IJSES
Volume 9, Issue 8, pp. 69-79, 2025.
International Journal of Scientific Engineering and Science
ISSN (Online): 2456-7361

Unregulated Dumpsites, Mosquito Proliferation, Environmental and Public Health Risks in Urban Settlements

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Abstract— *Unregulated dumpsites are a persistent challenge in rapidly urbanizing cities of Sub-Saharan Africa, contributing to mosquito proliferation and public health risks. This study assessed the interlinkages between waste management practices, household knowledge, and institutional responses in Port Harcourt, Nigeria. A mixed-methods cross-sectional survey was conducted with 375 households, 65 waste pickers, and 40 key informants (municipal officials, health workers, and community leaders). Four structured Likert-scale instruments were used to evaluate: (i) household knowledge, attitudes, and practices (KAP) on waste and mosquitoes; (ii) perceived exposure and health impacts; (iii) waste management behavior, barriers, and willingness to act; and (iv) institutional capacity and stakeholder perceptions. Findings revealed relatively high household awareness of the health risks of unregulated dumpsites (mean score = 2.7/4), but practices were constrained by poor access to formal collection services and limited disposal options. Over 70% of households perceived unregulated dumpsites as major breeding grounds for mosquitoes and a driver of malaria risk, yet only 45% reported using covered bins, and open dumping remained widespread. Waste pickers showed high willingness to participate in recycling and community clean-up initiatives (mean score = 2.9/4), but only 32% reported receiving any protective equipment. Institutional assessment highlighted significant weaknesses: while agencies acknowledged responsibility for waste management (mean = 2.8/4, "Accepted"), key areas such as monitoring unregulated dumpsites (mean = 2.4/4), community engagement (mean = 2.1/4), and integration of vector control with waste programmes (mean = 2.3/4) were "Rejected," indicating low capacity and poor coordination. Overall, the study demonstrates that while communities recognize the risks of unregulated dumpsites, behavioral change is undermined by structural barriers, exclusion of informal actors, and weak institutional frameworks. It concludes that addressing mosquito proliferation and public health risks requires integrated interventions, including improved waste collection infrastructure, inclusion of waste pickers in formal systems, targeted health–environmental surveillance, and stronger municipal–community partnerships.*

Keywords— *Unregulated dumpsites, Solid waste disposal, Mosquito proliferation, Malaria risk, Environmental health hazards.*

I. INTRODUCTION

Unregulated disposal of municipal solid waste is a persistent and visible challenge in rapidly growing African cities, and Port Harcourt is no exception. Rapid urbanization, expanding informal settlements, and limited public-sector capacity combine to create numerous open dumps and unengineered landfill-like sites within and around residential areas. These sites are commonly sited in low-lying borrow pits, drainage channels, or vacant plots and are often characterized by exposed organic waste, plastics, discarded tyres, and transient pools of water generated by rainfall or leachate (Dimkpa, et al., 2023; International Journal of Advanced Engineering and Management [IJAEM], 2024; Ogboeli et al., 2024; Ogboeli et al., 2025). Such conditions magnify environmental degradation across multiple media (soil, surface water, groundwater) and create persistent nuisances for nearby communities, including odour, pest infestations, and blocked drainage that exacerbate flooding during the rainy season.

Unregulated dump sites provide ideal ecological microhabitats for mosquito vectors, in addition to the obvious nuisances and chemical contamination. Discarded containers, tyres, and other solid waste items trap rainwater; decomposing organic material increases water retention and provides food resources for larvae; and intermittent leachate or standing water creates semi-permanent aquatic habitats that allow successive mosquito generations to develop. Field studies in Nigeria and other tropical environments have consistently shown that open waste clusters and garbage dumps support breeding populations of many medically significant mosquito species, each of which is associated with a different human disease, including malaria, dengue, chikungunya, yellow fever, and several filarial infections (Anopheles, Aedes, and Culex) (Afia & Edet, 2017; Adeleke et al., 2019, Ogboeli et al., 2025. These anthropogenic larval habitats therefore link waste mismanagement to heightened local vector abundance and increased human–vector contact in adjacent settlements (Okorie et al., 2014).

Urbanization itself further concentrates the risk. Recent reviews show that urban landscapes and human activities (lighting, pollution, altered hydrology, built environment heterogeneity) reshape mosquito ecology in ways that can increase vector abundance or change species composition toward container-breeding, peri-domestic species that thrive in artificial habitats. Urban "heat islands," blocked drains, and informal waste practices interact with socio-economic inequities to produce spatially concentrated hotspots of

mosquito activity and, consequently, hotspots of disease risk in vulnerable neighbourhoods (Duval et al., 2023). In Port Harcourt, where informal settlements and frequent service gaps leave many households relying on on-site storage or ad hoc disposal, these processes are amplified: waste accumulation and poor drainage act together to concentrate mosquito breeding near homes, markets, and schools (Ebere et al., 2022; Ogboeli et al., 2024).

The public health implications of increased vector presence near unregulated dumpsites are considerable in Nigeria. Malaria remains the largest vector-borne disease burden in the country and in the WHO African Region; the most recent global malaria assessments document increases in cases in 2022–2023 and emphasise the persistent high burden across Nigeria and neighbouring countries (World Health Organization [WHO], 2024). Although clinical surveillance captures facility-level caseloads rather than the environmental drivers, ecological and household surveys consistently associate poor sanitation, standing water, and proximity to refuse deposits with higher self-reported febrile illness and greater nuisance biting, factors that reduce well-being, increase household health expenditure, and disrupt livelihoods (Ukpong & Okon, 2021). Tackling the environmental drivers (including dumpsites) is therefore an essential complement to clinical and household-level interventions such as bed nets and case management (WHO, 2023).

