



**Knowledge, Awareness and Attitude of Healthcare Providers and Waste Handlers towards
Healthcare Waste Management in Kano State, Nigeria**

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Abstract

Effective healthcare waste management (HCWM) depends not only on infrastructure and regulation but on what healthcare providers and waste handlers know, believe and do. This study examines the knowledge, awareness and attitude of healthcare providers (HCPs) and waste handlers (WHs) towards healthcare waste management in Kano State, Nigeria. Data were drawn from a cross-sectional survey of 30 healthcare facilities (10 purposively selected, 20 by stratified random sampling) across urban and rural local government areas, supported by key informant interviews, field observation and a review of facility records. Awareness of colour-coded containers was generally low: only one-third of HCPs were moderately aware, 15% were not aware at all, and awareness was concentrated in tertiary and secondary facilities a pattern linked to the John Snow Incorporated Making Medical Injections Safer project that supplied colour-coded materials between 2004 and 2009 but was never sustained. Waste handlers were substantially less aware than HCPs, reflecting lower levels of formal education. Awareness of the health risks of poor HCWM was high among HCPs (100%) but over one-quarter of waste handlers were unaware of those risks. Only a small minority of either group had ever attended HCWM training, yet among those who had, over 90% considered it important citing the absence of segregation materials as the main barrier to applying what they learned. Nearly one-third of HCPs regarded HCWM as an extra burden on their clinical work, and about one-fifth considered segregation undesirable. Over one-third of waste handlers were involved in the re-use and sale of components of unsegregated healthcare waste, including plastic bottles, aluminium cans, drug vials and used syringes, creating serious public health risks. Almost half of HCPs and over 40% of waste handlers expressed dissatisfaction with how healthcare waste was managed in their facilities. The study concludes that deficits in knowledge, attitude and training compounded by the unavailability of basic segregation materials are central to poor HCWM practice in Kano State, and that training without the tools to apply it cannot change behaviour.

Keywords: healthcare waste management; knowledge; awareness; attitude; waste handlers; training; Kano State; Nigeria



Introduction

Knowledge, awareness and attitudes of healthcare providers (HCPs) and waste handlers (WHs) are important factors influencing effective healthcare waste management (HCWM) practices (Umar and Yaro, 2009). Inadequate knowledge of hazardous waste categories, improper segregation procedures and the risks associated with unsafe handling can undermine waste management systems at the point of generation. Similarly, even when staff possess adequate knowledge and awareness, the lack of appropriate materials, equipment and institutional support may hinder the application of safe practices. Against this background, the study examines the knowledge, awareness and attitudes of HCPs and WHs towards HCWM in Kano State, with particular attention to practices across different levels of the healthcare system.

The study sits within a broader body of evidence on HCWM in Nigeria and comparable settings. Studies in Katsina State found that 59% of healthcare personnel believed HCWM was the responsibility of auxiliary staff (Umar and Yaro, 2009), and 36% regarded it as an extra burden on their work. Research in Lagos, Ibadan and other Nigerian cities has repeatedly identified inadequate training and low awareness as among the principal obstacles to safe practice (Coker et al., 2009; Longe and Williams, 2006; Awodele et al., 2016). Internationally, the World Health Organization has long argued that safe management of healthcare waste depends on trained personnel at every level, from the generator to the final handler, and that training must be supported by the materials, supervision and organisational culture that make safe practice possible (WHO, 1999; WHO, 2014).

Against this background, the present study asks three questions. First, what do HCPs and waste handlers in Kano State know about colour-coding, hazardous waste streams and the risks of poor handling? Second, what are their attitudes towards HCWM, including their sense of responsibility for it and their willingness to practise segregation? Third, how does training—and the availability of the materials training presupposes—shape these knowledge and attitude patterns? The findings are presented thematically and are intended to inform facility-level training, supervision and supply decisions as much as state-level policy.

Methods

Study Area

The study was conducted in Kano State, one of Nigeria's thirty-six states, located between latitudes 12°40' and 10°30' N and longitudes 7°40' to 9°30' E (Ahmed, 2010). The state borders Jigawa to the northeast, Katsina to the northwest, Kaduna to the southwest and Bauchi to the southeast, and comprises 44 local government areas, of which 8 are metropolitan and 36 non-metropolitan. It is the most populous state in Nigeria, with a 2006 census population of 9,401,288 about 6.7% of the national total comprising 4,947,952 males and 4,453,336 females (Federal Republic of Nigeria, 2007a), and a land area of 20,131 km² at a density of about 470 persons per km². The Hausa and Fulani are the predominant ethnic groups, alongside Kanuri, Yoruba, Igbo and other northern Nigerian communities (Danyaro, 1997).



The state lies within the Sudan Savanna, bordering the Guinea Savanna to the south, with mean monthly temperatures ranging from 21°C in the coolest month to 31°C in the hottest, and average annual rainfall of about 1,000 mm in southern Kano and 800 mm around the metropolis (Olofin, 1987); the mean annual rainfall recorded at Mallam Aminu Kano International Airport is 883 mm. Kano's healthcare network has expanded considerably since state creation in 1967, when there were only 4 general hospitals, 1 infectious disease hospital, 1 dental hospital and 8 clinics with a combined bed capacity of 585 (Danyaro, 1997). The state now has 10 specialised hospitals, 19 general hospitals and 2 cottage hospitals with a total bed capacity of 5,625 (HMB, Kano, 2016); 1,078 primary health facilities comprising 11 comprehensive health centres, 167 primary health centres, 173 health clinics and 728 health posts (SPHCDB, Kano, 2016); and 258 registered private health facilities (PHIRU, 2016). These facilities are heavily concentrated in urban areas: most secondary and tertiary facilities are in the metropolis, while rural areas are served mainly by primary healthcare and a few secondary facilities.

Critical cadres of service providers as at 2011 included 786 doctors, 3,073 nurses and midwives, 2,791 community health workers, 732 pharmacy staff and 614 laboratory staff (Gaya, 2011), with the two tertiary facilities accounting for 371 doctors and 1,109 nurses and midwives, and the 34 secondary facilities for 307 doctors, 427 nurses and midwives and 909 community health workers. At present, based on reports obtained in this study, there are well over 15,000 healthcare personnel and waste handlers in Kano State across tertiary, secondary, primary and private facilities.

