide usage, mosquito (re)appearance, and knowledge about insecticide was found to influence the usage of insecticide brands.

Results

Socio-demographic Characteristics: More than half of the study participants were in age range of 40 years and less (25: 56%) and had secondary education (249: 55%). Living in a room and parlor apartment was the primary type of dwelling structure (45%), followed by three-bedroom apartments and single rooms (≈24% respectively), more than half (299: 66%) of the respondents earned less than 15,000 naira monthly. The household size was between 5 & 8 230 (51%).

Household perception and utilization of insecticides: One hundred and thirty-five (30%) participants used Raid insecticide. Household preference for insecticide brands was significantly dependent on the type of dwelling and varied significantly ($p < 0.05$) between sampled LGAs. The chosen inse-

cticides killed all insects (204; 45%), and factors that influenced the choice of a particular insecticide brand. Reasons for household preference for insecticides were insignificant ($p>0.05$). Focal point for insecticide acquisition was the marketplace (135: 30%). Within the LGAs and dwelling structure type, street hawkers and pharmacies were, respectively, significant points for insecticide acquisition ($p< 0.05$). Almost half (48%) of the pooled participants used insecticides of different brands for various reasons, especially for their effectiveness (58%), safety (≈44%), and other reasons. Education level and dwelling type of respondents significantly influenced ($p< 0.05$) reasons to spray indoors or not.

The insecticide usage duration in months was between 18 & 21%, the sensitization of government and non-governmental organizations as to mosquito control interventions was insignificant. Affordability, availability, and efficacy of insecticide brand(s) were significantly dependent on type of dwelling structure ($p<0.05$). The ability to continuous protection, the efficacy of insecticide brand (s), and lack of side effects differed significantly in LGAs ($p< 0.05$). Respondents' education level significantly influenced insecticides choice based on safety ($p< 0.05$).

Time for insecticide usage among respondents was varied. Some use them every 1-2 days /7 days (18%), some often use them (17.3%), and others use insecticides daily (12.7%). Undermining the usage time, the insecticide frequency usage differed within sampled LGAs ($p<0.05$). Insecticide application time was more in evenings (≈42%) than in mornings or both morning and evening, respectively (3%). Participants' education level and dwelling structure significantly informed with the insecticide application time ($p<0.05$). Almost all the participants who used insecticides didn't know the comp osition of insecticide brands 214 (≈48%). Respondent's level of education significantly influenced their knowledge about content of insecticide brands ($p<0.05$). Most participants used insecticide brands to control mosquitoes (391: ≈87%). However, some of them stopped using Raid insecticide (29:6.4%). Significant differences were found between LGAs as to discontinuation of specific kind of insecticide ($p<0.05$). Likewise, education level and income significantly influenced the discontinuation of a certain kind of insecticide. There were significant relationships between reasons for discontinued insecticide brands with LGAs, level of education dwelling, type, income, and number of family members. Some participants stopped using the ineffective insecticide brands 30 (6.7%). The mosquitoes reappearance even after insecticidal application showed a significant relationship between LGAs and dwelling structure type ($p<0.05$).

Insecticide brand survey: Surveys of insecticides showed that ES-biotin and permethrin were the most common constituents used. Others were mentioned. Local insecticides without known chemical composition, but KIs suggested that these are probably made from a mix of sniper and kerosene. Spray insecticidal time of brands ranged between 1 to 10 seconds, but diffusion time was between 10 to 30 minutes. Mean synergist concenration of Piperonyl butoxide was higher than other pyrethroids. S allethrin, transfluthrin, & permethrin were highly in pyrethro--ids. Others were up 100% of insecticidal composition. But, apart from perfume and lemon fragrances, inert-gases, isopropyl alcohol, were expected in these insecticides.

Perception of insecticide spraying, choice of insecticide brand, reasons for not using insecticide, and insecticide diffusion time significantly determined insecticide brand used for in-house spraying ($P<0.05$). The insecticide brand choice reasons for not using insecticide, and insecticidal diffusion time significantly determined mosquito reappearance, were based on knowledge of spraying in-house ($P<0.05$).

Details were given in tables (1, 2, 3, 4, 5, 6 & 7), and figures (1, 2, 3, 4 & 5).