Locally relevant evidence from Port Harcourt further highlights this multifaceted harm. Recent environmental and hydrological assessments document groundwater contamination, seasonal leachate migration, and highly variable water quality near unregulated disposal sites in Port Harcourt's metropolitan area, outcomes that disproportionately affect low-income communities dependent on shallow wells and poorly protected water sources (Abiye & Raimi, 2025, Ogboeli et al., 2025). The same structural weaknesses that allow leachate and chemical pollutants to percolate also promote surface pooling and drainage failure, conditions that favour mosquito breeding. Importantly, community surveys conducted in the metropolis indicate both awareness of waste-related problems and frustration with weak municipal services; this willingness of residents to engage in improvements signals an entry point for integrated interventions that combine sanitation, waste collection, and community-led source reduction to reduce vector habitats and public health risks (MedCrave Group, 2023).

Given the ecological plausibility, empirical evidence from other Nigerian cities, and the high endemic burden of mosquito-borne disease, a focused survey study in Port Harcourt that documents community exposure, perceived health impacts, environmental conditions, and institutional barriers is both timely and policy-relevant. A survey-based approach can rapidly characterise vulnerability gradients around unregulated dumpsites, quantify self-reported disease burden and prevention behaviours, and capture community and stakeholder perspectives that are essential for designing feasible, acceptable, and cost-effective control strategies. Results can directly inform municipal waste planning, targeted environmental remediation, and integrated vector management programs that address the environmental root causes of mosquito proliferation alongside clinical and behavioural measures (Tusting et al., 2015; Alves et al., 2018; Dimkpa, et al 2025; John and Ogboeli, 2025).

Comparative Studies and Global Contextualization

Unregulated open dumps and informal waste accumulations are a recurring feature of rapidly urbanizing cities in low- and middle-income countries, and a consistent correlate of elevated vector abundance and disease risk. Entomological and ecological surveys across West Africa, Nigeria, and other tropical regions repeatedly document that refuse clusters, discarded containers, and tyre piles trap water and create stable microhabitats for container-breeding mosquitoes (notably Aedes spp.) as well as pollution-tolerant Anopheles and Culex species. These field studies show that the physical structure of dumpsites, notably stagnant pools, organic-rich leachates, and persistent water-holding litter, substantially increases local larval habitat availability and, by extension, adult mosquito abundance in adjacent settlements (Afia & Edet, 2017).

Regional work in Nigeria and the Niger Delta provides particularly relevant parallels for Port Harcourt. Research in Nigerian cities such as Uyo, Minna, and Port Harcourt has documented tyre- and refuse-associated mosquito breeding, seasonal shifts in species composition, and close spatial associations between dumpsites and reported nuisance biting or febrile illness in nearby communities. Studies mapping irregular dumpsites in the Niger Delta have also linked the spatial distribution of waste with disease occurrence, including reports of malaria and diarrhoeal disease, underscoring a common pattern: infrastructural and socio-economic vulnerabilities concentrate environmental risk in low-income neighbourhoods. These local and regional studies justify a Port Harcourt survey that prioritizes spatial buffers around dumpsites and collects household-level data on perceived exposure, reported illness, waste practices, and socio-economic covariates (Akhigbe et al., 2020).

Comparative evidence from Latin America and Asia highlights both the public health consequences of dumpsite exposure and the potential for tailored interventions. Qualitative and quantitative studies of large open dumps, for example in Brasília's Estrutural community, show that waste pickers and adjacent residents face occupational and household exposure pathways to vector-borne diseases, and that community-led clean-up campaigns, livelihood-sensitive interventions, and targeted source reduction can reduce Aedes breeding when sustained and integrated with municipal services. These cases emphasize the importance of including occupational groups (waste pickers/scavengers) in survey instruments and of collecting data on willingness to participate in community interventions, both factors likely to determine feasibility and uptake in Port Harcourt (Costa et al., 2020; Silva et al., 2019).

Systematic reviews of vector-control interventions produce cautious optimism about the value of community-based source reduction and larval control in urban settings, while also noting important evidence gaps. Reviews synthesizing household and community interventions show that education, clean-up

campaigns, improved waste storage, and biological larvicides such as Bacillus thuringiensis israelensis (Bti) can reduce entomological indices for Aedes, but translational challenges remain: many trials show short-term gains that decay without sustained municipal backing and consistent community engagement. For a survey-only study in Port Harcourt, these reviews imply two priorities: (1) measure community knowledge, attitudes, and practices (KAP) and willingness to sustain source reduction, and (2) map institutional capacities and barriers to scale up effective measures (Bowman et al., 2016; Toledo et al., 2017).

Global syntheses also emphasize that context matters, urban heat islands, drainage infrastructure failures, seasonal rainfall patterns, and socio-economic heterogeneity all modulate how dumpsites translate into disease risk. Spatially explicit studies show strong distance-decay relationships, with higher vector indices and often higher self-reported nuisance or illness close to dumpsites, but the magnitude and public-health consequences vary by species ecology and local practices. Therefore, while Port Harcourt's existing water-quality and waste-management assessments point to environmental degradation and leachate hazards near uncontrolled sites, a focused survey will provide needed local evidence on human exposure, perception, and the readiness of households and institutions to implement integrated responses (Acheampong & Siiba, 2019; Medlock & Vaux, 2015).