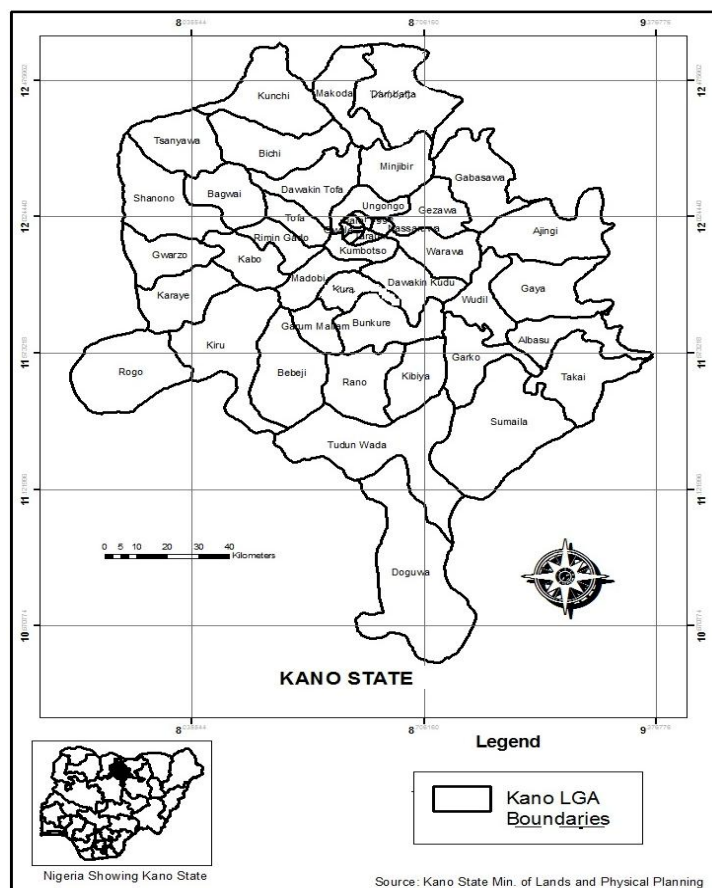


Figure 1: The Study Area

Research Design and Sampling

A cross-sectional survey design was employed, assessing variables of interest once and determining relationships between them (Adamu, 2006). Both quantitative and qualitative methods were combined—a triangulation or mixed-methods approach—in order to overcome the limitations of relying on either alone and to increase the validity of results.

Sampling of healthcare facilities combined probability and non-probability techniques, specifically stratified random sampling and purposive sampling. The strata were primary, secondary and tertiary facilities, with ownership (public/private) and location (urban/rural) also considered. A total of 30 healthcare facilities were selected: 10 purposively and 20 by stratified random sampling. HCWM is expected to vary with hierarchy, ownership, location and specialty, and all four conditions were therefore built into the sampling. Of the 30 facilities, 22 were urban and 8 rural—an urban bias justified by the concentration of specialised, private and tertiary facilities in metropolitan Kano. The state's only two tertiary and two specialist hospitals are located



in the metropolis, as are five of its six specialised hospitals, and over 80% of the 258 registered private facilities operate within urban Kano (PHIRU, 2016).

The purposively selected facilities were: Aminu Kano Teaching Hospital and National Orthopaedic Hospital, Dala (the only two tertiary facilities in the study area); the only two specialist hospitals in the state (Murtala Muhammad and Muhammad Abdullahi Wase Specialist Hospitals); and the six specialised hospitals (Infectious Diseases Hospital, Imam Wali Urology Hospital, Hasiya Bayero Paediatrics Hospital and others). The stratified random sample comprised four general hospitals (two metropolitan, two rural), eight primary facilities (two primary health centres, two basic health centres, two primary health clinics and two health posts) and eight private facilities (six hospitals and two diagnostic laboratories, six urban and two rural). These were drawn from four local government areas: Nassarawa and Gwale (urban) and Dambatta and Tudun Wada (rural), the two non-metropolitan LGAs included to allow examination of urban–rural variation in HCWM practice.

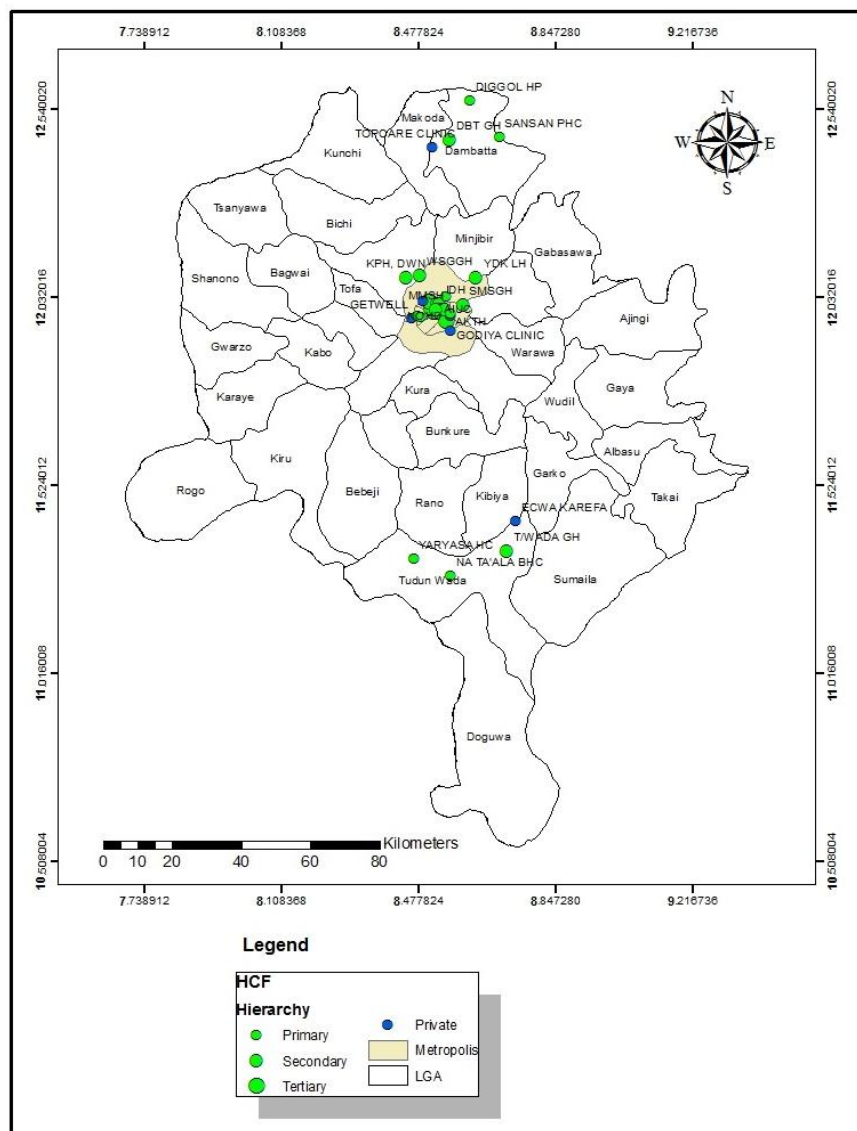


Figure 2: Distribution of the Sampled Healthcare Facilities by Hierarchy across the Sampled LGAs.