Table 1**:** Socio-demographic properties of respondents

Characteristics	n = 450 (%)
Age (in years)	
≤40	251 (55.8)
≥41	199 (44.2)
Education: None	35 (7.8)
Education: Primary level	93 (20.7)
Education: Secondary level	249 (55.3)
Education: University level	73 (16.2)
Type of dwelling structure: Single family house	24 (5.3)
Type of dwelling structure: Duplex	3 (0.7)
Type of dwelling structure: Two/three bedrooms flat	109 (24.2)
Type of dwelling structure: Mini flat	27 (6.0)
Room and parlor	180 (40.0)
Single room	106 (23.6)
Income per month ≤15000	299 (66.4)
Income per month 15001-40000	101 (22.4)
Income per month 40001-65000	21 (4.7)
Income per month 65001-90000	8 (1.8)
Income per month ≥90001	21 (4.7)
Household member:≤4	189 (42.0)
Household member:5-8	230 (51.1)
Household member:≥ 9	31 (6.9)

Table 2: Perception of insecticide utilization by respondents in Delta State, Nigeria

First brands of insecticide most prefer in spraying your home for mosquito control	n = 450 (%)
Not Using	234 (52.0)
BNC	5 (1.1)
Chetox	2 (0.4)
DD force	2 (0.4)
Local insecticide	23 (4.6)
Mobil	6 (1.3)
Morten	3 (0.6)
Raid	135 (30.0)
Rambo	3 (0.7)
Sniper	13 (2.9)
Top rank	26 (5.8)
Factors influenced your choice of the above listed brand(s) of insecticide	n = 450 (%)
Affordability	74 (16.4)
It is available	61 (13.6)
Ability to continuous protection	53 (11.8)
Efficacy/effectiveness (kills mosquitoes 100%)	116 (25.8)
It kills all insects	204 (45.3)
Safety/Lack of side effects	4 (0.9)
Pleasant fragrance	5 (1.1)
Place where insecticides are usually acquired	n = 450 (%)
Retail shop in on neighborhood	93 (20.7)
Market	135 (30.0)
Pharmacy	25 (5.6)
Chemist shop	71 (15.8)
Street hawkers	30 (6.7)

Table 3: LGA, level of education, type of dwelling on some notable factors on insecticides usage and choice of insecticide

Some notable factors	LGA	Education level	Dwelling type
Choice of insecticide usage	0.682	0.000*	0.000*
Household preference of insecticide brand	0.000*	0.059	0.004*
Reasons for insecticide preference	0.095	0.268	0.422
Government organization and NGO sensitization	0.166	0.154	0.733
Choice of insecticide brand(s):Affordability	0.361	0.516	0.000*
Choice of insecticide brand(s):Availability	0.063	0.755	0.007*
Choice of insecticide brand(s):Ability to continuous protection	0.021*	0.349	0.050
Choice of insecticide brand(s): Efficacy/effectiveness (kills mosquitoes 100%)	0.000*	0.292	0.006*
Choice of insecticide brand(s):It kills all insects	0.053	0.537	0.447
Choice of insecticide brand(s):Safety/Lack of side effects	0.025*	0.006*	0.422
Choice of insecticide brand(s):Pleasant fragrance	0.095	0.268	0.592

*Level of significance < 0.05.

Table 4: Attitude and practices as to insecticide usage by respondents, Delta State, Nigeria

Frequency of insecticide spraying in a week	n = 450 (%)
Sometimes (every 1-2days out of 7days)	81 (18.0)
Often (every 3-5 days out of 7 days)	78 (17.3)
Every day (7 days out of 7 days)	57 (12.7)
Do not use	234 (52.0)
Time of insecticide spraying	n = 450 (%)
Morning	14 (3.1)
Evening	188 (41.8)
Both morning and evening	14 (3.1)
Do not use	234 (52.0)
Content of the brand(s)	n = 450 (%)
Yes	2 (0.4)
No	214 (47.6)
Do not use	234 (52.0)
Used and discontinued insecticide brand(s)	n = 450 (%)
None	391 (86.9)
Angle 90	1 (0.2)
Baygon	3 (0.7)
Local insecticides	11 (2.4)
Mobil	2 (0.4)
Mosquito coil	2 (0.4)
Raid	29 (6.4)
Sniper	11 (2.4)
Reasons for discontinuous use	n = 450 (%)
No reason	391 (86.9)
Irritation and bad odour	1 (0.2)
Not available	3 (0.7)
Not effective	30 (6.7)
Not good for health	2 (0.4)
Suffocation	1 (0.2)
Too harsh	19 (4.2)
Too pricy	3 (0.7)

