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Securing the Diagnostic Chain in High-Threat Environments: The Interdependent Roles of Health Security, Health Assistants, Medical Laboratories, Nursing, Medical Secretarial Services, and Direct Patient Care in Maintaining Specimen Integrity and Result Reliability.

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Abstract

Diagnostic results are only as trustworthy as the chain of actions that produces them. In high-threat environments such as conflict zones, outbreaks, disasters, and cyber-compromised systems, that chain is exposed to physical danger, workforce depletion, supply disruption, and information failure. This narrative review synthesizes literature published between 2016 and 2025 on how health security, health assistants, nursing, medical secretarial services, medical laboratories, and direct patient care jointly protect specimen integrity and result reliability. Evidence was drawn from laboratory medicine, health-systems, infection-prevention, and humanitarian sources. The review proposes a conceptual model in which every role is both a safeguard and a potential failure point, and in which small upstream lapses propagate into clinically consequential errors. Two matrices link vulnerabilities to controls. Preanalytical vulnerability, administrative information flow, and workforce wellbeing emerge as under-recognized determinants of reliability. Integrated governance, shared quality indicators, and interprofessional training are recommended.

Keywords: diagnostic chain; specimen integrity; high-threat environments; preanalytical phase; interprofessional collaboration.

Introduction

Laboratory and point-of-care diagnostics underpin most pathways of modern clinical care, from triage and treatment selection to outbreak confirmation and public health decision-making. The clinical value of a test, however, is realized only when a correct result reaches the correct patient record at a time when it can still change management (Sikaris, 2017). That value depends on a long sequence of linked activities that begins with a clinical decision to test and ends with an interpreted result acted upon at the bedside. Failures at any link, whether mislabelled tubes, delayed transport, lost requisitions, or unreported critical values, can negate the sophistication of the analytical instrument at the centre of the process.

The global distribution of diagnostic capacity is highly unequal. The Lancet Commission on diagnostics estimated that nearly half of the world's population has little or no access to diagnostics, with the greatest deficits in primary care and in low- and middle-income settings (Fleming et al., 2021). Reviews of pathology and laboratory medicine reached similar conclusions about structural gaps in workforce, infrastructure, and quality systems (Sayed et al., 2018; Wilson et al., 2018). Poor-quality care, including unreliable diagnosis, is now recognized as a larger source of avoidable mortality than lack of access to care alone in many countries (Kruk et al., 2018). Even in well-resourced systems, diagnostic error is a persistent cause of serious harm across vascular events, infections, and cancers (Newman-Toker et al., 2021).

These baseline vulnerabilities are amplified in what this review terms high-threat environments: settings in which the diagnostic system is simultaneously exposed to hazards such as armed conflict, epidemic pathogens, natural disasters, mass-casualty events, displacement, and malicious cyber activity. Violence against health workers and facilities is a documented

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feature of contemporary conflict, and systematic evidence shows that attacks degrade service delivery, deplete staff, and erode trust (Haar et al., 2021). In Syria, the deliberate targeting of health care has been described as a weaponisation of health systems, with direct consequences for continuity of clinical and laboratory services (Fouad et al., 2017). During epidemics, diagnostic preparedness has repeatedly lagged behind outbreak response, leaving laboratories overwhelmed or absent when most needed (Perkins et al., 2017).

Most of the literature addressing these problems is organized by discipline. Laboratory medicine research concentrates on analytical and preanalytical quality, nursing research on staffing and safety, health-security research on system capacities and governance, and health informatics research on records and cybersecurity. Rarely are these bodies of evidence integrated around a single object of protection: the specimen and the result it generates. Medical secretarial services and health assistants, who handle requisitions, registration, results communication, specimen reception, and basic collection tasks, are particularly neglected in diagnostic quality scholarship despite occupying decisive positions in the chain.