Respondents and Instruments

Respondents were selected at 95% confidence level and 5% marginal error using sample selection software, from an estimated population of over 15,000 healthcare providers and waste handlers. Three categories of respondents were surveyed: officers in charge of healthcare facilities; officers in charge of selected units within each facility; and other healthcare personnel, including doctors, pharmacists, nurses, waste management officers, laboratory scientists and community

health practitioners. A total of 796 questionnaires were administered across the three categories, of which 693 were completed and returned (a response rate of 87.1%); in addition, 169 waste handlers were interviewed using a semi-structured interview schedule, because many waste handlers could not complete the questionnaire.

Three instruments were used in the study: A semi-structured questionnaire covering facility type, bed capacity, waste generation, segregation, collection, storage, transportation, treatment and disposal practices, use of personal protective equipment, and HCWM policy and training was administered to the three respondent categories. A semi-structured interview schedule captured waste handlers' practices, awareness, knowledge and attitudes. In-depth key informant interviews were conducted with senior officials in policy and regulatory bodies the Kano State Ministry of Health, the Ministry of Environment, NESREA and the Private Health Institutions Registration Unit and in operational agencies REMASAB, the Hospitals Management Board and the State Primary Healthcare Development Board covering policy, regulation, financing, training and staffing. Structured observation, recorded on a checklist (Kothari, 2004), documented waste receptacles, protective materials used by handlers, central collection areas and treatment methods.

Ethical Considerations

Ethical approval for this study was granted by the Health Research Ethics Committee of the Kano State Ministry of Health. Informed verbal and written consent was obtained from all key informants, facility administrators and survey respondents before interviews, questionnaire administration and retrieval of administrative records. Key informant quotes are attributed by institutional role rather than personal identity to preserve confidentiality. Historical administrative figures reported in this paper serve as a documented institutional baseline against which recent regulatory developments in healthcare waste management can be evaluated.

Data Analysis

Data were coded, entered into SPSS and analysed using descriptive and inferential statistics. Descriptive statistics were used to characterise respondents and HCWM practices, presented as frequencies, percentages, tables and charts. Chi-square tests were used to assess differences in HCWM practices across facility hierarchies, ownership types and locations. Qualitative information on policy issues and stakeholder roles was analysed narratively. The number of valid responses varies across tables and figures because not all respondents answered every question. Table 1 and Table 2 report awareness responses from 460 HCPs; Table 3 reports stream-identification responses from the same 460 HCPs (who could name more than one stream); Table 4 reports responsibility responses from 433 HCPs who answered that question; Table 5 reports re-use responses from 169 waste handlers; Table 6 reports the views of 203 unit officers on sources of HCWM problems. The overall questionnaire return rate was 693, but not all returned questionnaires were complete for every item, and the waste-handler interview schedule (n = 169) is separate from the questionnaire survey.

Results

Awareness of Colour-Coded Containers

Awareness of colour-coded containers among HCPs was generally low (Table 1). One-third of respondents were moderately aware of colour coding for segregation and storage of healthcare waste; only a small proportion were strongly aware, and these were concentrated in tertiary facilities. Up to 15% of respondents were not aware of colour-coded containers at all.

Table 1: Awareness of Colour-coded Containers among HCPs, by Facility Hierarchy (n = 460)

Hierarchy	Not indicated (%)	Not aware at all (%)	Slightly aware (%)	Moderately aware (%)	Aware (%)	Strongly aware (%)	Total (%)
Tertiary	4 (4.5)	2 (2.3)	7 (7.9)	13 (14.8)	44 (50.0)	18 (20.0)	88 (100.0)
Secondary	5 (1.6)	62 (20.1)	46 (14.9)	116 (37.7)	77 (25.0)	2 (0.6)	308 (100.0)
Primary	1 (2.7)	3 (8.1)	17 (45.9)	14 (37.9)	2 (5.4)	0 (0.0)	37 (100.0)
Private	1 (3.7)	2 (7.4)	10 (37.0)	5 (18.5)	6 (22.2)	3 (11.1)	27 (100.0)
Total	11 (2.4)	69 (15.0)	80 (17.4)	148 (32.1)	129 (28.0)	23 (5.0)	460 (100.0)

Source: Fieldwork, 2015

HCPs in tertiary and secondary facilities were more aware of colour coding than those in primary facilities, a pattern attributable to the John Snow Incorporated Making Medical Injections Safer (MMIS) project, which supplied colour-coded materials to tertiary and selected secondary facilities in Kano State between 2004 and 2009. Awareness in private facilities may reflect experience gained in other healthcare settings. The finding matters because the use of colour-coded materials for segregation is the single most important element of the entire HCWM process (WHO, 1999).

Waste handlers were markedly less aware than HCPs (Figure 3). Nearly half were only slightly aware of colour coding, and only 7.7% and 3.6% were aware or extremely aware respectively—a gap that tracks the lower levels of formal education among waste handlers compared with HCPs.