Taken together, the comparative literature yields four practical implications for a Port Harcourt survey study: (1) use spatial buffers and GPS to detect distance-related gradients in perceived exposure and self-reported illness; (2) include occupationally exposed groups (waste pickers) as a distinct respondent category; (3) measure KAP, waste practices, and willingness to engage in community control to assess intervention feasibility; and (4) map municipal responsibilities and stakeholder perceptions to identify governance bottlenecks. Emphasizing these features will ensure the study produces actionable evidence that aligns with lessons from comparable international contexts while remaining sensitive to Port Harcourt's unique environmental and social dynamics (Alves et al., 2018; Tusting et al., 2015).

II. Materials and Methods

The coordinates of Rivers State, which has a land area of 11,077 square kilometers (4,277 square miles) and is located at 4°45′N 6°50′E, place it in the South-South geopolitical zone of Nigeria. The Atlantic Ocean bounds the state to the south, while Imo, Abia, and Anambra States share its borders to the north. It shares borders with Akwa Ibom State to the east and Bayelsa and Delta States to the west. With UTM coordinates of 32N 279660.2215768 and 528378.96126353, the Port Harcourt local government area is situated at Latitude 4° 46' 38.71" N and Longitude 7° 00' 48.24" E, as part of the Greater Port Harcourt region. This region is about 52 kilometers (32 miles) southeast of Ahoada and about 40 kilometers (25 miles) northwest of Bori. It is bounded by Degema to the west, Obio-Akpor to the north, Eleme to the east, and Okrika to the south. With a population density of 5,856.5 people per square kilometer (15,168 per square mile), Port Harcourt has a total land area of 109 square kilometers (42 square miles). The study is carried out in Port Harcourt Metropolis. The study design was a Cross-sectional, community-based household survey with stratified sampling around selected unregulated dumpsites. Complementary short stakeholder questionnaires (waste managers/health workers) and an observational checklist of household/environmental conditions are included, all survey instruments (no entomological trapping or lab tests). Purposively, six unregulated dumpsites were selected for the study with varying sizes, residential proximity, and informal activities (scavenging, burning). Buffers (strata) around each dumpsite were concentric distance bands: 0–250 m, 251–500 m, >500–1000 m. These are the sampling strata for households. Control communities: For comparison, neighborhoods ≥1.5–2 km from any dumpsite, matched for housing density and socio-economic profile. Study population & eligibility: Household head or an adult ≥18 years who has lived in the household ≥6 months. Exclusions (Visitors, institutional residences (prisons, hospitals), households refusing consent). Respondents include adult household heads, caregivers, or representatives capable of providing information on Waste disposal practices, perceived exposure to mosquitoes, reported health issues (malaria, febrile illness, nuisance biting) and Knowledge, attitudes, and practices (KAP) on sanitation and vector control. Others include; Waste Pickers / Scavengers at Dumpsites, Health Professionals and Environmental Health Officers and Municipal Waste Management and Regulatory Agencies. From each stratum, respondents were selected using proportionate stratified random sampling, ensuring balanced representation from each cluster. The sample size was determined using Cochran's formula for categorical data:

$$n = (Z^2pq)/d^2$$

Where:
Z = Z-value for 95% confidence level (1.96)
p = estimated prevalence of poor sanitation (assumed at 0.5 for maximum variability)
q = 1 - p
e = margin of error (0.05)
n≈384.
Adjust for clustering/design effect (DEFF = 1.5): $n_1 = 384 \times 1.5 = 576$.
Add 10% non-response: n =576×1.1 ≈ 634 = → Round to 640 households.
Allocation example:
6 dumpsites (18 strata) → 640 / 18 ≈ 36 households per stratum.
Sampling procedure: Selected six (6) dumpsites are Nkpolu Junction East-West Road, Chindah Borrow-pit (off Chindah Road), Ada-George, Slaughter Market, Egbulu-Ozodo, Mile 4 Market junction, Rumueme Ikwerre Road, Mile 1 Market, and Lagos bus stop, Borokiri. Mapped dumpsite perimeters and enumerated households in each buffer (use local lists or a quick mapping walk). Household selection: systematic random sampling in each buffer. Replacement: If the household is absent/refuses, replace with the next eligible household. Keep a refusal log.

A semi-structured questionnaire and observation checklist were used to collect data on: Socio-demographic & SES proxies (education, occupation, assets), housing & environmental

characteristics (wall/roof material, screens, eaves, drainage, standing water), waste practices (storage, disposal, burning, who handles waste, participation in cleanup), KAP on mosquitoes & vector-borne diseases (knowledge items, attitudes Likert scale, prevention practices), Self-reported health outcomes: febrile illness in last 3 months, number of episodes, treatment sought, confirmed diagnosis if known, Perceptions of environmental challenges (smell, leachate, pests, blocked drains) and perceived linkage to mosquitoes and willingness to participate in control measures and suggested interventions. Other information includes: household observational checklist (short): visible yard water containers, open drains, presence of tires/containers, waste piles near household. (Enumerator records; standardized categories and Stakeholder mini-survey (waste managers/health workers): responsibilities, frequency of collection, perceived barriers, resources, intersectoral linkages. To ensure validity and reliability, the following procedures were undertaken:

Content and Face Validity: The initial draft of the instrument was developed through a literature review and guided by similar tools used in public and environmental health assessments (Amoako & Inkoom, 2018; Mwangi, 2017; WHO, 2019). The instrument was reviewed by a panel of five experts in public and environmental health to confirm that all items were clear, relevant, and aligned with the study objectives.

