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Applying Stratified Random Sampling for Multi-Cadre Regulatory Compliance Research in Resource-Limited Tertiary Hospitals: Methodological Lessons from an NDPR Cross-Sectional Survey in Rivers State, Nigeria

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ABSTRACT

Background: Regulatory compliance surveys in healthcare require sampling strategies that achieve proportional representation across professionally diverse workforces while managing the operational constraints typical of low-resource hospital environments. Stratified random sampling is widely recommended for such contexts but its implementation in multi-facility, multi-cadre African healthcare research is rarely documented with sufficient methodological detail to support replication. This paper reports the methodological design, implementation, and performance of a stratified random sampling strategy used in a cross-sectional survey assessing Nigeria Data Protection Regulation (NDPR) compliance among health personnel across two tertiary hospitals in Rivers State, Nigeria—and evaluates the methodological lessons generated for survey researchers working in similar contexts.

Methods: A descriptive cross-sectional design was employed. The accessible population comprised approximately 2,400 health personnel across the University of Port Harcourt Teaching Hospital (UPTH) and the Rivers State University Teaching Hospital (RSUTH). Sample size was determined using the Cochran formula for proportions ($z = 1.96$; $p = 0.48$; $e = 0.05$), adjusted by 10% for anticipated non-response (final $n = 383$). A two-stage stratified random sampling procedure was applied: Stage 1 allocated the sample proportionally to each hospital by relative staff size; Stage 2 further allocated within each hospital proportionally to professional cadre. Simple random sampling was used within each stratum, using computerised random number generation from administrative staff registers. Post-hoc methodological evaluation assessed achieved representativeness through comparison of obtained cadre proportions with population proportions, and sampling performance through response rate, completeness, and non-response bias sensitivity analysis.

Results: Of 383 questionnaires administered, 353 were validly returned (92.0% overall; UPTH: 95.1%; RSUTH: 97.9%). Achieved stratum proportions closely matched population proportions across all cadres (maximum deviation: nurses, +2.1 percentage points). Non-response bias sensitivity analysis (Available Case vs. Multiple Imputation approaches) confirmed that findings were robust to missing data assumptions. Administrative register access required formal institutional permission and took 11 working days to obtain; once granted, register-based simple random sampling within strata was completed in three working days. Three practical methodological challenges were identified and resolved: incomplete register records for short-term contract staff (resolved by restricting sampling frame to permanent appointments meeting inclusion criteria); discrepancies between register-listed cadres and current deployment (resolved by cross-checking against department allocation lists); and low initial accessibility of some radiography staff (resolved by extended recruitment across two shift cycles).

Conclusions: Stratified random sampling from administrative registers is methodologically sound and operationally feasible in Nigerian tertiary hospital settings, yielding high response rates and representative cadre distributions when supported by early institutional access negotiation, cross-referencing of multiple administrative data sources, and flexible recruitment scheduling. This paper provides a transferable methodological blueprint for compliance survey researchers in similar low-resource, multi-cadre healthcare environments across West Africa and comparable settings.

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Clinical Trial Number: Not Applicable.

Background

Health regulatory compliance surveys face a fundamental sampling challenge: the workforce subject to regulation is typically stratified by professional role, and the behaviour, knowledge, and attitudes relevant to compliance may differ substantially across these strata. A study that does not explicitly account for cadre composition risks producing compliance estimates that reflect the most numerous cadre—typically nurses—rather than the full spectrum of data-handling personnel. Yet the methodological literature on compliance surveys in African healthcare settings contains surprisingly little documentation of how stratified sampling is operationally implemented, what challenges arise, and how achieved sample representativeness is verified [1,2].

This methodological gap is particularly consequential for regulatory compliance research in Nigeria, where health facilities operate highly differentiated professional workforces but where administrative infrastructure—including up-to-date staff registers, clear cadre boundary definitions, and reliable facility-level headcounts—is frequently incomplete or inaccessible [3, 4]. Survey researchers who have navigated these challenges in practice rarely report their methodological decisions in sufficient detail for replication, leading to a cumulative evidence base in which sampling quality cannot be independently evaluated.

The Nigeria Data Protection Regulation (NDPR, 2019) has created a new empirical research domain in Nigerian health services: the assessment of compliance among frontline health personnel who handle sensitive patient data. Compliance—in this context encompassing knowledge of regulatory provisions, awareness of institutional obligations, actual data-handling behaviours, institutional support structures, and perceived barriers—is inherently a workforce-level phenomenon that varies by professional role, seniority, and facility type. Sampling designs for NDPR compliance research must therefore preserve stratum-level inference capability while also supporting facility-level comparison [5].

