

Sanitation, Overcrowding, and Cholera Risk in Insecure Internally Displaced Persons Camps in Nigeria: A Structured Evidence Review and Conceptual Risk-Stratification Framework

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Meyeyin-Bala Kelvin

Action Health International Institute, Lagos, Nigeria

 MK [0009-0000-3033-1765](https://orcid.org/0009-0000-3033-1765)

Correspondence: Meyeyin-Bala Kelvin, kelvinmeyeyin@gmail.com

Abstract

Background: Camps for internally displaced people (IDPs) can rapidly spring up as a result of violence – in north-eastern, north-western and north-central Nigeria – in the blink of an eye. IDP camps can be plotted in advance for predictable events like droughts or floods but are rarely so well-prepared for armed violence. WASH services are delayed or absent; cholera thrives. Despite this, most tools used to map the risk of cholera still omit insecurity as a factor in itself. This paper synthesise and appraises evidence on the contribution of WASH, crowding, environmental contamination, and access barriers to cholera risk in displacement settings and generates a risk-stratification framework based on that evidence for insecure camps in Nigeria.

Methods: An evidence review was conducted following a systematic search and reported following PRISMA 2020. The literature search was executed in Pub Med, Scopus, and Web of Science along with seven humanitarian grey-literature repositories. Primary studies were critically assessed using the Mixed Methods Appraisal Tool, evidence syntheses using the Joanna Briggs Institute checklist for systematic reviews and research syntheses, and grey literature using the AACODS checklist.

Results: After screening 519 search results and grey-literature reports, 18 sources satisfied inclusion criteria: 8 peer-reviewed articles, reviews and preprints, 8 grey-literature reports and 2 normative guidance documents. The evidence for associations between inadequate WASH conditions, crowding and contaminated water and cholera was consistent; primary data from Nigeria was limited and one ecological study showed no association with population density at district level. The majority of Nigerian evidence was from surveillance or humanitarian data collection. Insecurity was referenced in all the sources, but always indirectly via disrupted water supply, crowding or lower cholera surveillance. No source quantified

the relationship between insecurity and cholera. The synthesis argues for a new framework based on four domains: WASH environment, crowding, contaminated water and insecurity. The first three are well-established, the fourth is a new and untested hypothesis.

Conclusions: This tool provides a transparent platform for decision-makers to prioritize insecure camps for emergency WASH and surveillance. While the parameters are illustrative, the framework needs to be calibrated to camp-level data in Nigeria before operational use.

Keywords: Cholera, Internally Displaced Persons, WASH, Humanitarian Access, Risk

INTRODUCTION

No health impacts of forced displacement are as obvious as cholera. It is passed through the faecal-oral route, and the outbreak depends heavily on access to sanitation, as well as to safe drinking water (WHO, 2024). Records show that endemic countries experience around 2.86 million cases and around 95,000 deaths annually (Ali et al., 2015). The relationship between broken sanitation and water systems and cholera was empirically established during the London outbreaks of the 19th century (Snow, 1855). In the years since, health expertise in the aid sector has come to understand how crowding and lack of basic sanitation and clean water causes epidemic diarrhoea in refugee camps (Connolly et al., 2004), and these lessons underpin the minimum standards for water, sanitation, and shelter that almost all humanitarian agencies have adopted (Sphere Association, 2018).

What gets less focus is how armed insecurity alters the archetypal route. It can devastate water systems, prevent WASH agencies from operating those systems, disrupt cholera monitoring, and propel populations into sites meant for nothing more than a permanent absence of a population (Connolly et al., 2004; Elimian et al., 2020). The consequences of all that combined can make cholera's "usual suspect" factors escalate in intensity and become difficult to quantify. Nigeria illustrates the problem all too clearly. Boko Haram and Islamic State West Africa Province insurgents in Adamawa, Borno, and Yobe, and armed bandits spreading throughout Katsina, Niger, Sokoto, and Zamfara, have created multiple waves of displacement (ACAPS, 2024). The International Organization for Migration's displacement monitor has tallied sizable populations of displaced people in the north-central and north-western states, and the proportion in camps and camp-like environments ebbs and flows with security (IOM, 2025). Cholera continues to resurface; in 2018, its outbreaks affected 20 states, with 43,996 suspected cases and 836 deaths, and as of late August 2024, national surveillance has reported 6,782 suspected cases and 197 deaths in all 36 states (Elimian et al., 2019; Nigeria Centre for Disease Control and Prevention [NCDC], 2024). In the north-east, humanitarian agencies link seasonal cholera surges to floodwaters polluting water sources and to the circumstances in displacement camps (OCHA, 2022; UNICEF, 2024).