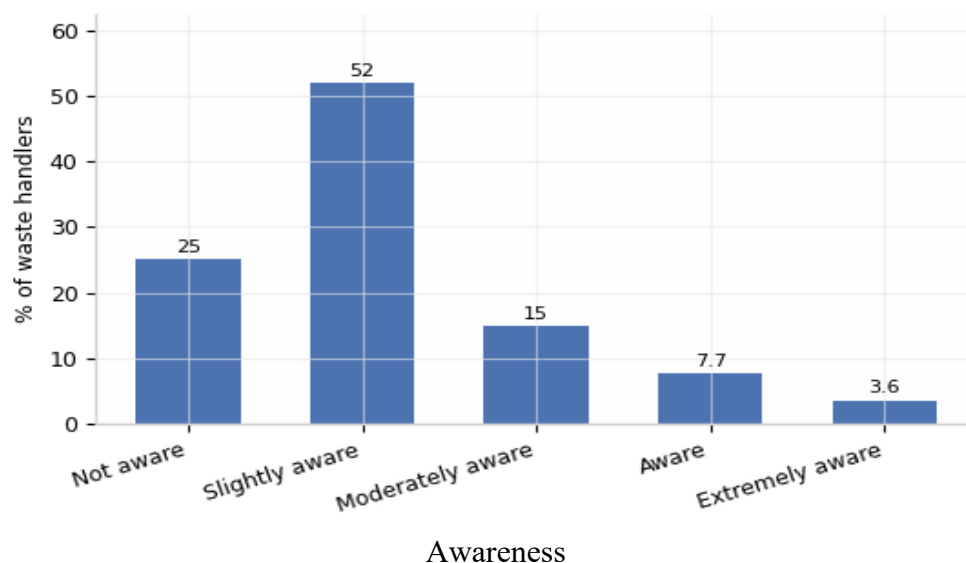


Figure 3: Awareness of Colour-coding by Waste Handle

3.2 Awareness of Healthcare Waste Risks

Awareness of the risks associated with poor HCWM was high among HCPs (Table 2): half were extremely aware and about one-third were aware, giving 100% awareness across the sample. Extreme awareness was highest among respondents in tertiary facilities and lowest in primary facilities, again reflecting the higher levels of knowledge among staff in tertiary settings.

Table 2: Awareness of Healthcare Waste Risks among HCPs, by Facility Hierarchy (n = 460)

Hierarchy	Moderately aware	Aware	Extremely aware	Total
Tertiary	12 (13.6)	26 (29.5)	50 (56.8)	88 (100.0)
Secondary	57 (18.5)	95 (30.8)	156 (50.6)	308 (100.0)
Primary	10 (27.0)	15 (40.5)	12 (32.4)	37 (100.0)
Private	6 (22.2)	8 (29.6)	13 (48.1)	27 (100.0)
Total	85 (18.5)	144 (31.3)	231 (50.2)	460 (100.0)

Source: Fieldwork, 2015

Beyond general awareness of risk, Table 3 shows which specific healthcare waste streams HCPs identified as hazardous. Sharps dominate, identified by 360 respondents (78.3%)—used syringes, needles, scalpels, blades and infusion sets. Infectious waste follows at 290 respondents (63.0%)—used gloves, tissues and blood-contaminated materials. Pathological waste is recognised by 220 respondents (47.8%) body parts, blood and other body fluids. Pharmaceutical and chemical waste is identified by only 60 respondents (13.0%)—expired drugs, damaged items and vials and radioactive waste by just 20 (4.3%)—X-ray films and radionuclide-contaminated items.

Table 3: Healthcare waste streams identified as hazardous by healthcare providers (n = 460)

Waste stream	Frequency	Percentage of respondents (%)
Sharp	360	78.3
Infectious	290	63.0
Pathological	220	47.8
Chemical / Pharmaceutical	60	13.0
Radiological	20	4.3

Source: Fieldwork, 2015.

Table 3 shows that hazard perception is organised around the visible and the immediate: the two highest-ranked streams, sharps and infectious waste, are those whose consequences are felt personally and at once, a pattern consistent with other Nigerian studies as asserted by Coker et al., 2009; and Awodele et al., 2016. Second, the non-infectious hazardous streams are poorly recognised. Pharmaceutical, chemical and radioactive waste carry delayed, cumulative or invisible risks, and their low ranking suggests awareness efforts have concentrated on acute infection and injury while neglecting environmental and chronic hazards. Streams not perceived as hazardous are unlikely to be segregated correctly. Third, the pattern helps explain the paradox reported earlier: HCPs are almost universally aware of the risks of poor HCWM (Table 2), yet largely unaware of colour coding and segregation practice (Table 1). Their knowledge is organised around personal protection rather than around the waste-management system that prevents exposure. Training should therefore be broadened to cover non-infectious hazardous streams and should explicitly link hazard recognition to segregation practice.

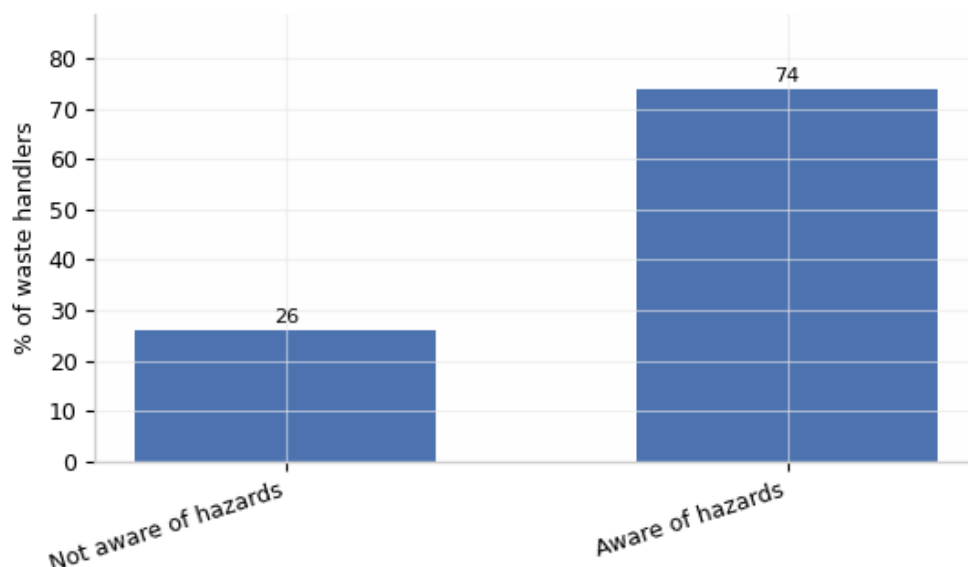


Figure 4: Awareness of HCW Hazards by Waste Handlers

Waste handlers, by contrast, were considerably less aware: over one-quarter were not aware of the hazards associated with improper handling of healthcare waste (Figure 4), a finding linked to their lower levels of formal education. Among those who were aware, injury and infection were the most commonly recognised hazards. That no HCP reported being either unaware or only slightly aware, while a substantial minority of waste handlers were unaware, indicates a knowledge gap that training and supervision would need to close.