Table 5: LGA, education level, dwelling type on some notable factors on insecticides usage and place of insecticide acquisition

Some notable factors	LGA	Education level	Dwelling type	Income
Frequency of insecticide usage	0.038*	0.278	0.266	0.331
Time of insecticide spray	0.113	0.010*	0.002*	0.202
Knowledge about brand content	0.162	0.039*	0.835	0.832
Insecticide type discontinued	0.010*	0.000*	0.991	0.000*
Reasons for insecticide discontinuation	0.002*	0.000*	0.991	0.000*
Coping with mosquito reappearance after interventions	0.014*	0.669	0.000*	0.797
Place of insecticide acquisition: Retail shop in my neighbourhood	0.313	0.208	0.096	0.406
Place of insecticide acquisition:Market	0.591	0.277	0.686	0.374
Place of insecticide acquisition: Pharmacy	0.268	0.147	0.044*	0.267
Place of insecticide acquisition: Chemist shop	0.15	0.755	0.471	0.122
Place of insecticide acquisition: Street hawkers	0.016*	0.541	0.899	0.562

*Level of significance < 0.05.

Table 6: Checklist of insecticide brands used in Delta State with their chemical composition.

Insecticide brand	Chemical composition	Conc. (%)	Spray time (Sec.)	Diffusion time (Min.)
Boxer	Tetramethrin	0.3	1-3, 8-10	20
	Cypermethrin	0.17		
	S-Bioallethrin	0.63		
	Lemon fragrance	0.31		
Good knight	Imiprothrin	0.05	4-5	10-15
	Cypermethrin	0.10		
	Prallethrin	0.09		
	Other ingredient	99.76		
Mortein	Imiprothrin	0.02	4-5	NI
	d-Phenothrin	0.03		
	D-trans alledthrin	0.10		
SWAN	Beta-Cypermethrin	0.004	6-10	30
	Tetramethrin	0.004		
Good knight	Transfluthrin	1.00		10-15
(Power shots)	Cypermethrin	0.25		
	Synergist (Piperonyl butoxide	1.00		
	Perfume	1.20		
	Isopropyl alcohol	96.55		
Sniper (flying insect)	Transfluthrin	0.04	2-4	10-15
	Deltamethrin	0.02		
Sniper (crawling insect)	Imiprothrin	0.1	NI	15
	Cypermethrin	0.2		
	D'allethrin	0.2		
Mobil	Neo-pynamin	0.25	4-6	15
	Prallethrin	0.04		
	Cyphenothrin	0.05		
	Solvents propellants, Essential oils	99.66		
Raid	D'allethrin	0.25	7-9	15-20
	Tetramethrin	0.15		
	Deltamethrin	0.015		
	Inert ingredient	99.585		
Mortein	Transfluthrin	0.04	4-5	NI
(Insta Kill)	Imiprothrin	0.05		
Read a Dream	Tetramethrin	0.4	2-4	10-15
	Permethrin	0.4		
Charm Magic	Esbiothrin	0.25	NI	10
	Permethrin	0.40		
Knockdown	ES-biothrin	0.1	6-10	30
	Permethrin	0.2		
	Cypermethrin	0.1		
BLITZ	ES-biothrin	0.25	NI	10
	Permethrin	0.40		
Top Rank	ES-biothrin	0.25	4-6	10-15
	Permethrin	0.40		
BNC	ES-biothrin	0.26	NI	20-25
	Permethrin	0.28		
	Beta-Cypermethrin	0.1		
	Lemon	0.31		
Local insecticide	Sniper liquid Dimethyl 2, 2-dichlorovinyl phosphate (Dichlorvos)	1000g/l	NI	NI
	Kerosene	NI		

Note: NI means not indicated

Table 7: Insecticide used, mosquito (re)appearance, insecticidal knowledge on some factors influenced insecticidal brand(s).