A scoping review of cholera drivers in Nigeria found armed conflict to be primarily indirect; through density, poor water and health services (Elimian et al., 2020). What has not yet been questioned is how insecurity could be incorporated into cholera risk assessment in Nigerian IDP camps. This review aims to address that lacuna. It set out with three goals; firstly, to review and synthesise evidence on WASH conditions, environmental contamination, density and restricted humanitarian access as cholera risk drivers in situations of displacement, notably in Nigeria; secondly, to appraise the available evidence critically, in view of the extensive grey literature; thirdly, to develop a conceptual risk-stratification framework underpinned by the synthesised evidence, which explicitly integrates restricted access due to insecurity as a distinct risk domain.

CONCEPTUAL BACKGROUND

WASH Conditions, Crowding, and Cholera Transmission

When people ingest water or food that contains toxigenic *Vibrio cholerae*, they become infected. Reliable water supply and sanitation are therefore the main programme changes that can reduce the risk of an outbreak (WHO, 2024). Over-crowding exacerbates the risks in a number of ways: more per water point or latrine; contamination spreading in and around the household; less space for key hygiene behaviours; and a greater number of people entering the camp during a period of mass influx (Sphere Association, 2018). A scoping review of faecal-oral transmission outbreaks in displacement camps identified cholera as the most common pathogen. It also linked the risk to a number of factors: relying on shallow well and river water; inconsistent handwashing; and high numbers of new arrivals overwhelming WASH facilities (Jaber et al., 2024). Spatial epidemiology has been employed for years to identify where these syndemics converge. Retrospective studies identified sources of contamination using spatial risk models (Caplan et al., 2020), found enduring space-time clusters of cholera in high-priority districts, including the Dadaab refugee camp (Mageo et al., 2023), and associated district cholera cases to environmental and climatic factors (Stoltzfus et al., 2014). Such models typically incorporate measures of water and sanitation access, population density, and proximity to surface water bodies to quantify relative risk of outbreaks.

Insecurity as a Modifier of Cholera Risk

In unstable parts of Borno, Yobe and Adamawa and bandit-affected areas of the north-west, attack and restriction to access can interrupt the delivery of WASH interventions, prevent environment sampling, and interrupt regular health services, no matter how a camp is planned and no matter how many it hosts (OCHA, 2026; REACH Initiative, 2023). Current risk-mapping frameworks often view these barriers as operational context rather than a risk domain. This review proposes that in these cases security/access restriction should be viewed as a risk domain on the same plane as WASH and crowding.

METHODS

Review Design and Reporting

This is a formal evidence review, with a systematic literature search, formal quality assessment, and framework synthesis. This review is described according to the PRISMA 2020 statement (Page et al., 2021), with the completed checklist provided in Supplementary File S1. Meta-analysis was not planned as the goal was to help guide the design of a risk model, not to calculate pooled effects, therefore no meta-analysis was performed. I did not register my protocol a priori, which I recognize as a limitation.

Information Sources and Search Strategy

For the initial database search, I searched Pub Med, Scopus and Web of Science for records published between 1st Jan 2000 and 31st Oct 2025. Since most of the operational evidence on Nigerian displacement settings is not published in journals, I also searched the following seven sources of grey-literature: Relief Web, NCDC website, WHO, IOM Displacement Tracking Matrix, OCHA, REACH Initiative, ACAPS. I also searched the reference lists of the included sources. The database search strategy was based on three sets of search term concepts: ("cholera" OR "acute watery diarrhoea") AND ("internally displaced" OR IDP OR camp OR displacement OR refugee OR humanitarian) AND (WASH OR sanitation OR "water supply" OR overcrowd* OR "population density" OR insecurity OR conflict OR "humanitarian access") and across grey-literature portals 13, 14 as follows: 1) simplified versions of these concepts, limited to Nigeria where the portal was accessible. Please see Supplementary File S2 for search strings for each source.