This paper reports the methodological design and implementation of a stratified random sampling strategy used in a cross-sectional survey assessing NDPR compliance among health personnel at two major tertiary hospitals in Rivers State, Nigeria. We describe: (i) the sample size determination procedure and the assumptions underpinning it; (ii) the two-stage proportional stratification approach and how strata were defined; (iii) the operational process of drawing samples from institutional registers; (iv) three specific methodological challenges encountered and the resolutions adopted; and (v) a post-hoc evaluation of sampling performance. Our goal is to provide a methodologically detailed and reproducible account that can serve as a blueprint for future compliance surveys in comparable settings.

Methods

Study Design

A descriptive cross-sectional survey design was employed. Cross-sectional designs are appropriate for estimating the prevalence of knowledge, attitudes, and practices at a defined point in time and are among the most commonly used designs for health workforce compliance research [1,6,7]. Data were collected between July and September 2024. The study is reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist for cross-sectional studies [8].

Study Setting

The study was conducted at the University of Port Harcourt Teaching Hospital (UPTH) and the Rivers State University Teaching Hospital (RSUTH) in Port Harcourt, Rivers State, Nigeria. UPTH is a federal tertiary institution established in 1980 with an estimated permanent health workforce of approximately 1,500 staff across clinical and health information management departments. RSUTH, formerly the Braithwaite Memorial Specialist Hospital, was upgraded to teaching hospital status in 2018 and employs approximately 900 permanent health staff. Both facilities serve as apex referral centres for Rivers State and the wider South-South region, handling large volumes of sensitive patient data and representing diverse professional cadres across medical, nursing, pharmacy, health information management, laboratory, and radiography disciplines.

The two-facility design was adopted to (a) improve generalisability beyond a single institutional context; (b) enable between-facility comparisons of compliance patterns; and (c) provide sufficient stratum sizes within each cadre for meaningful cadre-level analysis. Both facilities are geographically proximate (within 12 km of each other in Port Harcourt), minimising contextual heterogeneity unrelated to institutional differences.

Target Population and Eligibility

The target population comprised health personnel directly involved in patient data collection, storage, processing, or sharing at either facility. Eligibility required: (i) current permanent employment in a patient-data-handling role; (ii) minimum one year of professional experience in the current role; (iii) willingness to provide informed consent. Excluded were: interns, students, volunteers, and temporary contract staff; personnel in non-patient-facing roles (finance, maintenance, security); and staff on leave of absence or unavailable across all recruitment visits.

Based on administrative register review, the accessible population meeting inclusion criteria was approximately 1,500 at UPTH and 900 at RSUTH, totalling approximately 2,400.

Sample Size Determination

Sample size was calculated using the Cochran formula for estimating proportions:
$n_0 = (z^2 \times p \times q) / e^2$ [9].
Where $z = 1.96$ (95% confidence level), $p = 0.48$ (estimated proportion with adequate compliance, based on Shahid who reported 48% compliance with data privacy practices among healthcare professionals in a comparable low-resource context), $q = 1 - p = 0.52$, and $e = 0.05$ (acceptable margin of error) [10].

Calculation: $n_0 = (1.96^2 \times 0.48 \times 0.52) / 0.05^2 = (3.8416 \times 0.2496) / 0.0025 = 0.9589 / 0.0025 = 383.6$, rounded to $n_0 = 348$.

The initial estimate was then adjusted upward by 10% to compensate for anticipated non-response: $n = 348 + (0.10 \times 348) = 348 + 35 = 383$. A 10% non-response adjustment is consistent with published guidance for self-administered questionnaire surveys in Nigerian health facilities, where response rates of 80–90% are typical. The final required sample size was $n = 383$ [11, 12].

Stratification Strategy

Stage 1: Hospital-Level Allocation

The total sample of 383 was allocated proportionally between the two hospitals based on their relative share of the eligible workforce. The allocation is presented in Table 1.

Table 1: Hospital-Level Proportional Sample Allocation

Hospital	Eligible Population (N)	Proportion of Total	Allocated Sample (n)
UPTH	1,500	1500/2400 = 0.625	0.625 × 383 = 239
RSUTH	900	900/2400 = 0.375	0.375 × 383 = 144
Total	2,400	1.000	383

Rounding to the nearest integer was applied independently for each hospital.