Variations	Insecticide type	Mosquito (re)appearance	Insecticidal knowledge
Perception on IRS	0.000*	0.865	0.399
Choice of insecticide brand	0.027*	0.000*	0.001*
Reasons for not using insecticide	0.038*	0.000*	0.001*
Time required for insecticide diffusion	0.000*	0.000*	0.000*

*Level of significance < 0.05.

Discussion

The National Malaria Elimination Programme (NMEP) and Nigerian Centre for Disease Control (NCDC), under the surveillance of the Federal Ministry of Health classified Nigeria as an epidemiological state characterized by increased mosquito-activities and disease transmission all year seasons (WHO, 2023).

In this cross-sectional community study, insecticides were the most frequently used interventions by 47.8% of the respondents. Insecticide spraying in Ndokwa West LGA is a significant control measure despite the reported high cost of acquisition and content. High mosquito density was common as Ndokwa West LGA is a fish-rearing community. Also, area topography supports water

retention. The insecticidal sprays in this area are linked to the participants' good knowledge related to vector-borne biting activities.

In the present study, the used insecticide sprays level was lower than 80% recommended (WHO, 2023). Madani *et al*. (2017) reported more than quarter of population slightly used insecticidal sprays. Jumbam *et al.* (2020) found that the need for more utilizing insecticide in the rural settings due to least impact of knowledge on insecticidal value for vector control.

In the present study, knowledge of using insecticide usage among respondents were low, which low perception and knowledge could be linked to the fact that most respondents were below 40 years old, and secondary school education. In Nigeria, the educated of respondents were influenced the IRS choice. This disagreed with Madani *et al.* (2017), who discovered a high knowledge of insecticide spraying in Iran and further opined that insecticide sprays were sourced from the hospital, which is unlikely in this study. The secondary education obtained by most respondents explained why most of the participants in this study were aware that mosquitoes that rest indoors were borne from the environment, hence the need to spray insecticides.

In this study, commonly used insecticides are locally sold chemical insecticides. The majority of participants lived in a room and parlor apartment and earned less than fifteen thousand naira that could be the reason why most of them didn't use insecticides. After spraying insecticide indoors is a common African practice causes outdoor protection lack predispose respondents to mosquitoes" abundance. This agreed with Guglielmo *et al.* (2021) and Busari *et al.* (2023), who reported that sitting out of insecticide sprayed indoors, civil duties, domestic chores, and traditional and recreational activities to mosquito biting family members. Health education is a must to in-form community members on potential risks associated without protection (Onyinyechi *et al*, 2023). Pyrethroid pesticides high doses are toxic and expeditious insecticide exhibiting tremor-type syndrome, allergic reactions, and ataxia (El Bahnasawy *et al*, 2015).

To ensuring community insecticide usage, plant materials (scent leaves & wild spikenard) were put on hurricane lamps as insectcide alternatives. BNC, Chetox, DD force, local insecticides, Mobil, Morten, Raid, Rambo, Sniper, and top rank were the used ones. In this study, Raid, a pyrethroid-based insecticide, was the most used one. This agreed with Kouamé *et al.* (2022) in Cote d'Ivoire, where pyrethroid insecticides were majorly used. Also, recommended commonly insecticides for vector control (Enayati and Hemingway, 2010). The perception and choice of insecticide usage were influenced some extent by their efficacy. However, only 16.4% of the respondents afford them from the market as their partners found that it more accessible to purchase insecticide while purchasing food materials. This agreed with Madani *et al.* (2017), who pointed out those health-related issues, the insecticidal harsh odor, and the chances of food toxicity were amongst other reasons, as the deterring factors to insecticide usage. Affordability could have affected the insecticides availability indoors. Also, the financial status equally has a critical role in the continuous community insecticidal usage. This agreed with Alhoot *et al.* (2017), they reported that household financial strength was key factor for the sustained the IRS use.