Eligibility Criteria

The criteria for inclusion were described in Table 1. A source was eligible if it reported research or systematic analysis on cholera or acute watery diarrhoea or related WASH, crowding, contamination, or conditions that affect humanitarian access relevant to cholera in displaced, camp, or conflict settings. Methodological papers on cholera risk mapping or remote population estimation were included, as they were relevant to the approach used in the modelling. Literature published prior to 2000 was included as historical information only and not synthesised.

Table 1

Eligibility Criteria		
Criterion	Inclusion	Exclusion
Population and setting	Displaced populations in camps, camp-like or informal settlements, or conflict-affected areas; Nigeria prioritised, other low- and middle-income settings accepted	Non-displacement settings in high-income countries (methodological studies excepted)
Focus	WASH coverage, crowding or density, environmental contamination, humanitarian access or insecurity	Clinical management or vaccine efficacy only
Outcome or relevance	Cholera or acute watery diarrhoea incidence, outbreaks, or risk; conditions directly relevant to cholera risk	No relation to waterborne disease risk
Source type	Peer-reviewed studies and reviews, preprints, surveillance and situation reports, humanitarian assessments, normative guidance	Opinion pieces, news items, duplicate reports
Date and language	2000 onwards; English	Other languages

Selection of Sources

The records were imported into Zotero (6.0) and de-duplicated. A screening of titles and abstracts against the eligibility criteria was conducted and potentially relevant records moved into full text review. A second screener independently screened 20% of the total and disagreements were discussed between researchers. Reasons for exclusion at full text screening were also documented as indicated in Figure 1.

Data Extraction

The most common data extraction template included citation, source type, setting, period, design/data-collection method, risk domains covered, key findings related to cholera risk, and authors' stated limitations for each source.

Quality Appraisal

As the evidence base was an eclectic mix of primary research, evidence syntheses and grey literature with the use of different appraisal tools for each. Primary research articles and preprints were appraised using the Mixed Methods Appraisal Tool, version 2018 (Hong et al., 2018). Scoping and narrative reviews were appraised using the Joanna Briggs Institute checklist for systematic reviews and research syntheses (Aromataris et al., 2015). Grey-literature reports and normative guidance were appraised using the AACODS checklist, which addresses authority, accuracy, coverage, objectivity, date and significance (Tyndall, 2010). Then each source was assigned a total confidence score of high, moderate to high, moderate, or low (without dismissing any source on grounds of quality). These scores decided the number of points awarded to each source in the synthesis and the degree to which each framework domain could be said to be supported. I performed the appraisal, and another reviewer independently verified a quarter of the sample at random.

Synthesis and Framework Development

Findings were synthesized via best-fit framework synthesis (Carroll et al., 2013). I selected an a-priori framework adapted from the literature on cholera risk-mapping: comprising three domains, pre-existing factors – water, sanitation and hygiene (WASH) conditions; crowding; and environmental contamination (Caplan et al., 2020; Mageto et al., 2023; WHO, 2024). Findings were deductively coded into those three domains and any that did not fit were inductively coded. I repeatedly identified a theme: humanitarians either impact upon access or are impacted upon by access, resulting in knock-on impacts upon WASH services, health facilities and surveillance. This led to a fourth domain. I'd like to be transparent about the nature of this model. We are presenting a framework of four domains as a conceptual theory based on this synthesis. That is, it was not statistically pooled from these sources, no effect estimates were meta-analysed. The three predetermined domains are based on well-known evidence. The fourth one, the restriction of access based on security was my own suggestion that in all sources access restriction was consistently described, but not one of them quantified the relationship of that restriction to cholera.