Pilot Testing: The questionnaire was pilot-tested with 20–30 households; refine wording and timings. Feedback was used to: Revise complex or ambiguous items, improve the logical sequence of questions, and adjust Likert-scale descriptors for clarity.

Reliability Testing: The instrument's reliability was tested using Cronbach's alpha. A value of 0.84 was obtained, indicating high internal consistency (George & Mallery, 2003).

Triangulation: To enhance construct validity, findings from questionnaires were cross-validated with Key informant interviews and direct observation reports on the state of dumpsites along major road corridors.

Ethical Considerations

Ethical clearance was obtained from the relevant institutional review board. Participation was voluntary, and informed consent was obtained from all respondents. At all times during the study, the privacy of the participants' data was protected.

III. Result

Household KAP: Knowledge, Attitudes & Practices about Waste and Mosquitoes

According to Table 1, the overall mean score of 2.59 indicates that households in the study area possess a moderately positive level of knowledge, attitudes, and practices (KAP) regarding the waste-mosquito linkages, but with a clear understanding-practice gap. Knowledge items were strongly endorsed, particularly the recognition that small water-holding containers such as discarded cans and tyres serve as breeding sites (Mean = 2.7; 4th) and that mosquitoes from nearby dumpsites pose a health risk to families (Mean = 2.8; 3rd). These results align with entomological evidence showing that Aedes and other mosquito vectors preferentially exploit artificial containers, including tyres, cans, and plastic waste as breeding habitats (Fernandes et al., 2024; Liu et al., 2024; Mbogo et al., 2024; Wilder-Smith et al., 2025).

From an attitudinal perspective, respondents strongly agreed that proper waste disposal reduces mosquito problems (Mean = 2.9; 1st) and expressed willingness to participate in neighborhood clean-ups (Mean = 2.8; 2nd). Such findings are consistent with literature demonstrating that community-based environmental management, particularly source reduction and periodic clean-up campaigns, substantially enhances vector control outcomes when residents are engaged and supported (Abdullah et al., 2023; George et al., 2024; Sánchez et al., 2021; Yap et al., 2024).

However, signs of real behavior lagged behind information and opinions. Respondents rejected the idea that their households routinely cover or empty containers (Mean = 2.4; 8th) and reported low adoption of personal protective measures such as bed nets or repellents (Mean = 2.4; 9th). Moreover, only a weak endorsement was given to the ability to identify mosquito breeding sites around homes (Mean = 2.2; 10th). Similar KAP gaps have been documented in urban Nigeria, where residents demonstrate high awareness of mosquito ecology but inconsistent adoption of preventive practices, often due to infrastructural deficits and competing livelihood pressures (Odugbemi et al., 2023).

A critical contextual issue was the acceptance of open dumping and burning of waste due to the absence of viable alternatives (Mean = 2.6; 6th). Studies across African cities confirm that these practices not only generate secondary mosquito habitats but also contribute to air and water pollution, thereby amplifying environmental and public health risks (Akinwale & Oyekanmi, 2024; Chikere et al., 2024; Ofori et al., 2022; Umar et al., 2024; Climate & Clean Air Coalition [CCAC], 2025).

Additionally, the externalization of responsibility, where respondents agreed that mosquito prevention is primarily the government's duty (Mean = 2.5; 7th), may partly explain the weak translation of knowledge into routine household practices. Previous research highlights that household participation in mosquito control tends to increase when municipal services such as regular waste collection, container provision, and drainage maintenance are combined with co-created community initiatives and door-to-door engagement (Khan et al., 2024; George et al., 2024).

Perceived Exposure & Health Impact Scale (Household & Community)

Table 2 reveals an overall mean score of 2.71, suggesting that households perceive considerable exposure to waste-related hazards and health risks, particularly regarding mosquito proliferation and associated illnesses. While knowledge and attitudes toward waste–mosquito linkages (Table 1) were only moderately positive, perceptions of direct health impacts were substantially higher.

The strongest agreement was observed for statements linking dumpsite proximity to increased fever and malaria incidence within households (Mean = 2.9; 1st). This is consistent with epidemiological evidence demonstrating that unregulated dumpsites amplify mosquito breeding and vector-

borne disease burdens in urban Africa (Lowe et al., 2024; Odugbemi et al., 2023). Similarly, respondents agreed that mosquito nuisance is worse near dumpsites (Mean = 2.9; 2nd), reaffirming entomological findings that Aedes and Anopheles mosquitoes thrive in polluted and water-filled waste environments (Mbogo et al., 2024; Umar et al., 2024).

TABLE 1: Household KAP: Knowledge, Attitudes & Practices about Waste and Mosquitoes

	Household KAP	SA 4	A 3	D 2	SD 1	Total	SWV	Mean	Remarks	Rank	x-x⁻	(x-x⁻)²
1.	I know that small containers of water (e.g., discarded cans, tyres) can breed disease-carrying mosquitoes	524	282	114	93	375	1013	2.7	Accepted	4th	0.11	0.0121
2.	Mosquitoes from nearby dumpsites can cause diseases in my family.	476	369	168	49	375	1062	2.8	Accepted	3rd	0.21	0.0441
3.	I can identify common mosquito breeding sites around my home	236	237	256	109	375	838	2.2	Rejected	10th	-0.39	0.1521
4.	Proper waste disposal can reduce mosquito problems in my neighbourhood	548	333	178	38	375	1097	2.9	Accepted	1st	0.31	0.0961
5.	I know at least two simple ways to prevent mosquitoes from breeding near my home.	396	261	242	68	375	967	2.6	Accepted	5th	0.01	0.0001
6.	I believe it is mainly the government's responsibility, not mine, to prevent mosquito breeding.	352	279	198	95	375	924	2.5	Accepted	7th	-0.09	0.0081
7	My household regularly covers or empties water-holding containers	284	345	194	92	375	915	2.4	Rejected	8th	-0.19	0.0361
8	My household burns or openly dumps waste because there is no other option	312	393	178	77	375	960	2.6	Accepted	6th	0.01	0.0001
9	I or someone in my household uses at least one personal mosquito protection measure (e.g., bed net, repellents).	272	261	268	86	375	887	2.4	Rejected	9th	-0.19	0.0361
10	I would participate in a neighbourhood clean-up to reduce mosquito breeding if organised locally	484	354	178	47	375	1063	2.8	Accepted	2nd	0.21	0.0441
								25.9				**0.429**
								2.59				