In the present study, factors, such as respondents' LGA of origin and dwelling type, significantly influenced household preference for insecticide brands, as education level and dwelling type significantly influenced the decision to insecticidal use. This agreed with Kouamé *et al.* (2022), who opined that participant's acceptance of insecticides was significantly associated with the education level, household use of ITNs, and their socioeconomics. Also, this agreed with Rahman *et al.* (2021), they found that educational level influenced the willingness to use and

sustain insecticide.

In the present study, there was a diverse attitude ranges toward insecticide use among them. Most (18%) respondents sprayed insecticides in their houses sometimes (every 1 to 2 days/week). This disagreed with Larson *et al.* (2021), who reported that household use of insecticides every fourth night at two-month intervals. Also, about 42% of the studied participants sprayed insecticides in on the evenings before retiring to bed. Also, in this present study approximately 99% of them had an idea of the insecticidal composition they purchased and some participants stopped using Raid insecticide due to its ineffectiveness and harshness. This disagreed with Nalwanga and Ssempebwa (2011), they reported that people used the insecticidal was due to the effectiveness rather than constituents.

In the present study, the respondents' intention to acquire insecticides was high, though slightly below LLINs use occurred in Delta State, without guidance and delegated household routine monitoring may be the cause of the mosquitoes emerged resistance.

In the present study, insecticides used had different dosages and time required to appropriate mosquitoes killing. Thus, the routine prompt use of insecticide sprays was critical to the mosquito elimination.

In the present study, respondents hope was expected to reduce the mosquito population and also reduce the malaria transmission cycle, depending on the spraying dose and that they sought that different insecticide in their localities. Pyrethroids were used in the sublethal toxicity formulation (Bibbs *et al*, 2019). The local insecticides used by them had no definite chemical composition, but some of them had a mixture of sniper and kerosene, which necessitates unraveling constituents of the locally-made insecticides.

Conclusion and Implications

The level of insecticide coverage, access, and use was low in the study area and fell below WHO target of 80% for insecticide usage. Only 48% of the studied pooled population sprayed insecticides.

Respondents' LGA of origin, education level, and dwelling type significantly influenced household prefering for insecticide brands. Affordability, availability, and knowledge that insecticides completely killed mosquitoes were cogent reasons.

Demographic and socio-demographics of them, such as age, education level, and dwelling type were key drivers to respondents' choice of insecticides. But, there was a need to examine the local constituents making the insecticides, to design strategies to address financial barriers to insecticide access and associated factors to deter community coverage of commercial sprays. Policymakers should adequately design and enhance the practical guidelines for routine monitoring of insecticide usage to reduce the likelihood, build up, and increased insecticide resistance. Future research studies must be directed towards indoor screening of walls and roofs of houses where mosquitoes rest after blood feeding with environment-friendly bioactive substances, production and trial of affordable bio-insecticides, and public health education of residents in the malaria endemic region to curtailing the spread of insecticide resistance and disease transmission.

Authors' Contribution: CC, AO, and VN conceived and designed the study. VN collected field data and VN analyzed data. CC and AO supervised the work. All authors shared in writing and reviewing the manuscript as well as approved its publication.

Conflict of Interest: The authors declared neither have conflict of interest nor pledge conflict of interest.

Standards of reporting: STROBE guidelines were critically followed.

Availability of data and material: The authors confirm that data supporting the study findings are available within the manuscript.

Acknowledgements

The authors are grateful to Ese Oyibo, Taiwo Favour, and Josiah Marvelous for assisting with the questionnaire preparation. Also, grateful thanks are due to the Comm-

unity Leaders in Isoko South LGA, Ndokwa West, and Sapele LGA, as well as the participants kindly shared in the study.