Illustrative Model Specification

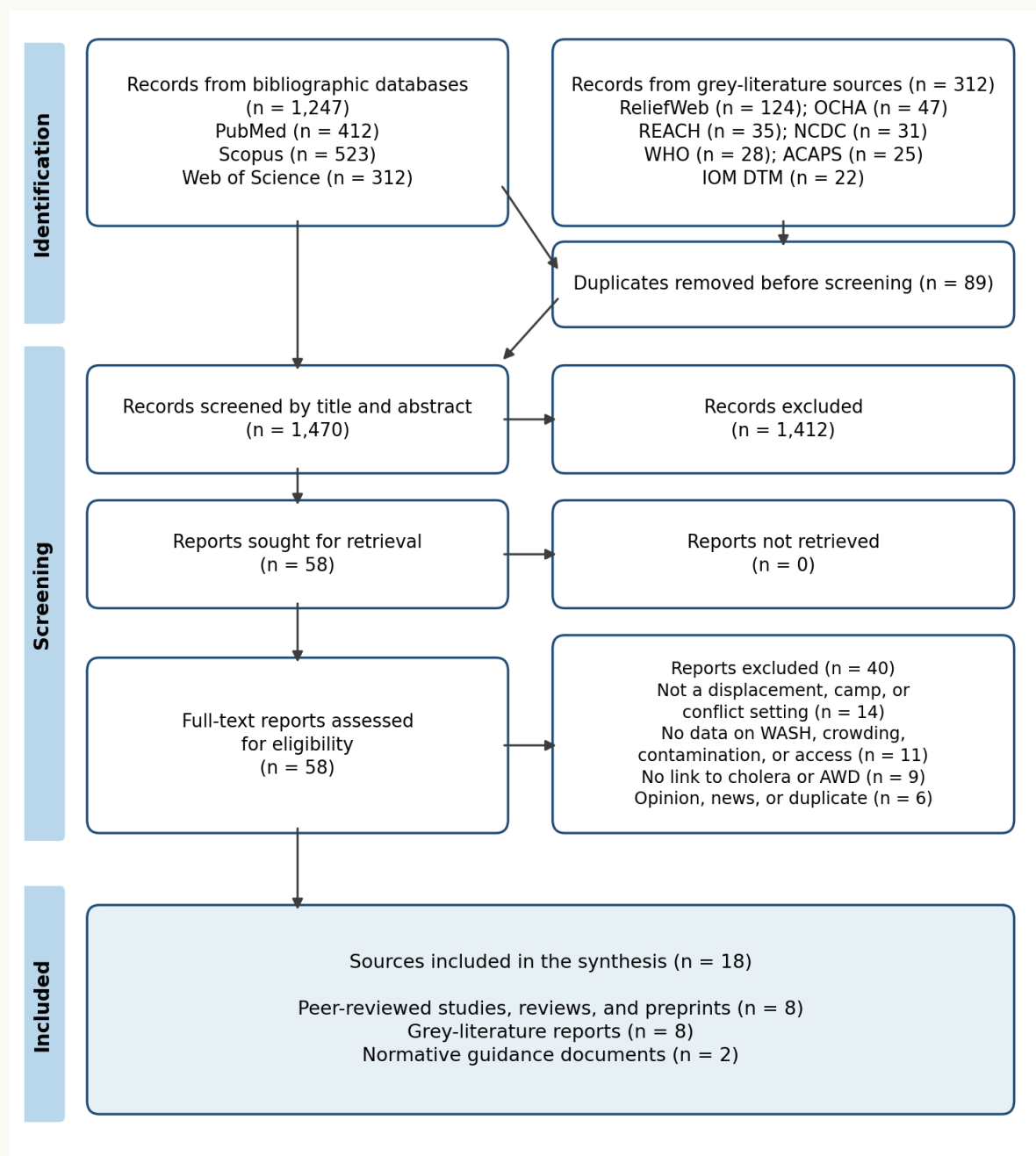
To demonstrate how the domains would function in practice, the framework is specified as a multivariable logistic regression. The log-odds of an outbreak of cholera in camp i at period t can be denoted by: $\text{Logit}[P(\text{outbreak}_{it})] = + (\text{WASH}) + (\text{crowding}) + (\text{contamination}) + (\text{access restriction})$. No primary data was collected. The coefficients used (Table 4 below) are hypothetical assumptions to demonstrate how the model functions, they are not fitted values. Any organisation intending to use the model should fit its own model using data from camp-level environmental sampling and outbreak data.