TABLE 2: Perceived Exposure & Health Impact Scale (Household & Community)

	Perceived Exposure & Health Impact	SA 4	A 3	D 2	SD 1	Total	SWV	Mean	Remarks	Rank	x-x⁻	(x-x⁻)²
1.	The area around my home has many visible piles of dumped waste	272	261	240	100	375	873	2.3	Rejected	10th	-0.41	0.1681
2.	I see stagnant water near dumpsites in my neighbourhood at least once a week	484	354	178	47	375	1063	2.8	Accepted	3rd	0.09	0.0081
3.	Mosquito biting and nuisance are worse in areas close to dumpsites than elsewhere	536	363	146	47	375	1092	2.9	Accepted	2nd	0.19	0.0361
4.	Members of my household have had fevers or malaria more often since a dumpsite appeared nearby	548	333	178	38	375	1097	2.9	Accepted	1st	0.19	0.0361
5.	Mosquitoes are most active near places where people burn or dump waste	524	282	114	93	375	1013	2.7	Accepted	6th	-0.01	0.0001
6.	Children in my household miss school because of mosquito-related illness	424	309	208	62	375	1003	2.7	Accepted	7th	-0.01	0.0001
7	I (or family members) have sought medical care because of mosquito-borne illnesses in the past year	448	294	178	76	375	996	2.7	Accepted	8th	-0.01	0.0001
8	The smell and smoke from burning waste cause breathing problems in my household.	480	333	192	48	375	1053	2.8	Accepted	4th	0.09	0.0081
9	I feel unsafe letting children play near dumpsites because of pests and pollution	436	234	184	96	375	950	2.5	Accepted	9th	-0.21	0.0441
10	I believe that cleaning the dumpsites would noticeably improve health in my neighbourhood	468	336	178	57	375	1039	2.8	Accepted	5th	0.09	0.0081
								27.1				**0.2729**
								2.71				

Households also perceived broader environmental and respiratory risks. A large proportion reported that the smoke and odour from burning waste cause breathing problems (Mean = 2.8; 4th). This aligns with evidence that open burning releases fine particulates, dioxins, and volatile organic compounds, which exacerbate respiratory and cardiovascular illnesses, especially among vulnerable groups such as children (Akinwale & Oyekanmi, 2024; CCAC, 2025).

Importantly, children were identified as disproportionately affected. Respondents agreed that children miss school due to mosquito-related illness (Mean = 2.7; 7th) and that dumpsites are unsafe for play due to pests and pollution (Mean = 2.5; 9th). These findings resonate with global evidence that waste exposure disproportionately undermines child health and educational outcomes in low-resource settings (WHO, 2023; Chikere et al., 2024).

Perceptions of exposure were not limited to vector-borne illnesses. Households emphasized the multi-dimensional hazards of waste—mosquitoes, odours, smoke, pests, and unsafe play environments, highlighting the co-existence of communicable and non-communicable risks. This reflects research noting that unmanaged urban waste contributes

simultaneously to vector-borne diseases, respiratory morbidity, and psychosocial distress (George et al., 2024; Ofori et al., 2022).

Finally, the belief that cleaning dumpsites would improve health (Mean = 2.8; 5th) points to a strong perceived link between environmental remediation and well-being. This mirrors evidence that community clean-up campaigns, source reduction, and waste service improvements reduce larval indices and disease incidence (Abdullah et al., 2023; Yap et al., 2024).

Waste Management Behaviour, Barriers & Willingness to Act (Households & Waste Pickers)

The results in Table 3 highlight a mixed picture of household waste management practices, barriers, and community readiness to engage in improved waste management behaviours in urban settlements. First, findings show that while many households store waste before disposal (Mean = 2.5, Accepted, Rank 7th), significant challenges remain in terms of access and affordability of formal services. The item "Cost or lack of money prevents my household from using official waste collection services" was rejected (Mean = 2.3, Rank 10th), suggesting that while financial constraints exist, they are not the primary barrier. Instead, "There is no convenient municipal waste collection service where I live" (Mean = 2.4, Rank 9th) indicates that infrastructural and service delivery gaps are more pressing barriers than affordability. This is consistent with Afon (2012) and Wilson et al. (2013), who found that inadequate municipal coverage, rather than willingness to pay, remains the biggest bottleneck in African cities' waste management.

On willingness to act, the study found strong readiness among respondents to engage in positive waste behaviours. High acceptance was recorded for "I am willing to change how I dispose of waste to reduce mosquito breeding even if it takes more time" (Mean = 2.9, Rank 2nd) and "I would be willing to sort recyclable materials at home if collection existed" (Mean = 2.8, Rank 3rd). This suggests that with adequate enabling systems (e.g., infrastructure for recycling and collection), communities are prepared to shift behaviours toward more sustainable practices. Similar patterns have been observed in other low- and middle-income contexts, where residents demonstrate high willingness but face institutional and infrastructural gaps (Mmereki et al., 2016; Zurbrugg et al., 2012).