The purpose of this narrative review is therefore threefold. First, it defines the diagnostic chain as an interdependent socio-technical system rather than a laboratory-centred process. Second, it examines the distinct contribution of each of six roles to specimen integrity and result reliability under threat. Third, it proposes an integrated framework, two practical matrices, and a research agenda for strengthening the chain as a whole.

2. Review Approach

A narrative review design was chosen because the topic spans heterogeneous disciplines, study designs, and outcome measures that are not amenable to quantitative pooling. The aim was interpretive synthesis rather than exhaustive enumeration. Literature published between 2016 and 2025 was considered, drawing on laboratory medicine, health-systems research, infection prevention and control, humanitarian health, nursing and workforce studies, and digital health security. Sources included peer-reviewed articles, consensus recommendations from professional bodies, and normative documents from international organizations and standards bodies.

Sources were selected for relevance to at least one of three questions: what threatens specimen integrity and result reliability; what each professional or functional group contributes to protecting them; and what organizational conditions enable or undermine those contributions. Priority was given to systematic reviews, international consensus statements, and high-impact commission reports, supplemented by empirical studies illustrating mechanisms. Evidence was organized thematically and integrated into a conceptual model. Because narrative reviews are susceptible to selection bias, the limitations section addresses the implications of this design for interpretation.

3. The Diagnostic Chain in High-Threat Environments

3.1 From the total testing process to a socio-technical chain

The classical description of laboratory work divides the total testing process into pre-examination, examination, and post-examination phases. Within this model, the preanalytical phase includes test selection, patient preparation, identification, collection, transport, and reception, while the post-analytical phase covers validation, reporting, interpretation, and clinical action. Plebani (2017) has argued that laboratory quality has progressed substantially in analytical performance, whereas errors and vulnerabilities now concentrate in activities that occur outside the analyser and often outside the laboratory walls. Lippi et al. (2019) similarly described the preanalytical phase as a domain of persistent and partly unresolved challenges, many of which involve people and processes beyond laboratory control.

The present review extends this view by treating the total testing process as a chain in which non-laboratory actors are not peripheral but constitutive. A tube is drawn by a nurse or health assistant, identified through a registration record created by a secretary, transported under conditions determined by security and logistics, received and processed by laboratory staff, and its result is communicated through administrative and clinical channels to a clinician who treats a patient. Each handoff transfers responsibility and creates an opportunity for loss of information or integrity. The chain is only as reliable as its weakest handoff.

3.2 Defining specimen integrity and result reliability

Specimen integrity refers to the degree to which a specimen remains a faithful representation of the patient's in vivo state from the moment of collection until analysis. It encompasses correct identification, appropriate container and additive, adequate volume, absence of contamination or haemolysis, preservation of analyte stability, and maintenance of chain of custody. Result reliability, in turn, refers to the likelihood that a reported result is analytically valid, correctly attributed, timely, and interpretable. Reliability therefore depends on integrity but also on analytical quality control, accurate reporting, and effective communication.

Formal standards codify these requirements. The current international standard for medical laboratories places explicit demands on pre-examination processes, personnel competence, risk management, and information management (International Organization for Standardization [ISO], 2022). Consensus recommendations on venous blood

collection further specify identification, labelling, order of draw, and handling requirements intended to reduce preventable error (Simundic et al., 2018). Such standards, however, presuppose conditions that high-threat environments often cannot guarantee.

3.3 What makes an environment high-threat

For the purposes of this review, high-threat environments share four characteristics. First, there is physical insecurity affecting staff, patients, facilities, and transport routes. Second, there is resource instability, including interrupted power, water, cold chain, consumables, and staff availability. Third, there is surge or disruption in demand, as in epidemics or mass-casualty events. Fourth, there is vulnerability of information systems and communication channels, whether through infrastructure damage or deliberate attack. Health-system resilience studies from the COVID-19 pandemic indicate that the capacity to absorb, adapt, and transform under such pressure depends on governance, workforce, information, and resource flexibility, rather than on any single technical component (Haldane et al., 2021).