RESULTS

Selection of Sources

The database searches yielded 1,247 records, and the grey-literature searches yielded 312. With 89 duplicates removed, 1,470 records were subjected to a title and abstract screen, leading to 1,412 reports being excluded. The remaining 58 full reports were subjected to a full reading, resulting in 40 reports being removed for the reasons given in Fig. 1. The remaining 18 sources included eight published (in the peer-reviewed literature) or preprint (unreviewed yet publicly available) papers, reviews, or protocols; eight grey-literature reports; and two normative guidance documents. A further three papers (Ali et al., 2015; Connolly et al., 2004; Snow, 1855) have been included in the background literature only.

Figure 1
PRISMA 2020 Flow Diagram



Note. Adapted from Page et al. (2021). AWD = acute watery diarrhoea. The 18 included sources correspond to those listed in Table 2.

Characteristics and Quality of Included Sources

Table 2 lists the included sources, and presents their appraisal and summary. Three of the eight peer-reviewed papers described Nigeria (an analysis of national surveillance data during the 2018 outbreak; Elimian et al., 2019; a review of the drivers of recurrent transmission; Elimian et al., 2020; a review of the data available from the past five decades of outbreak; Ogunniyi et al., 2025), and were all secondary reports of Nigeria during the 2018 outbreak. None analysed at camp level. The others, from other settings of displacement, other settings of displacement and nineteenth century London.

All the Nigerian evidence on camps was in the grey literature: national surveillance (NCDC, 2024),

displacement tracking (IOM, 2025), situation reports and dashboards (OCHA, 2022, 2023, 2026; UNICEF, 2024), a systematic assessment of hard-to-reach areas (REACH Initiative, 2023), and a secondary-data-based briefing (ACAPS, 2024). They were rated high on authority and date but low on methodology and coverage. For example, surveillance figures for the number of suspected cases, not confirmed, are provided by the camp. The hard-to-reach assessment uses key informants and is non-representative. Situation reports seek to inform coordination and advocacy, which may influence the weighting of content. In general, four sources were rated high confidence, five moderate-high, nine moderate; and none low. The source did not quantify how restricted humanitarian access was associated with cholera.

Table 2
Characteristics and Appraisal of Included Sources

Source	Type and design	Setting	Domain(s) informed	Tool	Confidence	Principal limitations
Caplan et al. (2020)	Peer-reviewed; retrospective spatial analysis (risk terrain modelling)	London, UK, 1854	Contamination; methods	MMAT	Moderate	Historical urban data; methodological precedent only
Checchi et al. (2013)	Peer-reviewed; validation of satellite-based population estimation	Displacement settings outside Nigeria	Crowding; remote measurement	MMAT	Moderate to high	Not Nigeria; accuracy depends on imagery and occupancy assumptions
Elimian et al. (2019)	Peer-reviewed; retrospective analysis of national surveillance data	Nigeria, 20 states, 2018	Outcome (burden)	MMAT	Moderate to high	Suspected cases; not disaggregated by camp
Elimian et al. (2020)	Peer-reviewed; scoping review (45 documents)	Nigeria, 1970–2018	All domains; conflict as indirect driver	JBIC	Moderate to high	Included studies not formally appraised; mostly cross-sectional evidence
Jaber et al. (2024)	Peer-reviewed; scoping review (48 records)	Displacement camps worldwide	WASH; crowding; contamination	JBIC	Moderate to high	Heterogeneous outbreak reports; not Nigeria-specific

