IJAAR PUBLISHING®

African Journal of Environment and Sustainable Development | ISSN: 3027-2718
Vol. 4, Issue 2 (2026) | https://doi.org/10.46654/e9tvn563

Structural Integrity, Information Coverage, and Reporting Completeness of Manual Inspection Tools in Urban Environmental Health Governance: Evidence from Kwara State, Nigeria

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Abstract

Background: *Municipal environmental health premises inspection serves as a vital regulatory mechanism for interrupting disease transmission and enforcing sanitary compliance across sub-Saharan Africa. In municipal administration throughout Nigeria, routine field monitoring continues to depend almost exclusively on legacy paper checklists (Form ES1/ES2). However, structural gaps and operational field missingness threaten the validity of regulatory decision-making.*

Objective: *This study systematically evaluated the structural architecture, environmental item coverage, and baseline reporting completeness of traditional paper-based premises inspection forms across urban Local Government Areas (LGAs) in Kwara State, Nigeria.*

Methods: *A cross-sectional census investigation was undertaken across three metropolitan LGAs (Ilorin South, Ilorin West, and Ilorin East), encompassing all 35 field-active registered Environmental Health Officers (EHOs). A total of 76 paired premises evaluations were audited across two distinct observer groups: Main EHOs (n=50) and SIWES student interns (n=26). Inspection instruments comprised the standardized 23-item ES1 tool (1–5 Likert scale; theoretical range: 23–115). Primary outcomes assessed included item-level content comprehensiveness, total completeness yields, field-level missingness rates, and score agreement verified via absolute-agreement Intraclass Correlation Coefficients (ICC) and Multiple Imputation by Chained Equations (MICE) sensitivity modeling.*

Results: *Content audit revealed critical omissions in the standard 23-item checklist, which entirely excludes ambient/indoor air quality parameters, direct microbial/chemical water safety metrics, toxic exposure indicators, and environmental noise assessments. Field audits established severe reporting missingness. Complete 23-item data were recorded in only 28 of 50 Main EHO forms (56.0% yield; 52/1,150 missing cells, 4.52% item missingness) and 15 of 26 SIWES forms (57.7% yield; 55/598 missing cells, 9.20% item missingness). Mean paper scores among complete cases were 83.21 ± 14.2 for Main EHOs and 77.07 ± 14.5 for SIWES interns. Paired mode comparisons against an electronic benchmark showed non-significant total score differences (Main EHO difference: -3.54, p=0.091; SIWES difference: +6.73, p=0.284), yet absolute-agreement ICCs remained low (Main EHO ICC = 0.476; SIWES ICC = 0.444), demonstrating lack of individual-level interchangeability. MICE sensitivity analysis confirmed stable pooled estimates (Main EHO paper mean = 84.82; SIWES paper mean = 77.27).*

Conclusion: *Paper-based environmental health inspection tools in urban Kwara State are compromised by structural content gaps and substantial field reporting missingness. Standardizing checklist parameters and transitioning toward digital capture with automated mandatory validation are required to strengthen municipal environmental surveillance.*

Keywords: Environmental health inspection; Sanitary surveillance; Paper-based data quality; Field reporting completeness; Local government health systems; Kwara State; Nigeria.

1. Introduction

Environmental health premises evaluation represents a foundational regulatory instrument within public health practice, enabling municipal authorities to enforce sanitary codes, identify environmental hazards, and mitigate vectors of communicable disease transmission. Across lower- and middle-income countries (LMICs), frontline Environmental Health Officers (EHOs) are legally tasked with conducting routine field inspections, issuing statutory compliance directives, and documenting sanitary conditions within residential, commercial, and industrial facilities (Aluko et al., 2016; WHO, 2021). In Nigeria, this regulatory oversight relies overwhelmingly on physical, paper-based reporting instruments—traditionally designated as Environmental Sanitation (ES) forms (FMoEN, 2010; FMoH, 2014).

Despite their long-standing integration into municipal administrative structures, physical paper checklists present severe structural and operational constraints that diminish data utility. Paper forms are susceptible to physical degradation, illegible handwriting, transcription errors during manual collation, lost records, and extensive transmission lag (Aungst et al., 2021; Karuri et al., 2019). In routine field operations, officers frequently leave critical entry fields blank, resulting in incomplete datasets that obscure localized public health risks and hinder timely regulatory enforcement (Oluwole et al., 2020). Empirical evaluations in other Nigerian jurisdictions demonstrate that standard instruments—such as Form ES1—exhibit substantial structural gaps. For example, Umar and Sawyerr (2019) observed that routine inspection checklists in Gombe Metropolis completely omit modern environmental safety parameters, including indoor and ambient air quality indicators, chemical pollution metrics, and direct water safety testing.