The first conceptual model (Figure 1) positions the specimen at the centre of six interdependent roles, with the threat environment as the surrounding context and quality governance as the integrating layer.

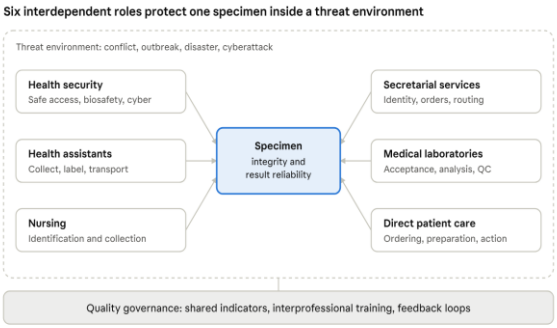


Figure 1. Conceptual model of the diagnostic chain in high-threat environments.

4. Health Security: Protecting the Conditions for Diagnosis

4.1 Scope of health security in the diagnostic context

Health security is commonly understood at the global level as the capacity to prevent, detect, and respond to health threats, as operationalized through the International Health Regulations and their monitoring tools. At facility and field level, however, it also includes physical security of personnel and premises, protection of specimen transport routes, biosafety and biosecurity, continuity planning, and security of information systems. Diagnostic capacity is explicitly a core element of national preparedness. Joint external evaluations assess laboratory systems, specimen referral and transport, and real-time surveillance as measurable capacities (World Health Organization [WHO], 2022). Analyses of annual reporting data from 182 countries found considerable variation in these capacities and showed that many countries entered the COVID-19 pandemic with substantial gaps (Kandel et al., 2020). The Board (2019) had warned in advance that the world was unprepared for a rapidly spreading pandemic, and diagnostic preparedness featured prominently among the deficiencies.

4.2 Physical security, access, and the protection of the workforce

Where violence threatens health workers, the diagnostic chain is among the first systems to break. Phlebotomy and specimen transport require movement between wards, clinics, communities, and laboratories, and each movement may be restricted or hazardous. Systematic evidence on violence against health care in conflict documents deaths and injuries among staff, destruction of facilities, theft of supplies, and diversion of resources, with cascading effects on service availability (Haar et al., 2021). The Syrian experience illustrates that when clinicians and laboratory personnel are targeted, expertise is lost faster than it can be replaced, and informal or improvised diagnostic arrangements emerge with uncertain quality (Fouad et al., 2017). Security measures that appear distant from laboratory practice, such as safe corridors, secure transport, and protected storage, are therefore direct determinants of specimen integrity.

4.3 Biosafety, biosecurity, and infection prevention

Biosafety is a second pillar of the security contribution. Contemporary guidance advocates a risk-based approach in which hazards are assessed and controls selected in proportion to risk, rather than prescriptive uniform requirements (WHO, 2020). This approach is particularly relevant where ideal containment infrastructure is unavailable, since it directs attention to procedures, training, and available protective measures. Safe transport of potentially infectious specimens is governed by international regulations that specify classification, packaging, and documentation (WHO, 2019). Core components of infection prevention and control programmes, including leadership, training, surveillance, and a supportive environment, protect both staff and the integrity of the clinical environment in which specimens are collected (Storr et al., 2017). A health worker who is infected, afraid, or absent cannot collect or process specimens reliably, so biosafety is a prerequisite of reliability and not merely a protective add-on.

4.4 Cybersecurity and the integrity of diagnostic information

Information security is increasingly inseparable from diagnostic reliability. Bibliometric analysis shows that research on health care cybersecurity has expanded rapidly, reflecting the growing dependence of clinical operations on networked systems (Jalali et al., 2019). Analysis of ransomware attacks affecting health care delivery organizations documented a substantial rise over the period 2016 to 2021, with operational disruption extending to laboratories and diagnostic

services (Neprash et al., 2022). When laboratory information systems or interface engines are unavailable, requisitions cannot be received, results cannot be transmitted, and manual workarounds introduce risks of transcription error and misattribution. Security in this domain therefore includes downtime procedures, verified backup, and the ability to authenticate results.