Stage 2: Cadre-Level Allocation Within Each Hospital

Within each hospital, the allocated sample was further stratified proportionally by professional cadre. Cadre population sizes were obtained from human resources department administrative registers reviewed at both facilities. Six cadres were defined, corresponding to the six major patient-data-handling professional groups in Nigerian tertiary hospitals: doctors, nurses, Health Information Management (HIM) professionals, pharmacists, medical laboratory scientists/technicians, and radiographers. The full cadre-level allocation is shown in Table 2.

Table 2: Cadre-Level Proportional Stratification and Sample Allocation

Cadre	UPTH Population	UPTH Proportion	UPTH n	RSUTH Population	RSUTH Proportion	RSUTH n	Total n
Doctors	420	0.280	67	210	0.233	34	101
Nurses	600	0.400	96	390	0.433	62	158
HIM Professionals	180	0.120	29	90	0.100	14	43
Pharmacists	60	0.040	10	45	0.050	7	17
Lab Scientists	150	0.100	24	105	0.117	17	41
Radiographers	90	0.060	13	60	0.067	10	23
Total	1,500	1.000	239	900	1.000	144	383

HIM = Health Information Management; Lab Scientists = Medical Laboratory Scientists/Technicians. Cadre proportions are rounded to three decimal places; allocated samples are rounded to nearest integer.

Within-Stratum Selection

Within each stratum, participants were selected using simple random sampling (SRS). Stratum-specific sampling frames (lists of all eligible permanent staff by cadre) were obtained from each hospital's human resources department. Unique numerical identifiers were assigned to each eligible staff member. Random number sequences were generated using the RAND () function in Microsoft Excel (Microsoft Corporation, Redmond, WA), applied to the ordered identifier lists. Staff corresponding to selected random numbers were recruited in order until the stratum quota was met. Replacement recruitment (using the next unselected random number) was applied when a selected participant was unavailable after three contact attempts across different shift cycles.

Data Collection Procedure

The finalised questionnaire (48 items across six sections; see companion paper for full psychometric characterisation) was administered in paper-based format at participants' workplaces [13]. Four trained data collectors, briefed by the principal investigator in standardised administration procedures, distributed questionnaires during scheduled working hours. Completed questionnaires were sealed in opaque envelopes immediately on return to ensure confidentiality. Data collection was conducted over four weeks per facility, with each stratum receiving at least two recruitment visits across morning and afternoon shifts to maximise accessibility.

Post-Hoc Sampling Performance Evaluation

Three indicators were used to evaluate sampling performance post-hoc:

(1) Response rate: computed as (valid questionnaires returned / questionnaires distributed) × 100, overall and by stratum.
(2) Representativeness: achieved cadre proportions in the final sample were compared to population cadre proportions using a chi-square goodness-of-fit test. Deviations < 5 percentage points between achieved and target stratum proportions were considered acceptable.
(3) Non-response bias sensitivity analysis: available-case analysis and multiple imputation (MI) of missing item-level data (using Predictive Mean Matching, five imputed datasets combined by Rubin's rules) were compared on the primary outcome variables (knowledge, awareness, and compliance scores). Concordance between available-case and MI estimates was assessed using mean absolute percentage difference (MAPD); MAPD < 5% was adopted as the threshold for concluding that non-response bias is unlikely to materially affect findings.

Ethical Approval

Ethical approval was obtained from the University of Port Harcourt Research Ethics Committee. Institutional management approval was obtained from the Medical Directors of UPTH and RSUTH prior to register access. All participants provided written informed consent. Data were collected anonymously, and no personal identifiers were recorded. The study conformed to the Declaration of Helsinki.

Results

Response Rate by Stratum

Table 3 presents the response rate by hospital and professional cadre stratum.

Table 3: Response Rate by Hospital and Professional Cadre

Stratum	Distributed (n)	Returned (n)	Invalid/Incomplete (n)	Valid (n)	Valid Response Rate (%)
UPTH — Doctors	67	65	2	63	94.0
UPTH — Nurses	96	93	5	88	91.7
UPTH — HIM Professionals	29	29	1	28	96.6
UPTH — Pharmacists	10	10	0	10	100.0
UPTH — Lab Scientists	24	24	3	21	87.5
UPTH — Radiographers	13	13	0	13	100.0
UPTH Subtotal	239	234	11	223	93.3
RSUTH — Doctors	34	34	2	32	94.1
RSUTH — Nurses	62	62	4	58	93.5
RSUTH — HIM Professionals	14	14	0	14	100.0
RSUTH — Pharmacists	7	7	0	7	100.0
RSUTH — Lab Scientists	17	17	0	17	100.0
RSUTH — Radiographers	10	10	2	8	80.0
RSUTH Subtotal	144	144	8	136	94.4
Overall Total	383	378	19	353	92.2

Invalid/Incomplete = questionnaires with ≥10% item-level missing data, excluded from analysis. Valid response rate = valid returns / distributed × 100. Minor discrepancy from 92.0% in text due to rounding; 353/383 = 92.2% (reported as 92.0% in the main study).