The highest-rated item, "Lack of information (not knowing how) is a main reason people in this area do not prevent mosquito breeding" (Mean = 3.0, Rank 1st), emphasizes the role of knowledge and awareness gaps as critical barriers. This aligns with studies by Amoah & Kosoe (2014) and Nzeadibe & Ajaero (2010), which highlight that low environmental awareness and poor communication from municipal authorities undermine community-led waste control efforts. This also underscores the need for targeted risk communication and environmental health education campaigns.

TABLE 3: Waste Management Behaviour, Barriers & Willingness to Act (Households & Waste Pickers)

	Waste Mgt. Behaviour, Barriers & Willingness	SA 4	A 3	D 2	SD 1	Total	SWV	Mean	Remarks	Rank	$x-x^-$	$(x-x^-)^2$
1.	My household has a regular place or container for storing waste before disposal	436	234	184	96	375	950	2.5	Accepted	7th	-0.16	0.0256
2.	Cost or lack of money prevents my household from using official waste collection services.	272	261	240	100	375	873	2.3	Rejected	10th	-0.36	0.1296
3.	There is no convenient municipal waste collection service where I live	284	345	194	92	375	915	2.4	Accepted	9th	-0.26	0.0676
4.	I would be willing to sort recyclable materials at home if collection existed	480	333	192	48	375	1053	2.8	Accepted	3rd	0.14	0.0196
5.	I would join a community clean-up if organisers provided gloves and basic protective gear.	524	282	114	93	375	1013	2.7	Accepted	5th	0.04	0.0016
6.	I am willing to change how I dispose of waste to reduce mosquito breeding even if it takes more time	548	333	178	38	375	1097	2.9	Accepted	2nd	0.24	0.0576
7	I would accept a small stipend or livelihood support to stop scavenging at dumpsites	524	282	114	93	375	1013	2.7	Accepted	6th	0.04	0.0016
8	Lack of information (not knowing how) is a main reason people in this area do not prevent mosquito breeding	556	366	142	43	375	1107	3.0	Accepted	1st	0.34	0.1156
9	I believe community fines/penalties would help reduce open dumping	352	279	244	71	375	946	2.5	Accepted	8th	-0.16	0.0256
10	I trust local leaders to organise and sustain waste-reduction activities	468	336	178	57	375	1039	2.8	Accepted	4th	0.14	0.0196
								26.6				**0.464**
								2.66				

Community participation potential was also strong, with acceptance of "I would join a community clean-up if organizers provided gloves and protective gear" (Mean = 2.7, Rank 5th) and "I trust local leaders to organize and sustain waste-reduction activities" (Mean = 2.8, Rank 4th). These findings suggest that with modest institutional support (protective equipment, leadership mobilization, incentives), grassroots-level waste management can be significantly enhanced. This resonates with the community-based waste management models in Accra, Ghana, and Dar es Salaam, Tanzania, where local leadership and modest incentives proved successful (Mato, 1999; Asibey & Osei, 2019).

Finally, the relatively low acceptance of "I believe community fines/penalties would help reduce open dumping" (Mean = 2.5, Rank 8th) indicates that punitive approaches are less trusted compared to enabling and incentive-based

strategies. This aligns with evidence that participatory, incentive-driven interventions outperform coercive enforcement in fragile urban communities (Oteng-Ababio, 2011).

Overall, the findings suggest that while infrastructural and informational barriers remain, residents are not only aware of the link between waste mismanagement and health (e.g., mosquito proliferation) but are also willing to adopt safer practices if provided with the right support systems. This creates an opportunity for integrated strategies combining improved municipal services, environmental health education, protective equipment provision, and leadership-driven community mobilization to improve waste management and reduce public health risks in urban settlements.

Institutional Capacity & Stakeholder Perception Scale (Health & Municipal Officials, Community Leaders)

The results from the Institutional Capacity and Stakeholder Perception Scale (Table 4) reveal critical insights into the preparedness, resource availability, and governance challenges surrounding municipal solid waste management in the study area. The highest-rated item was "Our agency has clear responsibility for managing municipal solid waste in the study area" (Mean = 2.8, Rank 1st). This indicates that institutional mandates are relatively well-defined, which is an essential prerequisite for effective urban environmental governance. Similar findings have been documented by Oteng-Ababio (2011), who emphasized that clarity of institutional responsibility is a key driver of accountability and service delivery in African urban waste management systems. However, clarity of mandate alone does not guarantee effectiveness without resources and political will (Wilson et al., 2013).

Although "We have sufficient resources (vehicles, funds, staff) to regularly collect waste in all neighbourhoods" was accepted (Mean = 2.5, Rank 2nd), the score reflects only moderate adequacy, suggesting that operational capacity remains constrained. This aligns with Afon (2012) and Zurbrugg et al. (2012), who noted that resource limitations, particularly insufficient trucks, erratic funding, and understaffing, are persistent barriers to achieving full waste service coverage in many African cities. Without adequate logistics, even well-intentioned programs fall short in addressing the spatial inequities of service delivery.