5. Health Assistants: Frontline Extension of the Chain

5.1 Roles and contribution

Health assistants, a broad category that includes nursing aides, phlebotomy and sample-collection assistants, laboratory aides, community health workers, and orderlies, perform many of the most frequent and least visible tasks in the diagnostic chain. They may collect capillary or venous samples, label and transport specimens, prepare supplies, escort patients, and relay information between wards and laboratories. Systematic reviews of community health worker programmes show that these cadres can contribute effectively to a range of health tasks when adequately trained, supervised, supplied, and integrated into health systems (Scott et al., 2018). The same conditions apply to diagnostic tasks.

5.2 Specimen-handling risks

Because health assistants often operate with limited formal laboratory training, their work is highly sensitive to the quality of standard operating procedures and supervision. Common preanalytical vulnerabilities, including wrong container, incorrect order of draw, prolonged tourniquet time, inadequate mixing, and delayed transport, are well described. The sequence in which tubes are filled, for example, can lead to additive carry-over and spurious results, and consensus guidance on order of draw seeks to minimize this risk (Cornes et al., 2017). Haemolysis is the single most frequent cause of specimen rejection in many settings, and its occurrence is strongly associated with collection technique, device selection, and handling during transport (Lippi et al., 2018; Simundic et al., 2020). In blood culture collection, inadequate skin antisepsis and poor technique produce contamination that can lead to false-positive results, unnecessary antimicrobial treatment, and prolonged hospitalization (Doern et al., 2019).

5.3 Task-shifting under surge and insecurity

In high-threat environments, task-shifting to health assistants is often unavoidable, since professional staff are depleted or reassigned. The evidence suggests that task-shifting is safe and effective when accompanied by explicit competency definition, checklists, supervision, and quality monitoring (Scott et al., 2018). Without these safeguards, task-shifting can transfer risk from the staffing gap to the specimen. Point-of-care and rapid diagnostics may reduce dependence on transport and centralized laboratories, and the REASSURED criteria for diagnostics emphasize affordability, ease of use, robustness, and connectivity as design goals for such settings (Land et al., 2019). Even so, decentralized testing shifts the burden of quality assurance onto frontline operators, which makes training and data connectivity essential.

6. Nursing: Clinical Custodianship of the Specimen

6.1 Nursing as the principal collectors and identifiers

In many health systems nurses are the main collectors of specimens and therefore the primary custodians of patient identification at the point of collection. Positive patient identification, correct labelling at the bedside, selection of appropriate containers, and accurate documentation of collection time and conditions are nursing responsibilities with direct analytical consequences. International recommendations for venous blood sampling emphasize that identification and labelling at the time of collection, in the presence of the patient, are fundamental safeguards against misidentification (Simundic et al., 2018). Because errors of this kind are not detectable by the analyser, they are among the most dangerous in the chain.

6.2 Staffing, skill mix, and safety

Nurse staffing and skill mix are associated with patient outcomes. A large longitudinal cohort study found that lower registered nurse staffing and substitution by nursing assistants were associated with worse hospital mortality outcomes, which suggests that staffing structures influence care processes of which specimen handling is one (Griffiths et al., 2019). In high-threat environments, where nurse-to-patient ratios deteriorate and shifts lengthen, the margin for careful collection and labelling narrows. A parallel literature on workforce wellbeing links burnout and poor staff wellbeing to reduced patient safety (Hall et al., 2016). Fatigue, moral distress, and fear for personal safety plausibly increase the probability of slips in identification, labelling, and transport, although direct evidence specific to specimen error is limited.