In Kwara State, routine sanitary oversight across metropolitan Local Government Areas (LGAs) remains anchored in these historical paper forms. While health information management systems in clinical settings have progressively digitized through national frameworks like DHIS2 (Adedeji et al., 2022), local government environmental health departments operate within a technological vacuum. Establishing baseline empirical evidence regarding the structural comprehensiveness and field reporting fidelity of current paper tools is an essential prerequisite for health system modernization. Accordingly, this paper addresses Objective 1 of the broader Digital Environmental Health Inspection System (DEHIS) project by systematically auditing the structural parameters, item coverage, and data completeness yields of traditional paper-based premises inspection tools in Kwara State, Nigeria.

2. Theoretical and Conceptual Framework

To rigorously interpret why incomplete paper inspection practices persist and how they impact public health governance, this study synthesizes two established theoretical perspectives: Institutional Theory and Systems Theory.

2.1 Institutional Theory

Formulated by Meyer and Rowan (1977), refined by DiMaggio and Powell (1983), and extended in contemporary organizational policy literature (Kauppi, 2022), Institutional Theory asserts that administrative entities frequently adopt and maintain structured practices to secure social legitimacy, regulatory compliance, and institutional stability, rather than to

optimize technical efficiency. In Nigerian local government administrations, Environmental Health Departments operate under strict normative and legal mandates requiring the utilization of standardized ES inspection forms (ES1–ES14) (FMoEN, 2010). Over decades, the completion of these paper forms has transformed into an entrenched administrative ritual. Consequently, field officers continue to utilize these physical forms due to institutional inertia and bureaucratic habituation, even when the instruments are recognized as structurally deficient and prone to severe field missingness.

2.2 Systems Theory

Originally articulated by Ludwig von Bertalanffy (1968), Systems Theory conceptualizes operational processes as integrated structures comprising inputs, throughput processing, outputs, and feedback mechanisms. Applied to municipal environmental health surveillance (Figure 1), paper inspection checklists, statutory regulations, and personnel serve as system inputs. Field evaluation, manual recording, and physical form transmission constitute the throughput processes. The resulting system outputs consist of calculated sanitary scores, compliance classifications, and enforcement notices. Systems Theory posits that data omissions or structural defects at the input phase directly propagate through throughput processing, generating unreliable public health intelligence and compromised regulatory feedback loops.

3. Materials and Methods

3.1 Study Location and Target Population

The investigation was executed across the three metropolitan Local Government Areas comprising the Ilorin urban confluence in Kwara State, Nigeria: Ilorin South, Ilorin West, and Ilorin East. This urban center serves as the administrative, commercial, and demographic hub of Kwara State. The target study population comprised all 35 registered Environmental Health Officers (EHOs) actively assigned to premises inspection duties within these three municipal LGAs. Given the compact, defined cadre size, a complete enumeration (census) methodology was implemented, enrolling 100% of eligible field-active officers to eliminate sampling bias.

3.2 Inspection Instrument and Scoring Architecture

The primary paper instrument evaluated was the standard Form ES1 (Routine Premises Inspection Checklist). The tool comprises 23 explicit inspection items categorized across four functional structural domains: (1) Building Structure and Ventilation, (2) Water Supply and Hygiene, (3) Waste Management and Drainage, and (4) Sanitary Facilities. Each item is evaluated on an ordinal scale ranging from 1 (Very Poor / High Risk) to 5 (Excellent / Compliant), yielding a continuous theoretical score range of 23 to 115 points. According to established municipal regulatory criteria, a premise is classified with a binary verdict of 'Sanitary' if and only if three conditional thresholds are satisfied simultaneously: (a) Total percentage score $\geq 50.0\%$, (b) Water supply adequacy sub-score > 1, and (c) Latrine/toilet facility condition sub-score > 1. Premises failing any single condition receive a 'Not Sanitary' designation.

3.3 Field Data Auditing and Paired Assessment Protocol

Field inspection records were audited across two distinct participant groups operating during the evaluation period: the Main EHO professional cohort (50 premises inspections) and the Student Industrial Work Experience Scheme (SIWES) intern cohort (26 premises

inspections). To establish rigorous comparative benchmarks, inspections were conducted using a paired crossover protocol wherein premises were concurrently or immediately evaluated using the electronic KoboToolbox capture framework. Paper forms were audited for cell-level missingness, structural item completeness, section yields, and score calculations. In accordance with epidemiological standards, missing paper entries were preserved as true missing values rather than imputed as zeros during primary analysis.