Source	Type and design	Setting	Domain(s) informed	Tool	Confidence	Principal limitations
Mageto et al. (2023)	Preprint; space–time scan analysis of line-list data, 2012–2022	High-risk areas of Kenya, including Dadaab camp	WASH; crowding; contamination	MMAT	Moderate	Not peer reviewed at time of review; not Nigeria
Ogunniyi et al. (2025)	Peer-reviewed; narrative review	Nigeria, five decades	Context; health-system response	JBI	Moderate	Secondary synthesis; no camp-level estimates
Stoltzfus et al. (2014)	Peer-reviewed; ecological study, 1999–2009	Kenya, district level	Crowding; contamination	MMAT	Moderate	Ecological design; district scale may mask camp-level effects
ACAPS (2024)	Grey; briefing note based on secondary data	North-east and north-west Nigeria	Security-access	AACODS	Moderate	Rapid compilation; limited methodological detail
IOM (2025)	Grey; Displacement Tracking Matrix, round 15	North-central and north-west Nigeria	Crowding; context	AACODS	High	Key-informant site assessments; insecure areas may be under-covered
NCDC (2024)	Grey; national cholera situation report	Nigeria, 36 states	Outcome (burden)	AACODS	High	Suspected cases; reporting completeness varies in insecure areas
OCHA (2022)	Grey; situation report	Borno, Adamawa, and Yobe	Contamination (flooding); outcome	AACODS	Moderate	Situational reporting; limited methodological detail

Source	Type and design	Setting	Domain(s) informed	Tool	Confidence	Principal limitations
OCHA (2023)	Grey; humanitarian dashboard	Borno, Adamawa, and Yobe	Security-access; WASH	AACODS	Moderate	Aggregated indicators; coordination purpose
OCHA (2026)	Grey; situation report	Borno, Adamawa, and Yobe	Security-access	AACODS	Moderate	Situational reporting; limited methodological detail
REACH Initiative (2023)	Grey; structured assessment of hard-to-reach areas	Adamawa and Yobe	WASH; security-access	AACODS	Moderate to high	Key-informant based; non-probability sampling
UNICEF (2024)	Grey; humanitarian situation report	North-east Nigeria	Outcome; contamination	AACODS	Moderate	Programmatic reporting; possible reporting bias
WHO (2024)	Normative; fact sheet	Global	WASH; transmission	AACODS	High	General; not context-specific
Sphere Association (2018)	Normative; minimum standards	Global humanitarian settings	WASH; crowding thresholds	AACODS	High	Consensus-based thresholds, not derived from outcome data

Note. MMAT = Mixed Methods Appraisal Tool (Hong et al., 2018); JBI = Joanna Briggs Institute checklist for systematic reviews and research syntheses (Aromataris et al., 2015); AACODS = authority, accuracy, coverage, objectivity, date, significance (Tyndall, 2010).

Synthesis by Domain

WASH Conditions

Consistent with normative guidance and research, camp outbreak reports consistently identified the exposures that interventions could address as safe-water coverage and access to sanitation (Sphere Association, 2018; WHO, 2024). Routine exploration of exposures in camp outbreak reports showed the same pathway for transmission from surface water and shallow wells to disease, as well as unreliable hand hygiene (Jaber et al., 2024). A scoping review in Nigeria found inadequate water supply and sanitation among the most frequently cited drivers of transmission (Elimian et al., 2020), and field assessments for cholera in Nigeria and the north-east of Nigeria found severe gaps in coverage of WASH services in fragile contexts (REACH Initiative, 2023).

Overcrowding

Crowding was always characterized as enhancing WASH-related transmission through higher user loads at individual facilities (Sphere Association, 2018). Sudden waves of new arrivals regularly triggered camp outbreaks (Jaber et al., 2024), while Nigerian findings linked overcrowding with displacement as a result of conflict and flooding (Elimian et al., 2020). It wasn't all or nothing. Population density didn't appear to be statistically linked to cholera for districts in Kenya, based on a district-level ecological analysis (Stoltzfus et al., 2014). This could be because the scale of analysis is too coarse to detect such effects; population densities in displacement camps in Nigeria are high and variable (IOM, 2025) and satellite-based enumeration provides methods to estimate and monitor camp populations from afar (Checchi et al., 2013). But density estimates for Nigerian displacement camp populations at the camp level seem to be scarce.

Environmental Contamination

The geographically- or spatially-based studies identified connection between clusters of cholera and water body size and close proximity to polluted water sources (Caplan et al., 2020; Mageto et al., 2023; Stoltzfus et al., 2014). In Nigeria, the evidence consistently showed flooding. The 2022 outbreaks in Borno, Adamawa, and Yobe were largely explained away by flooding of water sources (OCHA, 2022), flooding was identified as an environmental driver for Nigeria by the national literature (Elimian et al., 2020) while the 2024 response in the north-east was driven by cholera outbreaks in flood-affected displacement sites (UNICEF, 2024).