6.3 Nursing in infection control and critical communication

Nurses also operate at the interface between infection prevention and specimen collection. Collection from patients with suspected highly infectious disease requires correct use of protective equipment, safe handling of sharps, and prevention of environmental contamination, all of which are core components of infection prevention programmes (Storr et al., 2017). Studies during COVID-19 noted additional preanalytical vulnerabilities in respiratory sampling, including variability in swab technique, transport media, and storage conditions (Lippi et al., 2020). Nurses are also frequently the recipients of critical value calls from the laboratory and must relay them promptly to clinicians. In this role they act as the final human link in post-analytical safety.

6.4 Psychological safety and speaking up

Nurses and assistants are often the first to notice that a specimen is questionable, a label is doubtful, or a transport step was compromised. Whether they report these concerns depends on team climate. A systematic review identified leadership inclusiveness, team structure, and organizational support as enablers of psychological safety in health care teams (O'Donovan & McAuliffe, 2020). In diagnostic terms, psychological safety is the condition under which a nurse feels able to say, before the sample leaves the ward, that something is wrong.

7. Medical Secretarial Services: The Information Backbone

7.1 Why administrative roles matter for diagnostic reliability

Medical secretaries, unit clerks, registration staff, and health information personnel create and maintain the information that gives a specimen its identity and context. They enter demographic data, register encounters, transcribe or process requisitions, schedule tests, file and route reports, and often manage telephone communication of results and appointments. Errors in these tasks may produce duplicate records, merged identities, incorrect test orders, misrouted results, or missed follow-up. Because these errors occur upstream of any laboratory activity, they can render an analytically perfect result clinically useless or dangerous.

The diagnostic literature has paid limited attention to this group, even though a large proportion of result-communication failures are administrative in nature. The electronic health record has been shown to expand the volume and complexity of information handled by clinical teams, and studies of physician workload demonstrate that a substantial share of time is spent on inbox management and documentation (Arndt et al., 2017). Where secretarial support is absent or overwhelmed, this burden shifts to clinicians, and the risk that results are overlooked increases. Reviews of electronic health record use also emphasize that benefits for care coordination depend on data quality and on the people and processes that sustain it (Kruse et al., 2018).

7.2 Registration, requisition integrity, and result routing

Registration is the first control point for identity. In conflict and displacement settings, patients may lack documentation, share names, or use variable transliterations, so that duplicate or ambiguous identities are common. Secretarial staff require clear rules for identification, temporary identifiers, and later reconciliation. At the requisition stage, completeness of clinical information, test selection, urgency, and collection details contributes to correct processing and interpretation. At the reporting stage, routing results to the ordering clinician, particularly after patient transfer or discharge, is a recurrent weakness. Quality indicators for post-analytical processes, developed through international consensus, include measures of report turnaround and critical result communication that depend on administrative as well as laboratory performance (Sciacovelli et al., 2016).

7.3 Confidentiality, downtime, and security

Medical secretarial services are also the front line of information security and confidentiality. Phishing, credential sharing, and unsafe handling of paper records are well-recognized vulnerabilities in health care cybersecurity (Jalali et al., 2019). During system outages caused by attack or infrastructure damage, secretaries often operate the downtime procedures, maintaining paper requisitions, logging specimens, and later reconciling manual with electronic records (Neprash et al., 2022). Training, rehearsal, and clear authority for these roles are rarely emphasized, yet reliability under threat depends on them.

Table 1 summarizes the principal vulnerabilities and controls associated with each role in the diagnostic chain.