Training in Healthcare Waste Management

Results in figures 5 and 6 indicate that only a small proportion of HCPs and waste handlers had ever attended HCWM training. Among those who had, however, the great majority attached importance to it: only 7% of HCPs and 6.1% of waste handlers who had attended training considered it unimportant. The most common explanation offered was the absence, or inadequacy of segregation and other HCWM materials in their facilities, which made important aspects of the training impossible to put into practice and, in their view, defeated the purpose of the training itself.

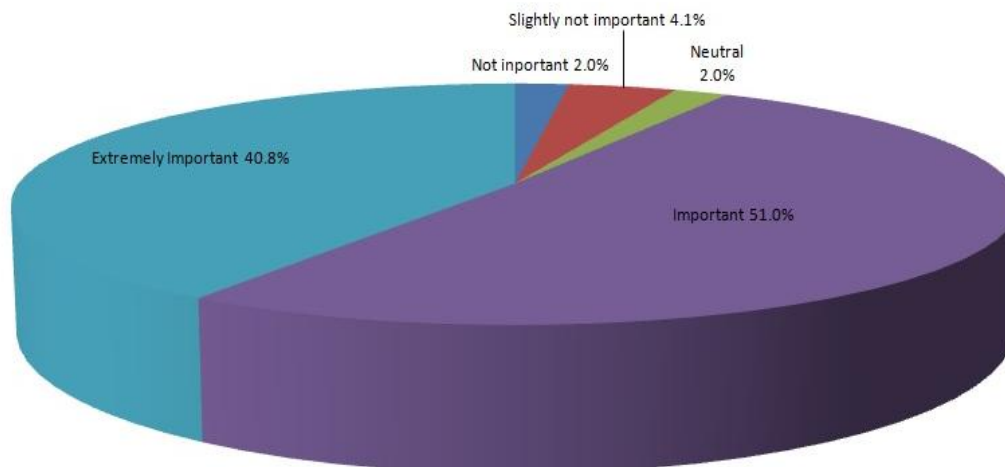


Figure 5: Importance of HCWM Training to Waste Handlers

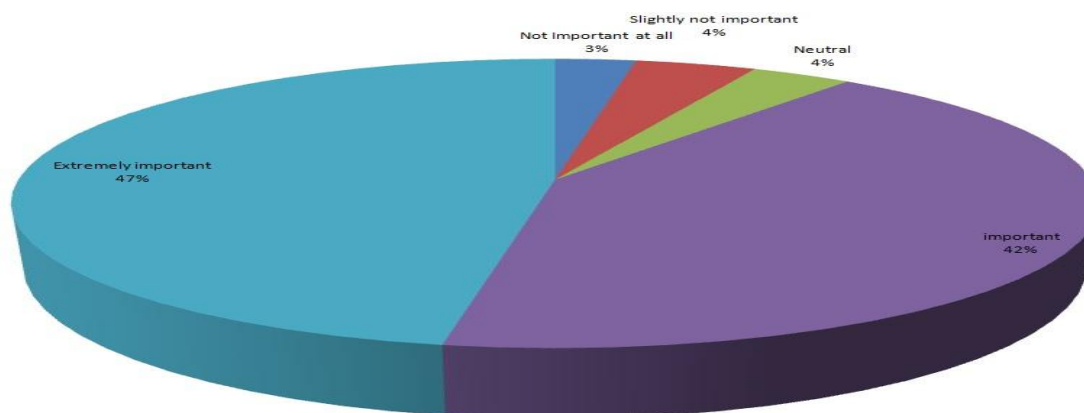


Figure 6: Importance of HCWM Training to HCPs

This finding is important for policy because it suggests that the problem is not resistance to training but the absence of the material conditions—bins, liners, colour-coded containers, PPE—that would allow trained staff to act on what they have learned. Training delivered without those conditions risks producing cynicism rather than compliance.

Attitude towards Healthcare Waste Management

The first step in assessing HCP attitudes was to examine how they perceived their own responsibility for HCWM (Table 4). Most considered HCWM to be their responsibility in some degree, but only 6.2% regarded themselves as responsible and 1.6% as completely responsible; about half regarded themselves as moderately responsible, and 15.5% considered themselves not responsible at all.

Table 4: Perceived Responsibility of Healthcare Personnel in HCWM (n = 433)

Hierarchy	Not responsible at all	Slightly responsible	Moderately responsible	Responsible	Completely responsible	Total
Tertiary	7 (8.0)	30 (34.1)	40 (45.5)	6 (6.8)	5 (5.7)	88 (100.0)
Secondary	58 (18.8)	69 (22.4)	158 (51.3)	21 (6.8)	2 (0.6)	308 (100.0)
Primary	2 (5.4)	21 (56.8)	14 (37.8)	0 (0.0)	0 (0.0)	37 (100.0)
Total	67 (15.5)	120 (27.7)	212 (49.0)	27 (6.2)	7 (1.6)	433 (100.0)

Source: Fieldwork, 2015

HCPs in tertiary and secondary facilities had a better perception of their responsibility than those in primary facilities: about two-thirds of HCPs in tertiary and secondary facilities held a satisfactory opinion of their responsibility for HCWM. This finding is consistent with Umar and Yaro (2009), who found that 59% of HCPs in Katsina State believed HCWM was the responsibility of auxiliary staff.

Nearly one-third of HCPs perceived HCWM as an extra burden on their work and therefore not their responsibility (Figure 7), a finding that points to a serious awareness and attitudinal problem contributing to poor HCWM in the study area. It agrees closely with Umar and Yaro (2009), whose survey in Katsina State found that 36% of healthcare personnel regarded HCWM as an extra burden.