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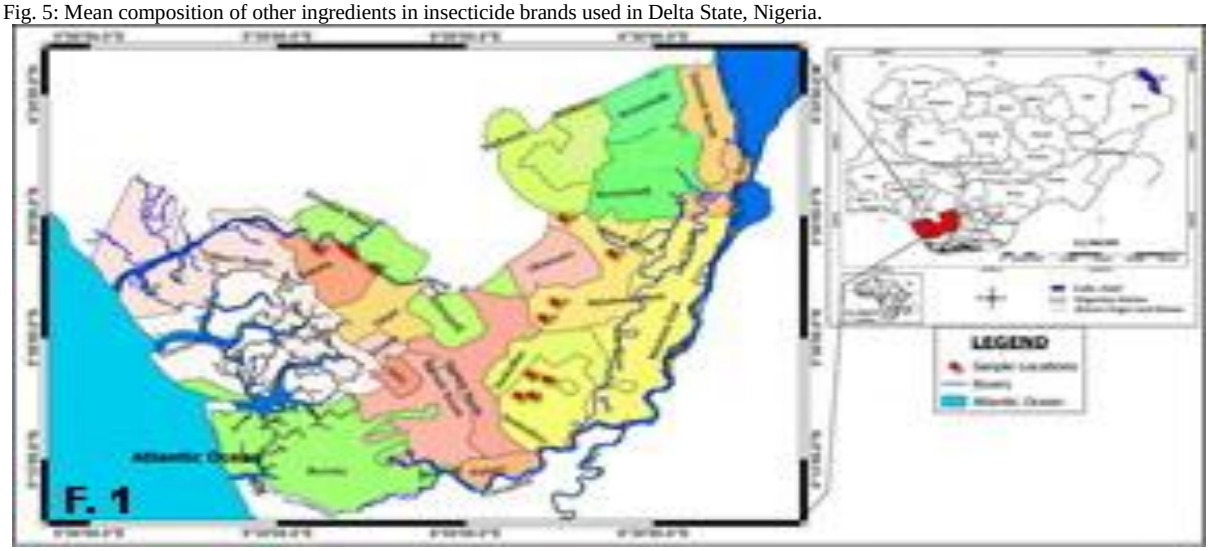
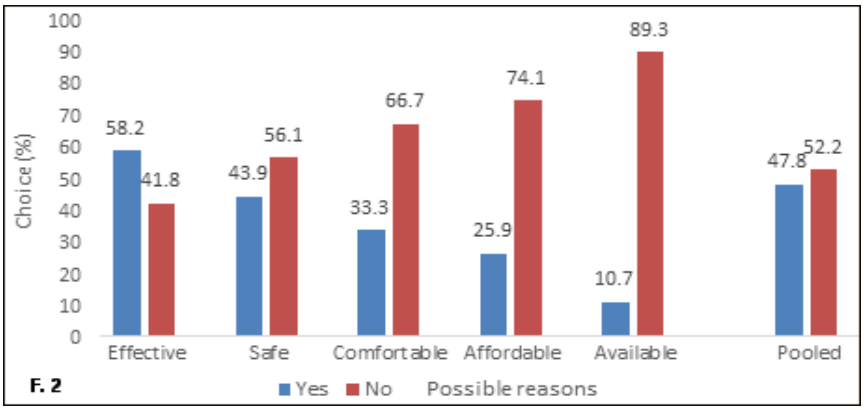
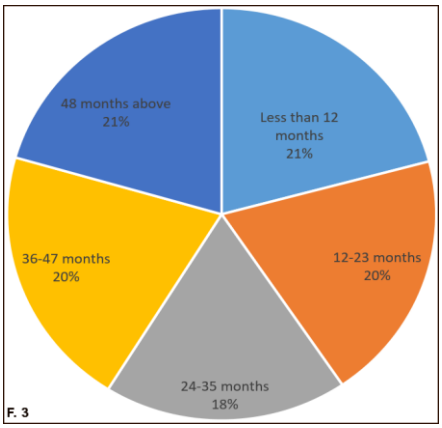
Explanation of figures

Fig. 1: Map of the Delta State showing Isoko South, Sapele and Ndokwa West LGA.
Fig. 2: Respondents' choice and acceptance of insecticide spraying in Delta State.
Fig. 3: Time span record of insecticide usage in Delta State.
Fig. 4: Mean occurrence of chemical concentrations in insecticide brands available for use in Delta State, Nigeria.
Fig. 5: Mean composition of other ingredients in insecticide brands used in Delta State, Nigeria.