3.4 Statistical Analysis and Sensitivity Modeling

Data were analyzed using SPSS Version 28 and R Version 4.3.2. Complete-case yields were calculated as percentages of fully completed forms across all 23 items. Item-level missingness was calculated as missing data cells over total theoretical data points (1,150 cells for Main EHOs; 598 cells for SIWES). Total scores were compared between paper forms and electronic benchmarks using Wilcoxon signed-rank tests for paired ordinal data and paired t-tests with 95% confidence intervals (CI). Measurement interchangeability was evaluated via absolute-agreement Intraclass Correlation Coefficients (ICC; two-way random model, single measures) and Bland-Altman agreement analysis (Koo & Li, 2016; Bland & Altman, 1986). To test the sensitivity of primary complete-case findings to missing data assumptions, Multiple Imputation by Chained Equations (MICE) with predictive mean matching (50 imputed datasets, 20 iterations, donor pooling) was performed under Rubin's rules (White et al., 2011; Rubin, 1987).

4. Results

4.1 Structural Domain Coverage and Content Audit

A rigorous content audit of the 23-item paper ES checklist demonstrated that while basic physical infrastructure parameters are present, modern environmental health indicators are systematically absent. Table 1 contrasts the functional domain coverage of the standard paper instrument against international environmental health surveillance guidelines (WHO, 2022).

Table 1: Content audit highlighting structural domain inclusions and critical parameter omissions in the paper ES1 checklist.

Domain Category	Included Checklist Parameters	Omitted Critical Parameters	Status
Structural Hygiene	Building condition, ventilation, lighting, roof integrity	Indoor air quality (PM2.5/PM10), toxic paint indicators	Partial
Water Sanitation	Water source type, proximity to latrine, storage state	Direct microbial testing, heavy metal/chemical contamination	Partial
Waste & Drainage	Refuse storage receptacle, liquid waste flow, vector presence	Hazardous waste segregation, effluent chemical monitoring	Partial
Sanitary Facilities	Toilet type, cleanliness score, superstructure condition	Handwashing facility water/soap presence, ratio per habitant	Partial
Environmental Pollution	None (completely absent)	Ambient air particulate, environmental noise, chemical hazards	Absent

4.2 Field Reporting Yields and Missingness Rates

Field audits revealed substantial data incompleteness across both Main EHO and SIWES paper assessments. Out of 50 paired Main EHO inspections, complete data across all 23 items were recorded on only 28 paper forms, yielding a complete-case rate of 56.0%. Across the 1,150 total data cells required for the Main EHO cohort, 52 cells were left completely blank, representing an item-level missingness rate of 4.52%. For the SIWES intern cohort (26 paired inspections), complete forms were obtained for 15 records (57.7% complete-case yield), with 55 blank cells out of 598 theoretical entries, representing an item missingness rate of 9.20% (Table 2).

Table 2: Field completeness yields and item-level missingness rates across paper inspection cohorts.

Observer Group	Total Audited	Complete Forms	Complete Yield (%)	Missing Cells	Item Missingness (%)
Main EHO Cohort	50 pairs	28 forms	56.0%	52 / 1,150	4.52%
SIWES Intern Cohort	26 pairs	15 forms	57.7%	55 / 598	9.20%

4.3 Score Distributions and Method Agreement Analysis

Among complete paper records, the mean inspection score for Main EHOs was 83.21 ± 14.2 (out of 115 theoretical points), compared to a paired electronic mean score of 79.68 ± 14.8. The mean paired difference (electronic minus paper) was -3.54 points (95% CI: -8.96 to 1.89; Wilcoxon W = 132.5, p = 0.091). For the SIWES cohort, complete paper forms yielded a mean score of 77.07 ± 14.5, whereas paired electronic assessments yielded 83.80 ± 15.1 (mean difference: +6.73 points, 95% CI: -1.15 to 14.61; Wilcoxon W = 38.0, p = 0.284). While statistical testing indicated no significant population mean difference in either cohort, Intraclass Correlation Coefficients for total scores were low (Main EHO ICC = 0.476, 95% CI: 0.134 to 0.722; SIWES ICC = 0.444, 95% CI: -0.062 to 0.771). Bland-Altman analysis confirmed wide 95% limits of agreement (Main EHO: -31.8 to +24.7 points; SIWES: -22.5 to +36.0 points), proving that paper and electronic individual assessments lack interchangeability.