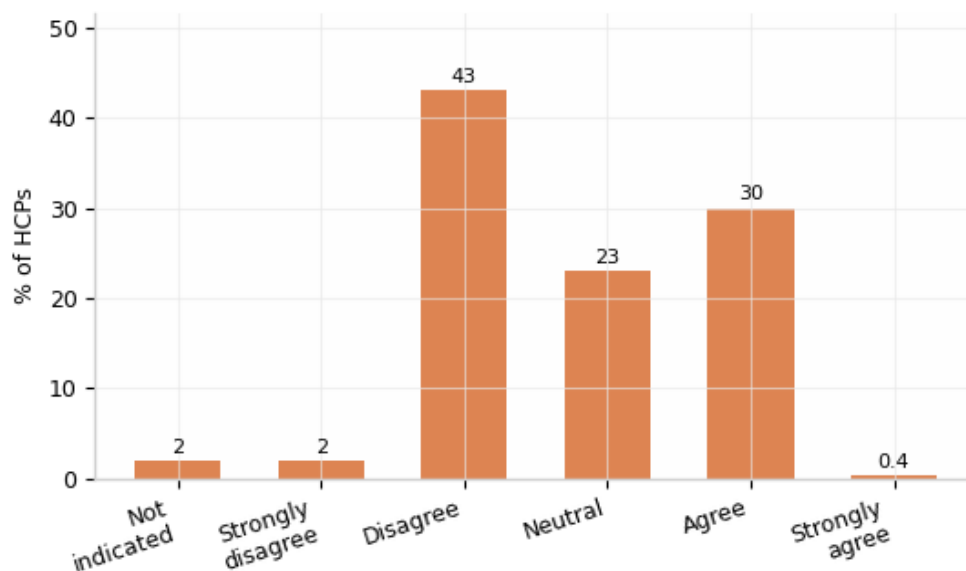


Figure 7: HCWM as an Extra Burden to HCPs

Attitudes towards segregation were more encouraging but not uniform. Most HCPs believed strict adherence to the segregation principle recommended by WHO (1999) was desirable, but about one-fifth regarded it as undesirable and 3.3% considered it very undesirable (Figure 8). This aligns with the earlier finding that about one-third of HCPs saw HCWM as an extra burden on their primary responsibility of patient care. Because segregation is a responsibility of HCPs at the point of generation, its perception as an added burden translates directly into poor practice.

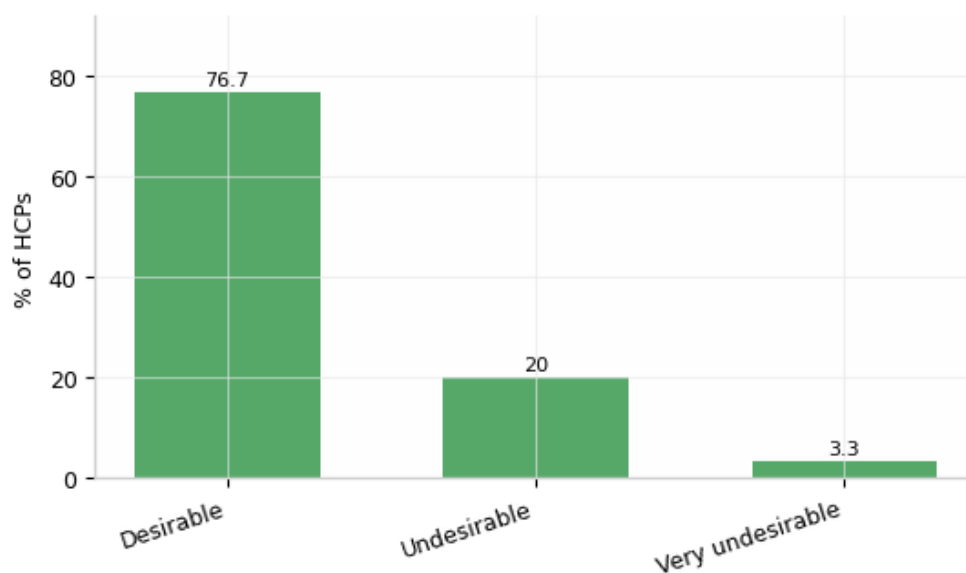


Figure 8: Desirability of HCW Segregation by HCPs

Re-use of Healthcare Waste Components by Waste Handlers

Re-use of healthcare waste is unacceptable under any circumstances because of its high potential to cause disease and injury—contrary to the popular 4Rs concept applied to municipal solid waste. Despite this, a significant proportion of waste handlers were involved in re-using components of unsegregated healthcare waste that had perceived re-use value (Table 5).

Table 5: Re-use of Healthcare Waste Components by Waste Handlers (n = 169)

Components of re-use value	Frequency	Percent	Cumulative percent
Not re-used	104	61.5	61.5
Plastic materials	7	4.1	65.7
Plastics and aluminium materials	33	19.5	85.2
Plastics, aluminium materials and empty vials	7	4.1	89.3
Plastics, aluminium materials and metals	1	0.6	89.9
Plastic materials and empty vials	1	0.6	90.5
Aluminium materials	6	3.6	94.1
Aluminium and empty vials	2	1.2	95.3
Empty vials	5	3.0	98.2

Metals	3	1.8	100.0
Total	169	100.0	

Source: Fieldwork, 2015

Most waste handlers were not involved in re-use of any healthcare waste component, but over one-third were involved in re-using materials of perceived value—mainly plastic bottles and aluminium cans. Female waste handlers engaged in re-use mostly identified plastic bottles as the main item, while males picked any re-usable component. Plastic bottles were sold outside the facilities and typically used as containers for locally made drinks such as zobo, kunun aya and kunun zaki, a practice of serious public health concern. Drug bottles, injection vials, used intravenous infusion bags and used syringes were also sorted and sold out of the facilities for various uses (Plates 1 and 2).



Plate 1: Sorting of Different Components of Re-usable HCW. Source: Fieldwork, 2015



Plate 2: Sorted Components of Re-usable HCW Ready for Sale. Source: Fieldwork, 2015.

A waste handler who had been engaged in the business for over ten years reported generating as much as or more than his monthly salary from the sale of re-usable healthcare waste items. He indicated strong awareness of the hazards associated with the business, but claimed that nothing negative had happened to him over a long period in the trade, attributing his survival to the use of hand gloves and, in his words, to prayers.

Satisfaction with Healthcare Waste Management

Perceptions of satisfaction with HCWM were closely similar between HCPs and waste handlers. Almost half of HCPs (Figure 9) and slightly over 40% of waste handlers (Figure 10) were not satisfied with the way healthcare waste was managed in their facilities. The closeness of the two independent findings—across groups differing in education and professional affiliation—is itself a clear indication of the extent of the HCWM problem in the study area.