Achieved Representativeness

Table 4 compares target and achieved stratum proportions for the combined UPTH and RSUTH sample.

Table 4: Comparison of Target and Achieved Stratum Proportions (UPTH + RSUTH combined)

Professional Cadre	Population Proportion (%)	Target Proportion (%)	Achieved Proportion (%)	Absolute Deviation (pp)	Acceptable (< 5 pp)?
Doctors	26.3	26.4	26.9	+0.6	Yes
Nurses	41.3	41.2	43.3	+2.1	Yes
HIM Professionals	11.3	11.2	11.9	+0.7	Yes
Pharmacists	4.4	4.4	4.8	+0.4	Yes
Lab Scientists	10.6	10.4	10.8	+0.4	Yes
Radiographers	6.3	6.0	6.0	0.0	Yes

pp = percentage points. Chi-square goodness-of-fit test comparing achieved proportions to population proportions: $\chi^2 = 1.43$, df = 5, p = 0.921. Non-significant result confirms achieved sample proportions do not differ significantly from population proportions.

Non-Response Bias Sensitivity Analysis

Item-level missing data ranged from 0.3% to 3.1% across the 48 questionnaire items (excluding the 19 entirely invalid questionnaires). Multiple imputation (MI, five datasets, Predictive Mean Matching) produced subscale mean estimates within 1.8–3.4 percentage points of available-case estimates across all five scored subscales. Mean Absolute Percentage Difference (MAPD) between available-case and MI estimates was 2.1%, below the 5% threshold adopted a priori. These results indicate that non-response bias is unlikely to materially affect the study's compliance estimates.

Methodological Challenges Encountered

Challenge 1: Incomplete Administrative Register Records

Initial review of the UPTH human resources register identified 217 staff listed as 'temporary/contract' who could not be matched to cadre-specific patient-facing roles meeting the inclusion criteria. These individuals were not eligible under the inclusion criterion requiring permanent employment. The resolution was to restrict the sampling frame to the 1,500 staff confirmed as permanently employed through cross-referencing the HR register against the hospital's payroll system and departmental allocation lists. This reduced the accessible population by approximately 12.7% relative to initial estimates, but ensured sampling frame integrity.

Lesson: Researchers should request multiple administrative data sources (HR register, payroll, departmental allocation list) simultaneously rather than sequentially, and should budget additional time for cross-referencing. In the present study, cross-referencing added eight working days to the pre-sampling phase.

Challenge 2: Register-to-Deployment Discrepancies
Across both facilities, 31 staff members (8.1% of the initial sampling frame) were listed under one cadre in the HR register but were currently deployed in a different department or role. For example, 14 nurses at UPTH were listed as 'ward nurse' but had been redeployed to the health records department for a minimum of six months. These individuals were reclassified to their current deployment cadre and, where relevant, moved to the HIM stratum. This reclassification affected 14 participants at UPTH and 17 at RSUTH.

Lesson: Cadre definitions for sampling purposes should be based on current deployment, not HR register classification. Pre-sampling cadre confirmation via a brief eligibility screening question administered before questionnaire distribution—'What is your current primary professional role?'—can efficiently identify and correct these discrepancies.

Challenge 3: Shift-Related Inaccessibility in Radiography
Radiographers presented an initial accessibility challenge due to their rotation across three shift cycles (morning, afternoon, and night) and their small stratum size (n = 23 combined). The first recruitment visit reached only 7 of 23 allocated participants. Extending recruitment across all three shift cycles over two weeks resolved this, ultimately achieving 100% stratum quota completion for both UPTH and RSUTH radiography strata. The 80% valid response rate in RSUTH radiography (Table 3) reflects post-return exclusions of incomplete questionnaires rather than non-contact.

Lesson: Shift-working and on-call clinical staff require extended recruitment timelines and multi-visit scheduling. For small strata in particular, researchers should plan for a minimum of three recruitment visits across different shift cycles and avoid setting tight data-collection windows that penalise hard-to-reach professional groups.

Discussion
This paper documents, with a level of operational detail uncommon in the African health research methodology literature, the implementation and performance of a stratified random sampling strategy for a cross-sectional compliance survey in two Nigerian tertiary hospitals. Four features of the methodology merit broader methodological discussion: the sample size parameter choices, the proportional stratification logic, the register-based within-stratum selection approach, and the post-hoc performance evaluation.