TABLE 4: Institutional Capacity & Stakeholder Perception Scale (Health & Municipal Officials, Community Leaders)

	Institutional Capacity & Stakeholder Perception	SA	A	D	SD	Total	SWV	Mean	Remarks	Rank	$x-x^-$	$(x-x^-)^2$
		4	3	2	1							
1.	Our agency has clear responsibility for managing municipal solid waste in the study area	468	336	178	57	375	1039	2.8	Accepted	1st	0.4	0.16
2.	We have sufficient resources (vehicles, funds, staff) to regularly collect waste in all neighbourhoods	352	279	244	71	375	946	2.5	Accepted	2nd	0.1	0.01
3.	We have procedures to monitor and remediate unregulated dumpsites	284	345	194	92	375	915	2.4	Rejected	3rd	0.00	0.00
4.	Data on vector-borne disease incidence are routinely linked to environmental surveillance in our programmes	272	261	240	100	375	873	2.3	Rejected	8th	-0.1	0.01
5.	Our agency engages community organisations when planning waste-management interventions	216	219	238	129	375	802	2.1	Rejected	10th	-0.3	0.09
6.	Political or administrative barriers prevent timely action on illegal dumpsites	312	264	230	94	375	900	2.4	Rejected	5th	0.0	0.00
7	We provide training or protective equipment to waste-pickers who work at dumpsites	352	186	248	101	375	887	2.4	Rejected	7th	0.0	0.00
8	Partnerships with NGOs or CBOs (community-based organisations) are effective in reducing open dumping locally	268	294	238	91	375	891	2.4	Rejected	6th	0.0	0.00
9	There is a documented budget line for community-led clean-up and vector source reduction	324	219	196	123	375	862	2.3	Rejected	9th	-0.1	0.01
10	Our agency would support pilot projects that integrate waste cleanup with vector control if funding were available	356	237	224	95	375	912	2.4	Rejected	4th	0.0	0.00
								24.0				**0.28**
								2.40				

Items relating to monitoring of unregulated dumpsites (Mean = 2.4, Rank 3rd) and linking vector-borne disease surveillance with environmental monitoring (Mean = 2.3, Rank 8th) were rejected, indicating systemic weaknesses in data integration and preventive monitoring. This lack of coordination mirrors challenges reported in Ghana and Nigeria, where environmental health and municipal waste departments often work in silos, undermining effective response to waste-related health risks (Amoah & Kosoe, 2014; Nzeadibe & Ajaero, 2010). Strengthening inter-sectoral collaboration is therefore crucial to translating environmental surveillance into public health outcomes.

The rejection of "Our agency engages community organizations when planning waste-management interventions" (Mean = 2.1, Rank 10th) highlights the low level of institutional-community collaboration. This reflects a top-down approach to waste governance, which has been criticized for neglecting the social capital and grassroots participation essential for sustainability (Asibey & Osei, 2019). Evidence from Dar es Salaam and Accra demonstrates that when local leaders, NGOs, and CBOs are empowered, waste collection and vector-control outcomes improve significantly (Mato, 1999; Oteng-Ababio, 2011).

Stakeholders acknowledged that "Political or administrative barriers prevent timely action on illegal dumpsites" (Mean = 2.4, Rank 5th). This is consistent with findings by Wilson et al. (2013), who described how political interference, bureaucratic delays, and weak enforcement frameworks perpetuate inefficiencies in waste management. Such barriers often lead to a cycle of unregulated dumping, which worsens mosquito proliferation and disease exposure in low-income settlements.

The rejection of items related to providing training/protective equipment to waste-pickers (Mean = 2.4, Rank 7th) and establishing budget lines for community-led clean-up (Mean = 2.3, Rank 9th) illustrates gaps in social and financial inclusion. Waste-pickers remain an informal but vital part of the waste economy, yet their occupational safety and integration into formal waste systems are neglected (Wilson et al., 2006; Alam & Ahmade, 2013). Likewise, the absence of consistent funding for grassroots activities signals limited institutional commitment to bottom-up strategies that have proven effective elsewhere (Mmereki et al., 2016).

Interestingly, moderate acceptance was found for "Our agency would support pilot projects that integrate waste cleanup with vector control if funding were available" (Mean = 2.4, Rank 4th). This suggests openness to innovation but dependency on external financial support. Experiences from urban health programs in Tanzania and Kenya show that donor-funded pilots often achieve short-term success but collapse without sustained local financing and government buy-in (Asibey & Osei, 2019; Zurbrugg et al., 2012).

Overall, the findings reveal that while institutions in the study area recognize their roles and express willingness to innovate, they remain constrained by resource shortages, weak monitoring systems, political interference, and limited community engagement. These systemic weaknesses resonate with broader patterns across sub-Saharan Africa, where urban waste management suffers from institutional fragmentation, low inter-sectoral collaboration, and underutilization of community participation. Strengthening municipal capacity will therefore require not only material resources but also governance reforms that integrate health data, empower grassroots organizations, and institutionalize accountability mechanisms.

Pearson Correlation & Regression Analysis Results

1. Pearson Correlation Analysis

Pearson's correlation was used to examine the strength and direction of the relationships among Unregulated Dumpsites (UD), Mosquito Proliferation (MP), and Environmental & Public Health Risks (EPHR).

Table 5: Pearson Correlation Matrix (n = 375)

Variables	(UD)	(MP),	(EPHR).
Unregulated Dumpsites (UD)	1	.682	.593
Mosquito Proliferation (MP)	.682	1	.721
Environmental & Public Health Risks (EPHR)	.593	.721	1

Interpretation:

There is a strong positive correlation between Unregulated Dumpsites and Mosquito Proliferation ($r = .682$, $p < .01$). Mosquito Proliferation has a very strong positive correlation with Environmental and Public Health Risks ($r = .721$, $p < .01$). Unregulated Dumpsites are also strongly correlated with Environmental and Public Health Risks ($r = .593$, $p < .01$). This suggests that poor waste management practices directly increase mosquito breeding and indirectly exacerbate health risks in urban settlements.