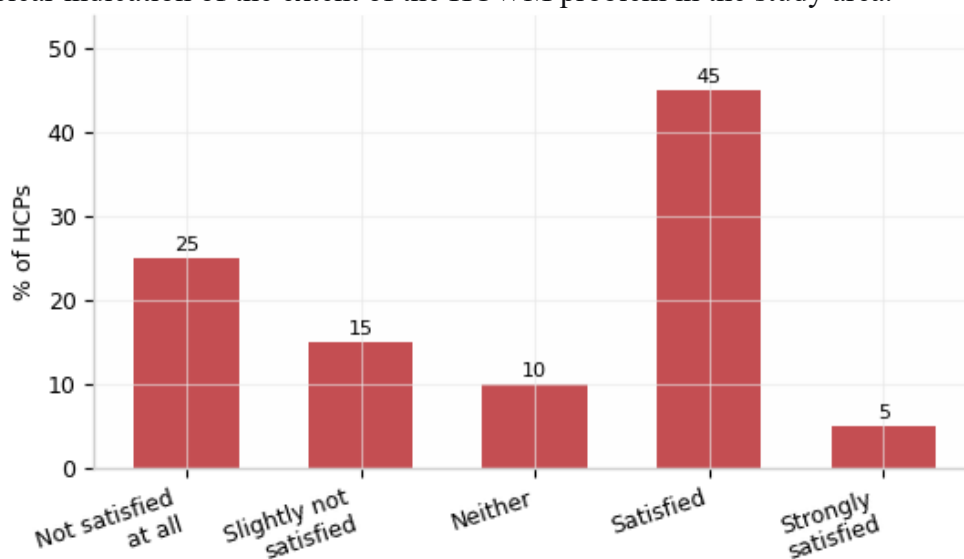


Figure 9: HCWM Satisfaction by HCP

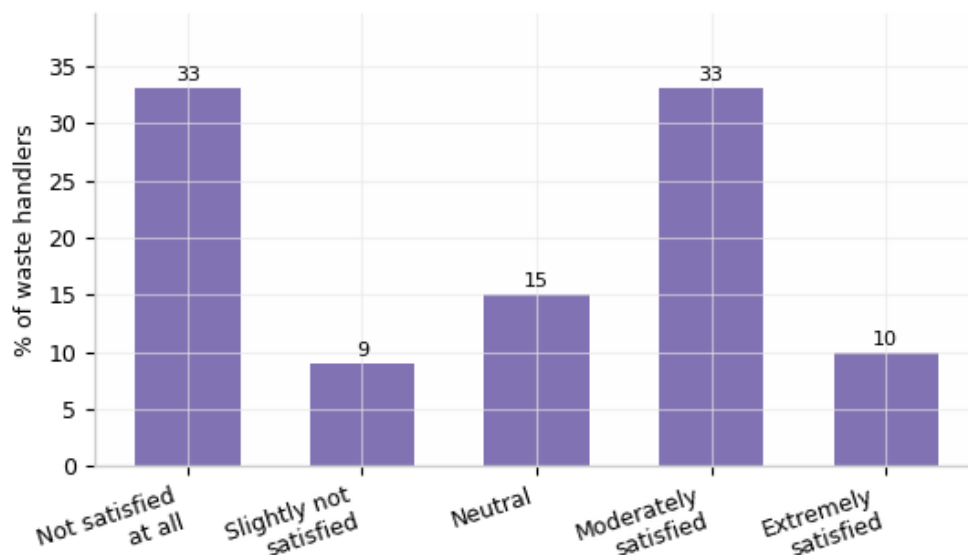


Figure 10: HCWM Satisfaction by Waste Handlers

Perceived Problems of Healthcare Waste Management

Unit heads identified several key drivers of healthcare waste management (HCWM) challenges within their respective facilities (Table 6). Nearly two-thirds of respondents (62.9%) confirmed the existence of operational problems in waste management. Among those who acknowledged these issues, the primary causes cited ranked by priority were a lack of government commitment, unsupportive facility management, and negative staff attitudes. Respondents further highlighted inadequate budgetary allocation, insufficient waste management facilities, and a lack of training and behavior-change advocacy as major structural barriers. These observations align with findings by Khairun et al. (2001), who noted that limited awareness and knowledge across organizational tiers remain central obstacles to effective HCWM in developing countries.

Table 6: Sources of HCWM problems as identified by unit officers (n = 203)

Source of problem	Frequency	Percent (%)	Cumulative percent (%)
No problem	77	37.9	37.9
Government	43	21.2	59.1
Government and management	27	13.3	72.4
Management	27	13.3	85.7
Management and staff attitude	10	4.9	90.6
Staff attitude	9	4.4	95.1
Government, management and staff attitude	4	2.0	97.0
Government and staff attitude	3	1.5	98.5
Government, management, staff attitude and patients	1	0.5	99.0

Patients	1	0.5	99.5
Government and patients	1	0.5	100.0
Total	203	100.0	

Source: Fieldwork, 2015

Waste handlers similarly reported widespread concerns with the HCWM system, with only about a quarter (28.0%) indicating that no problem existed. Table 7 details the severity of HCWM issues as perceived by waste handlers. A plurality viewed the problems as moderate (25.0%), whereas those holding a neutral stance represented the smallest group (7.5%). The primary grievances reported by waste handlers included a shortage of suitable working tools, inadequate personal protective equipment (PPE), and understaffing, which created an excessive daily workload.

Table 7: Level of HCWM problem perceived by waste handlers (n = 169)

Perceived Level of Problem	Frequency	Percent (%)
Not indicated	12	7.0
No problem	47	28.0
Minor problem	41	24.5
Neutral	13	7.5
Moderate problem	42	25.0
Serious problem	14	8.0
Total	169	100.0

Source: Fieldwork, 2015

General Discussion

Taken together, the empirical findings illustrate a healthcare workforce that is broadly aware of the biohazards associated with healthcare waste, yet systematically constrained—in technical knowledge, physical materials, and organizational support—to manage it safely. While healthcare providers (HCPs) generally recognize disease risks and accept segregation as a necessary clinical duty, a notable minority continue to view healthcare waste management (HCWM) as an administrative burden or someone else's responsibility. Awareness of color-coding systems remains patchy and strongly stratified by institutional hierarchy. Waste handlers—who bear the highest occupational exposure risk—are the least informed and least trained segment of the workforce, with a significant minority supplementing their livelihoods by salvaging and selling reusable components of unsegregated waste into nearby communities.