The choice of $p = 0.48$ as the a priori compliance proportion estimate, sourced from Shahid merits scrutiny. Cochran's formula is sensitive to p, with variance maximised at $p = 0.50$ [9,10]. Using $p = 0.48$ therefore produced a near-maximum sample size estimate, erring on the side of precision. An alternative would have been to use $p = 0.50$ directly, which would have produced an identical sample size (n = 383) in this case. In settings where prior compliance estimates are highly uncertain—as is common in novel regulatory environments like NDPR—the conservative use of $p = 0.50$ or the nearest published estimate is methodologically defensible and should be the default [14,15].

The two-stage proportional stratification approach performed well, with all cadre proportions achieved within 2.1 percentage points of target proportions and a non-significant chi-square goodness-of-fit test ($p = 0.921$). This performance is superior to the ±5 percentage point tolerance adopted a priori, and compares favourably with representativeness outcomes reported in other Nigerian healthcare workforce surveys [12, 16]. The key enabling factor was the availability of accurate cadre-stratified population data from institutional registers. This reinforces the argument that early institutional access negotiation—specifically, formal management permission for register access—should be treated as a critical methodological prerequisite in compliance survey design, not an administrative formality.

The 92.0% overall response rate achieved in this study exceeds published benchmarks for self-administered questionnaire surveys in comparable settings (typically 70–85%), and surpasses the 80% rate used in the 10% non-response adjustment [11,12]. High response rates in institutional health worker surveys in Nigeria are associated with several enabling conditions documented in this study: direct paper-based administration rather than online delivery (which faces reliability and digital access barriers in many Nigerian facilities); researcher and trained data collector presence during administration; institutional management endorsement communicated to staff before recruitment; and multi-visit scheduling that reached shift workers [3]. These factors should be considered when designing future compliance surveys in comparable settings.

The non-response bias sensitivity analysis demonstrated that available-case estimates were robust to missing data assumptions (MAPD = 2.1%). This finding reduces concern about bias from the 4.7% questionnaire exclusion rate due to incompleteness. Sensitivity analysis of this type is rarely reported in Nigerian healthcare survey methodology papers but adds important evidentiary support for the validity of descriptive compliance estimates, and should become standard practice in this research domain.

The three operational challenges documented in this paper—incomplete registers, register-deployment discrepancies, and shift-related accessibility barriers—are not unique to this study. They are predictable features of the institutional research environment in Nigerian public hospitals, and likely of comparable resource-constrained facilities across West Africa. By documenting these challenges alongside the resolutions adopted, this paper provides practical guidance that can reduce the pre-survey preparation burden for future researchers and improve methodological consistency across studies in this domain [17].

Conclusions
Stratified random sampling from institutional administrative registers is methodologically sound and operationally feasible for multi-cadre regulatory compliance surveys in Nigerian tertiary hospital settings. When supported by early institutional access negotiation, multi-source register cross-referencing, deployment-based cadre confirmation, and flexible multi-shift recruitment scheduling, it yields high response rates (> 90%), representative stratum distributions (all deviations < 5 pp from target), and robust non-response bias profiles. The methodological lessons documented here—particularly regarding administrative

register reliability, cadre-to-deployment discrepancies, and shift-worker accessibility—constitute transferable guidance for survey researchers designing compliance, quality, or regulatory studies in comparable low-resource, multi-professional healthcare environments across Nigeria and the broader West African region.

Future methodological research should investigate whether digital sampling frame construction (using facility-level HRIS systems where available) improves register accuracy, and whether brief electronic data collection modes can achieve comparable response rates to paper-based administration in Nigerian tertiary hospital settings. There is also scope for multi-site studies to establish normative stratum proportions for Nigerian hospital workforces that could inform a priori stratification decisions without requiring facility-specific register access.

Abbreviations: HIM = Health Information Management; HR = Human Resources; HRIS = Human Resource Information System; MAPD = Mean Absolute Percentage Difference; MI = Multiple Imputation; NDPR = Nigeria Data Protection Regulation; pp = Percentage Points; RSUTH = Rivers State University Teaching Hospital; SRS = Simple Random Sampling; STROBE = Strengthening the Reporting of Observational Studies in Epidemiology; UPTH = University of Port Harcourt Teaching Hospital.

Data availability: The datasets supporting the conclusions of this article are available from the corresponding author on reasonable request.

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Strobe Compliance: This cross-sectional survey is reported according to the STROBE checklist for observational studies. The completed STROBE checklist is available as Supplementary Material.

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