Table 1. Role-specific contributions, vulnerabilities, and controls in the diagnostic chain under threat

Role	Primary contribution to the chain	Key vulnerabilities in high-threat settings	Core controls
Health security	Safe access, transport routes, biosafety, continuity, information security	Attacks on staff and facilities; blocked routes; weak biosafety; cyberattack	Secured transport and storage; risk-based biosafety; downtime and recovery plans
Health assistants	Basic collection, labelling, transport, specimen reception support	Limited training; improvised tasks; inconsistent supervision	Competency checklists; simple SOPs; supervised task-shifting
Nursing	Patient identification, collection, documentation, critical result relay	Understaffing; fatigue; infection risk; identification error	Bedside positive identification; staffing safeguards; psychological safety
Medical secretarial services	Registration, requisitions, result routing, records	Duplicate identities; missing data; misrouted reports; phishing	Identity rules; requisition completeness checks; downtime drills

Medical laboratories	Acceptance criteria, analysis, quality control, validation, reporting	Power and reagent shortage; surge; workforce loss; unreliable referral	Rejection criteria; QC and EQA; referral networks; quality indicators
Direct patient care	Clinical ordering, patient preparation, interpretation, action	Inappropriate ordering; poor preparation; unrecognized specimen limits	Ordering guidance; preparation instructions; result feedback loops

8. Medical Laboratories: Gatekeepers of Analytical and Post-Analytical Quality

8.1 Acceptance, rejection, and the laboratory as a control point

The laboratory is the point at which integrity is formally assessed. Reception staff and technologists apply acceptance and rejection criteria, check identification against requisitions, assess volume, additive, and visible quality, and decide whether a specimen can produce a reliable result. Haemolysis, clotting, insufficient volume, and labelling discrepancies are the most frequent reasons for rejection, and consensus guidance provides practical recommendations for deciding whether and how to report results from compromised samples (Lippi et al., 2018; Simundic et al., 2020). A rejection policy is only effective if it is applied consistently and communicated back to the point of collection, because the laboratory cannot repair a problem it does not report.

8.2 Monitoring the preanalytical phase

Monitoring preanalytical quality remains inconsistent across laboratories. A European survey found considerable heterogeneity in the way laboratories define, collect, and use preanalytical quality indicators (Cadamuro et al., 2019). A national study in the United Kingdom similarly showed variation in the monitoring and reporting of preanalytical errors, which limits benchmarking and learning (Cornes et al., 2016). International efforts have defined quality indicators and performance specifications intended to harmonize this practice, and recent syntheses describe the state of the art and the strategies required for broader adoption (Sciacovelli et al., 2023). More recent thinking argues that the preanalytical phase should be reconceived from an instrument-centred to a patient-centred perspective, with laboratories taking an active role in guiding and supporting those who collect specimens (Cadamuro & Simundic, 2023).

8.3 Operating under constraint

In low-resource and high-threat settings, laboratories face interrupted power, unreliable cold chain, shortages of reagents, and staff loss. Reviews of laboratory medicine in low- and middle-income countries describe how quality systems, accreditation, and workforce development have advanced unevenly, and how investment in laboratory networks has often been tied to vertical disease programmes rather than to integrated systems (Nkengasong et al., 2018; Sayed et al., 2018). Roadmaps for strengthening pathology services emphasize national laboratory policies, workforce training, quality management, and supply chain reliability (Sayed et al., 2018). During outbreaks, diagnostic preparedness requires pre-positioned capacity, validated assays, specimen referral networks, and agreed procedures for rapid scale-up (Perkins et al., 2017). The pandemic further demonstrated that diagnostic strategy should be linked to control objectives and to realistic assessment of logistic constraints (Peeling et al., 2022).

8.4 Quality management and accreditation

The international standard for medical laboratories emphasizes risk management, competence assurance, and control of the entire examination process, including pre-examination activities that occur outside the laboratory (ISO, 2022). Applying such requirements in unstable settings calls for pragmatic adaptation: prioritizing critical controls, documenting deviations, and maintaining traceability even when ideal conditions cannot be met. The laboratory's responsibility extends to its role as an educator and auditor of the wider chain, by providing collection manuals, feedback on rejection, and training for those who handle specimens.