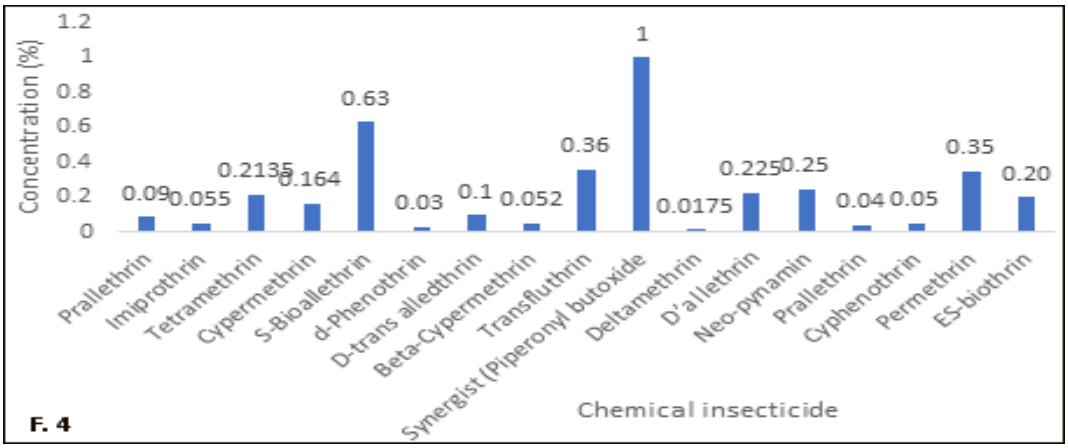



100
90
80
70
60
50
40
30
20
10
0
Choice (%)
58.2
41.8
43.9
56.1
33.3
66.7
25.9
74.1
10.7
89.3
47.8
52.2
Effective
Safe
Comfortable
Affordable
Available
Pooled
Yes
No
Possible reasons

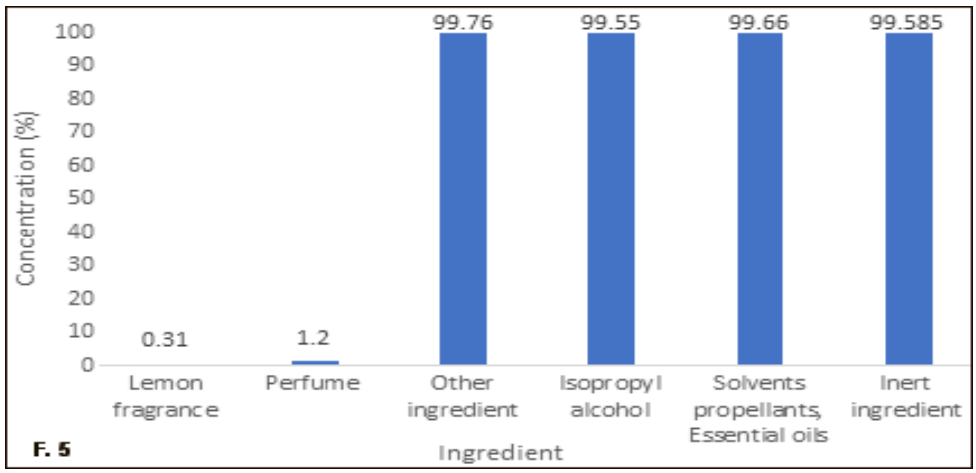
F. 2


48 months above
21%
Less than 12
months
21%
36-47 months
20%
12-23 months
20%
24-35 months
18%

F. 3


1.2
1
0.8
0.6
0.4
0.2
0
Concentration (%)
0.09
0.055
0.2135
0.164
0.63
0.03
0.1
0.052
0.36
1
0.0175
0.225
0.25
0.04
0.05
0.35
0.20
Prallethrin
Imiprothrin
Tetramethrin
Cypermethrin
S-Bioallethrin
d-Phenothrin
D-trans alledthrin
Beta-Cypermethrin
Transfluthrin
Synergist (Piperonyl butoxide
Deltamethrin
D'allethrin
Neo-pynamin
Prallethrin
Cyphenothrin
Permethrin
ES-biothrin
Chemical insecticide

F. 4


100
90
80
70
60
50
40
30
20
10
0
Concentration (%)
0.31
1.2
99.76
99.55
99.66
99.585
Lemon
fragrance
Perfume
Other
ingredient
Isopropyl
alcohol
Solvents
propellants,
Essential oils
Inert
ingredient
Ingredient

F. 5