Three defining empirical patterns emerge from this investigation:

1. **Hierarchy-Driven Awareness:** Operational knowledge tracks institutional tier. Tertiary and secondary hospitals consistently outperform primary health centers and private clinics. This disparity reflects the lasting legacy of uneven coverage under the Making Medical Injections Safer (MMIS) project (2004–2009), alongside the greater administrative and logistical capacity of larger facilities.
2. **The Knowledge–Practice Gap:** Risk recognition does not automatically translate into compliant practice. HCPs' high awareness of general health risks coexists with limited technical knowledge of color coding, as well as attitudes—such as viewing segregation as an undesirable extra chore—that directly compromise waste management protocols.
3. **Training Deficits and Material Barriers:** Specialized training is rare across facilities, though highly valued where provided. Crucially, the primary obstacle to applying learned practices is the physical absence of segregation supplies (containers and color-coded liners) rather than worker resistance to learning.

These patterns align with observations from comparable resource-constrained healthcare environments across Nigeria and the broader Global South. Umar and Yaro (2009) documented similar attitudinal barriers in Katsina State; Coker et al. (2009) and Longe and Williams (2006) identified severe training deficits in Ibadan and Lagos; and Khairun et al. (2001) found widespread knowledge gaps across administrative tiers to be a fundamental HCWM challenge in developing nations. The World Health Organization has consistently maintained that training must be structurally paired with adequate supplies, active supervision, and a supportive institutional culture to enable safe waste management (WHO, 1999; WHO, 2014). The findings in Kano reinforce this consensus: the principal barrier is not an unwillingness to adopt safe behaviors, but the absence of enabling conditions under which training can be practically applied.

The informal salvaging and commercial resale of healthcare waste is particularly alarming. The diversion of used syringes, vials, and intravenous infusion bags from healthcare facilities into local markets, households, and informal beverage packaging represents an immediate vector for bloodborne pathogen transmission into the general public. That this practice persists despite handlers' general awareness of the risks—and that children and young adults dominate dumpsite scavenging—underscores a structural and economic driver rather than a purely educational one. The practice is perpetuated by the market value of recycled plastics, the lack of secure waste storage facilities, and the absence of alternative economic livelihoods for low-income waste handlers.

Consequently, poor waste management transcends institutional and occupational boundaries to pose severe public health risks for surrounding communities. Studies on urban solid waste and health outcomes in Kano Metropolis demonstrate that environmental sanitation systems are weakest in low- and medium-density residential areas lacking formal collection infrastructure. Dumpsites in these neighborhoods are frequently situated adjacent to homes and commercial spaces, exposing residents to direct and vector-borne infection risks (Danbuzu et al., 2014). The broader evidence confirms that biohazardous waste risks do not remain confined within hospital

walls. Where basic physical infrastructure—containers, dedicated collection, secure storage, and final disposal—is absent, even well-intentioned practices collapse, and the health burden falls disproportionately on vulnerable neighboring populations.

It is important to note that, the empirical data presented in this study reflect the 2015–2016 baseline survey. As such, they establish a documented historical benchmark against which the impact of subsequent regulatory frameworks, state environmental reforms, and pilot interventions in Kano State can be systematically evaluated.

Conclusion

This study examined the knowledge, awareness, attitudes, and operational practices of healthcare providers and waste handlers regarding healthcare waste management across Kano State. The empirical evidence demonstrates that while HCPs possess a high baseline awareness of general health risks, their practical knowledge of waste segregation and color coding remains limited. Waste handlers are consistently less informed and less trained than clinical staff across all evaluated measures. Although training programs are scarce, they are highly valued by staff; however, their practical utility is severely constrained by the chronic unavailability of basic segregation materials. Furthermore, a notable proportion of clinical staff perceive waste management as an extra burden outside their core duties, while over one-third of waste handlers actively salvage, reuse, or sell components of unsegregated healthcare waste. Near-equal proportions of HCPs (nearly 50%) and waste handlers (over 40%) expressed dissatisfaction with current waste handling practices in their facilities.

In summary, sub-optimal HCWM practices in Kano State are driven not by pure ignorance of disease risk, but by a combination of limited practical knowledge regarding segregation systems, diffused responsibility, scarce professional training, and chronic shortages of basic waste handling supplies. Interventions that target only one of these dimensions while ignoring structural supply and economic factors are bound to fail.

Recommendations

To address these multi-faceted challenges, an integrated intervention strategy is proposed across facility and regulatory levels:

At the Healthcare Facility Level:

1. Supply Chain Provision: Equip all clinical areas with standardized color-coded bins, heavy-duty liners, and safety boxes so that staff can apply waste segregation protocols effectively.
2. Routine Training and Visual Standard Operating Procedures (SOPs): Institutionalize mandatory HCWM orientation and periodic refresher training for all HCPs and waste handlers, supported by clear, visual SOP signage installed directly at waste generation points.
3. Role Clarification in Job Descriptions: Explicitly define HCWM duties within clinical job descriptions and ward routines to eliminate the perception that waste segregation falls outside clinical responsibilities.



4. Occupational Health and Financial Protections: Fully equip waste handlers with complete personal protective equipment (PPE) and mandatory Hepatitis B immunizations. Provide risk-adjusted occupational allowances to alleviate the financial pressures driving waste salvaging.
5. Secure Storage Infrastructure: Construct and maintain locked, secure temporary waste storage areas within facilities to prevent unauthorized access, scavenging, and the removal of reusable medical items.
6. Internal Audits and Supervision: Establish facility-level waste management committees to perform routine audits and monitor compliance with segregation and disposal protocols.

At the Government and Regulatory Level:

1. Sustainable Regulatory Funding: Allocate dedicated state budgetary funding for continuous HCWM training, and tie instructional programs directly to the procurement and distribution of waste segregation consumables.
2. Enforcement and Inspection: Enforce strict prohibitions against the informal resale and reuse of medical waste components through rigorous inspections and legal sanctions enforced by NESREA, PHIRU, and the Kano State Ministry of Environment.
3. Public Awareness Campaigns: Launch community-level public health campaigns highlighting the severe risks associated with reused medical plastic containers, specifically targeting their informal use as domestic food and beverage packaging.
4. Curricular Integration: Formally incorporate standardized HCWM modules into the undergraduate curricula of medical, nursing, and health technology institutions, as well as continuing professional development (CPD) frameworks.
5. Multi-Agency Coordination: Establish a standing multi-agency HCWM Coordination Committee comprising representatives from the Ministries of Health and Environment, Local Government Authorities, REMASAB, NESREA, and the State Primary Healthcare Development Board to harmonize regulatory oversight, supply chains, and enforcement efforts statewide.

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