Security-Access Restriction

According to the grey literature, the restriction of supply routes, limited access to communities for months at a time, WASH and health services disruption in the north-east (ACAPS, 2024; OCHA, 2023, 2026; REACH Initiative, 2023). A peer reviewed synthesis of the Nigerian literature found that armed conflict increased cholera transmission indirectly, via overcrowding, damaged water supply, and weak surveillance system (Elimian et al., 2020). The other three domains, on the other hand, have very strong evidence (Table 3).

Table 3
Evidence Summary by Domain

Domain	Candidate indicators	Principal supporting sources	Strength of evidence	Basis for inclusion
A. WASH conditions	Safe-water coverage; persons per latrine; handwashing access	WHO (2024); Sphere Association (2018); Jaber et al. (2024); Elimian et al. (2020); REACH Initiative (2023)	Consistent; primary data mostly from outside Nigeria	A priori; established in risk-mapping literature
B. Overcrowding	Persons per shelter; persons per square metre; density above planning threshold	Sphere Association (2018); Jaber et al. (2024); Elimian et al. (2020); Checchi et al. (2013); IOM (2025)	Consistent mechanism; one null ecological finding; scarce Nigerian camp data	A priori

Domain	Candidate indicators	Principal supporting sources	Strength of evidence	Basis for inclusion
C. Environmental contamination	Distance from water points to latrines, open defecation, or waste sites; flood exposure	Caplan et al. (2020); Mageto et al. (2023); Stoltzfus et al. (2014); OCHA (2022); UNICEF (2024)	Moderate; spatial evidence mostly from outside camps	A priori
D. Security-access restriction	Weeks of disrupted humanitarian access; health-facility functionality; supply-chain interruption	Elimian et al. (2020); OCHA (2023, 2026); REACH Initiative (2023); ACAPS (2024)	Indirect and descriptive only; no measured association with cholera	Emerged during synthesis; proposed by the author; requires empirical testing

The Proposed Risk-Stratification Framework

The index that we propose is based on four sets of indicators established at camp level (Table 3), that could theoretically still be gathered with limited access: For WASH, safe water source coverage and people per latrine; for crowding, people per shelter and floor area per person; contamination can be gauged by distance to the latrine, water point, open-defecation area or waste pit; and flooding can be assessed in terms of per cent of the camp population exposed. Limited access would be unlikely to prevent assessment of camp populations (for example, using satellite images, Checchi et al., 2013), and thus crowding, and bits of the other domains in the index. If implemented fully, the indicators would be selected based on the ease and affordability of collection, and the reliability of field data, and a multivariable logistic regression could predict whether an outbreak would occur within a specified timeframe. Response teams could then apply the fitted model to choose new or growing camps or parts of camps for priority surveillance and response. The potential design is summarized in table 4.

Table 4
Illustrative Model Specification

Risk indicator	Assumed direction of association	Illustrative odds ratio
Safe-water coverage (per 10% increase)	Protective	~0.80
Latrine-to-population ratio (per unit improvement)	Protective	~0.75
Population density (per 10% above planning threshold)	Harmful	~1.30

Risk indicator	Assumed direction of association	Illustrative odds ratio
Water-point proximity to contamination site (per 100 m closer)	Harmful	~1.20
Humanitarian access disruption (per additional disrupted week)	Harmful	~1.40

Note. These odds ratios are assumptions chosen to demonstrate the logic of the framework. They are not statistical estimates and should not be cited or used to set operational priorities until they are replaced with parameters estimated from empirical data.

Even in this simplified form the structure leaves one issue that is policy relevant. It attributes an effect of access disruption to the same magnitude or greater than the standard WASH indicators. This is not an empirical assumption; it is based on a consistent pattern of reports that the routes of supply in Borno are unsafe for people, cargo and humanitarian workers, and that under certain conditions some settlements are accessibly only periodically over long stretches of time (OCHA, 2026; REACH Initiative, 2023). An empirical estimate of this size would require explicit modelling of security constraints. This was beyond the scope of the paper.