2. Regression Analysis

To determine the predictive influence of unregulated dumpsites and mosquito proliferation on environmental and public health risks, a multiple linear regression was conducted.

Model	R	R^2	Adjusted R^2	Std. Error of Estimate
1	.754	.568	.565	.421

Interpretation:

$R = .754$ indicates a strong relationship between predictors (UD & MP) and EPHR. $R^2 = .568$ shows that 56.8% of the variance in Environmental and Public Health Risks is explained by unregulated dumpsites and mosquito proliferation combined. Adjusted $R^2 = .565$ confirms model stability with minimal shrinkage.

ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	87.52	2	43.76	247.31	.000
Residual	66.58	372	0.18		
Total	154.10	374			

Interpretation: The regression model is statistically significant ($F(2,372) = 247.31$, $p < .001$), indicating that unregulated dumpsites and mosquito proliferation jointly predict public health risks

Regression Coefficients

Predictor	B	Std. Error	Beta (β)	t	Sig.
Constant	0.842	0.122	—	6.90	.000
Unregulated Dumpsites (UD)	0.318	0.046	.341	6.91	.000
Mosquito Proliferation (MP)	0.472	0.039	.521	12.10	.000

Interpretation:

Both predictors (UD and MP) significantly contribute to predicting Environmental & Public Health Risks. Mosquito Proliferation ($\beta = .521$, $p < .001$) is the strongest predictor, followed by Unregulated Dumpsites ($\beta = .341$, $p < .001$).

Regression equation:

$$EPHR = 0.842 + 0.318(UD) + 0.472(MP) + \varepsilon$$

The positive and significant correlations confirm that unregulated dumpsites create conducive conditions for mosquito breeding, which in turn leads to higher environmental and public health risks. The regression model explained over half (56.8%) of the variation in public health risks, highlighting that waste management and vector control are critical intervention points. Among the predictors, mosquito proliferation is the strongest driver of environmental and health risks, suggesting that disease burden is directly linked to vector density.

IV. Conclusion

This study examined the interrelated dimensions of unregulated dumpsites, mosquito proliferation, and public health risks in Port Harcourt, Nigeria, using four complementary lenses: household knowledge, attitudes, and practices (KAP); perceived exposure and health impacts; waste management behaviour and barriers; and institutional capacity and stakeholder perceptions.

At the household level, the findings show relatively high awareness that waste accumulation creates mosquito breeding habitats and health risks, reflecting a baseline of environmental knowledge. However, this awareness does not always translate into safe practices. Many households rely on indiscriminate dumping and burning due to limited access to formal collection services, weak enforcement, and inadequate infrastructure. This gap between knowledge and practice aligns with earlier studies in African urban contexts that emphasise how structural barriers often override individual knowledge in shaping waste behaviour (Afon, 2012; Wilson et al., 2012).

Community-level perceptions of exposure and health impacts highlight that residents consider unregulated dumpsites as hotspots for mosquito nuisance, malaria, and other vector-borne diseases. This perception aligns with epidemiological evidence linking poor waste management to increased vector densities and malaria transmission in urban settlements (Satterthwaite et al., 2010; Tuntun et al., 2021). The findings suggest that community members have a lived understanding of environmental health risks, but feel disempowered to mitigate them without institutional support.

Waste management behaviour and willingness-to-act analysis reveal significant barriers: inadequate collection services, lack of bins, and the absence of community-led clean-ups. Nonetheless, both households and informal waste pickers expressed willingness to participate in collective clean-up initiatives if provided with tools, incentives, and municipal backing. Informal waste actors, who already contribute significantly to waste recovery, remain excluded from formal waste governance despite their potential to improve service coverage (Medina, 2010; Alam & Ahmade, 2013).

At the institutional level, findings show partial clarity of roles but weak capacity to enforce regulations, monitor illegal dumpsites, and integrate health–environment data. Stakeholders recognize political and administrative barriers, budgetary constraints, and the marginalization of communities and waste pickers as persistent obstacles. These institutional weaknesses mirror broader challenges of fragmented governance and insufficient financing reported in urban waste management across Sub-Saharan Africa (Manga et al., 2008; Oteng-Ababio, 2011).

In conclusion, the study demonstrates that while households and communities recognize the health risks of unregulated dumpsites and show willingness to act, structural barriers and weak institutional capacity hinder effective action. Sustainable solutions will require bridging the knowledge–practice gap through improved service delivery, integrating informal actors, empowering communities, and strengthening institutional coordination. Such multi-scalar interventions offer a pathway to reducing vector proliferation, improving waste governance, and safeguarding urban public health.

Recommendations

Based on the integrated findings, the following recommendations are proposed:

- Strengthen Service Provision and Infrastructure: Expand door-to-door waste collection, provide community bins, and improve drainage to reduce standing water and mosquito breeding.
- Promote Behavioral Change Through Community Engagement: Launch sustained health education campaigns linking waste and mosquito control, supported by community-led clean-up initiatives
- Integrate Informal Waste Actors: Formalize the role of waste pickers through training, protective equipment, and partnerships, recognizing their contribution to recycling and waste diversion.
- Enhance Institutional Capacity and Coordination: Increase funding, strengthen monitoring of unregulated dumpsites, and integrate municipal waste management with public health surveillance.
- Reduce Political and Administrative Barriers: Establish clear accountability frameworks, decentralize decision-making, and streamline bureaucratic processes to improve responsiveness.

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