4.4 Multiple Imputation Sensitivity Analysis

To verify whether missing paper items distorted the complete-case findings, a 50-dataset MICE predictive mean matching sensitivity model was executed. Pooled MICE estimates confirmed complete-case results. For Main EHOs (n=50), pooled paper mean score was 84.82 and electronic mean was 83.34 (pooled difference: -1.48, 95% CI: -5.25 to 2.29, p = 0.441, Fraction of Missing Information [FMI] = 0.003). For SIWES interns (n=26), pooled paper mean score was 77.27 and electronic mean was 81.96 (pooled difference: +4.69, 95% CI: -0.30 to 9.69, p = 0.065, FMI = 0.024) (Table 3).

Table 3: Comparison of complete-case score distributions and MICE missing-data sensitivity models.

Cohort / Model	Sample (n)	Paper Mean (SD)	Complete Case p	MICE Paper Mean	MICE Diff (95% CI)	MICE p
Main EHO	50 (28 cc)	83.21 (14.2)	p = 0.091	84.82	-1.48 (-5.25 to 2.29)	p = 0.441
SIWES Interns	26 (15 cc)	77.07 (14.5)	p = 0.284	77.27	+4.69 (-0.30 to 9.69)	p = 0.065

5. Discussion

This empirical evaluation provides critical baseline evidence regarding the structural gaps and operational limitations of paper-based premises inspection tools in urban Kwara State. The content audit demonstrated that the 23-item ES1 checklist is heavily biased toward visible structural parameters while entirely neglecting critical modern environmental risks such as indoor air pollution, direct drinking water quality, chemical hazards, and environmental noise. These findings directly align with prior observations by Umar and Sawyerr (2019) in Gombe Metropolis, confirming that legacy ES forms across Nigerian municipalities are outdated and structurally insufficient for comprehensive environmental health surveillance.

Operationally, the observation that over 42% of audited paper forms suffered from item missingness underscores the vulnerability of paper workflows to field data loss. In routine practice, unentered fields force administrative officers to make subjective assumptions during compliance scoring, introducing error and delaying enforcement. As predicted by Systems Theory (Von Bertalanffy, 1968), missing data inputs at the field level distort throughput processing and undermine the validity of municipal public health outputs. Furthermore, Institutional Theory (DiMaggio & Powell, 1983; Kauppi, 2022) explains why local government departments continue to rely on these deficient forms: bureaucratic habituation and formal regulatory mandates enforce adherence to established routines despite recognized technical inefficiencies.

Importantly, the agreement analysis revealed a subtle but crucial methodological insight. While aggregate mean scores between paper forms and electronic benchmarks showed no statistically significant difference, individual record agreement was remarkably low (ICC < 0.50; wide Bland-Altman limits). This indicates that paper forms suffer from substantial individual measurement noise and operator variability. Relying solely on paper forms in regulatory practice creates substantial risk of misclassifying premises compliance status, potentially issuing sanitary clearances to high-risk premises or penalizing compliant facilities.

6. Conclusion and Policy Recommendations

6.1 Conclusion

Existing paper-based environmental health premises inspection tools in Kwara State exhibit severe structural omissions and substantial field reporting missingness. While paper checklists provide a rudimentary mechanism for assessing basic housing structure, they fail to capture critical modern environmental safety parameters and suffer from high field data loss. Transitioning toward a standardized, digitally validated inspection model is necessary to ensure robust, real-time environmental health surveillance in Nigerian municipalities.

6.2 Actionable Policy Recommendations

To address the structural and operational deficiencies identified in this study, a phased implementation matrix is presented in Table 4.

Table 4: Prioritized policy action matrix for environmental health inspection modernization.

Phase / Horizon	Recommended Action Strategy	Responsible Agency	Measurable Key Indicator
Immediate (Months 1–3)	Redesign Form ES1 checklist to incorporate missing variables: indoor air quality, water quality testing, and environmental noise metrics.	Ministry of Environment / EHORCON / Research Team	Approved expanded 30-item revised checklist
Short-Term (Months 4–6)	Deploy digital capture system (DEHIS) with mandatory form validation to eliminate blank fields and automate scoring logic.	LGA Environmental Health Depts / System Developers	Field missingness rate reduced below 1.0%
Ongoing (Months 7–12)	Establish routine supervisory auditing, standardized EHO digital training, and automated database backups.	State Primary Health Care Development Agency / LGAs	100% EHO digital field compliance audit score

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