DISCUSSION

Principal Findings

This review identified a clear link between bad WASH, crowded conditions and contaminated water and increased risk of cholera in displacement settings. It identified very little primary evidence from Nigerian camps and no evidence on the effect of insecurity on risk. Much of the Nigeria evidence identified was from humanitarian reports and disease surveillance data which are reliable and useful for the purpose but not always transparent. This framework is not designed to replace existing risk assessment tools, but to clarify a pre-existing assumption in humanitarian practice, and to articulate what data would be necessary to test it.

Relationship to Existing Evidence

These findings fit with the body of literature around communicable disease in complex emergencies that has historically placed the emphasis on crowding, sanitation and poor health services facilitating one another (Connolly et al., 2004). They build on the Nigerian scoping review by Elimian et al., 2020 which describes conflict as an indirect driver through other determinants. This framework takes that a step further by suggesting that access restriction should be assessed directly and added into the risk score. The null association between population density and cholera at district level in Kenya (Stoltzfus et al., 2014) serves as an important warning: indicators need to be measured at the level of transmission and in camps that means the site or block not the district.

Implications for Policy and Practice

Four implications follow for Nigeria:

1. The NCDC and humanitarian coordination structures (including CCCM and WASH sector leads in Borno, Yobe, Adamawa, Zamfara and Sokoto) can incorporate a security-access indicator into their current camp-level cholera risk-scoring as opposed to viewing insecurity only as an operational challenge.

2. It may be impossible to collect environmental samples inside insecure camps, so preparedness is to establish what signs could be collected under a limited access. This creates a very gradual down-turn in the quality of risk scoring rather than a sudden failure. Remote estimation of population size is one example (Checchi et al., 2013).
3. If sampling is not possible under any circumstances, the lower score might be estimated through proxies: remotely sensed density, observed WASH access replaced by self-reported access, and existing access-monitoring publications from humanitarian partners.
4. The framework is intended to steer the distribution of emergency WASH and surveillance resources throughout the distribution of camps/ camp blocks. It will not and cannot be addressing the political challenges of how to improve security and humanitarian access.

Priorities for Future Research

Validation will be conducted in three phases:

1. Creation of a retrospective camp-level database for north-eastern Nigeria with WASH, crowding, contamination and access-disruption metrics linked to each outbreak record,
2. Model fitting and internal validation with and without the security-access domain, and
3. Prospective testing of the model and its utility from the perspective of decision-makers over an entire cholera season.

Strengths and Limitations

One of the strengths of this review was the systematic, transparent search of a variety of academic and humanitarian literature sources, the formal way in which each source was ranked according to its type, and the clear narrative of where each domain of the framework originated. Most importantly, however, the model is conceptual. It has not been fitted or validated and the ORs presented in Table 4 are for illustrative purposes only. The security–access domain is based on indirect, mostly descriptive evidence and is the least robust of the domains proposed. The evidence bases on which the framework is based is limited, is predominantly grey literature with limited methodological detail and likely reporting bias, and much of the primary data about it was obtained from outside Nigeria; limiting the search to English language sources may have missed relevant francophone data from the Lake Chad Basin. Screening and appraisal was done largely by one reviewer, with only partial independent cross-checking, risking selection and appraisal bias. Using indicators that are easy to measure in an insecure setting involves a trade-off between feasibility and accuracy, which we did not attempt to quantify. Cholera risk is also highly context-dependent, so the framework may require modification before use in any given camp.

CONCLUSION

The majority of the cholera risk in Nigeria's fragile IDP camps can be explained by a familiar pathway – crowded conditions and poor water, sanitation and hygiene (WASH) which permit faecal-oral transmission. Insecurity exacerbates this pathway by degrading WASH and surveillance infrastructure in the north-east and the north-west. The evidence for the known determinants is robust but non-Nigerian, and the evidence for insecurity remains indirect.

We present the four-domain framework proposed here as a transparent and flexible way to determine where emergency health efforts should be directed, if it is adjusted and validated with data from camps. We also outline a hypothesis that could be empirically tested: that access is a determinant of cholera risk in its own right, in the context of armed conflict.

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