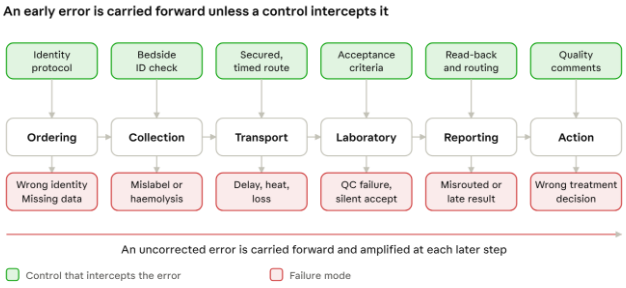


Figure 2. Propagation of failures along the diagnostic chain and points of interception.

9. Direct Patient Care: Where Reliability Becomes Clinical Consequence

9.1 Ordering, preparation, and interpretation

Direct patient care encompasses the clinical decisions that begin and end the diagnostic chain: the choice of test, the preparation of the patient, the interpretation of the result, and the action taken. Inappropriate ordering increases the volume of specimens, burdens already stretched laboratories, and produces results that are difficult to interpret. Patient preparation, including fasting status, medication timing, posture, and exercise, affects many analytes and must be

communicated clearly. In high-threat environments, where patients may be malnourished, dehydrated, injured, or displaced, baseline physiological variation increases and interpretation requires awareness of the context in which the specimen was obtained.

9.2 Diagnostic error and its consequences

Diagnostic error is a major and underappreciated cause of harm, and research using large-scale data estimated substantial annual numbers of serious misdiagnosis-related harms among a limited set of conditions (Newman-Toker et al., 2021). Many diagnostic errors involve failures in ordering, specimen handling, or follow-up rather than in analysis. Clinicians depend on the integrity of upstream processes that they rarely see, and consequently cannot easily distinguish a reliable result from an unreliable one. For this reason, laboratory comments, specimen quality flags, and direct communication between laboratory and clinical staff are essential components of safe reporting.

9.3 Patients as participants in the chain

Patients themselves contribute to specimen integrity, whether by correct preparation, truthful identification, or adherence to collection instructions for self-collected samples such as urine, sputum, or swabs. In the patient-centred view of the preanalytical phase, clear communication and respectful engagement are treated as quality interventions rather than courtesies (Cadamuro & Simundic, 2023). In conflict and displacement settings, language barriers, mistrust, and fear of identification can undermine participation, so culturally appropriate communication and protection of confidentiality are directly relevant to reliability.

10. Interdependence and the Propagation of Failure

The roles described above are not independent safeguards arranged in parallel. They are sequential and mutually dependent, so an error introduced by one role is usually invisible to the next and amplified by those that follow. A misidentified patient at registration is faithfully labelled by the nurse, accurately analysed by the laboratory, and confidently acted upon by the clinician. Similarly, a haemolysed specimen accepted under pressure produces a spurious potassium result that triggers inappropriate treatment. Interprofessional collaboration has been shown to improve professional practice and, in some contexts, healthcare outcomes, which supports the premise that coordination between roles is itself an intervention (Reeves, 2018).

Three propagation mechanisms deserve emphasis. The first is information loss at handoffs, where identifiers, collection times, or clinical context are not carried forward. The second is invisible compromise, where deterioration of a specimen is not detectable by the next actor. The third is delayed or absent feedback, where laboratories reject or question specimens but collectors never learn of the problem, so errors recur. Each mechanism is intensified under threat by fatigue, fear, workforce turnover, and improvised procedures. Table 2 translates these mechanisms into an integrated control matrix organized by phase of the chain.

Table 2. Integrated control matrix across phases of the diagnostic chain

Phase	Typical failure	Principal roles	Integrated control	Indicator of performance
Registration and ordering	Wrong or duplicate identity; incomplete requisition	Secretarial services, direct patient care	Identity protocol with temporary identifiers; mandatory requisition fields	Proportion of requisitions with identification discrepancies
Collection	Misidentification; wrong tube; haemolysis; contamination	Nursing, health assistants	Bedside two-point identification; order-of-draw job aids; competency sign-off	Haemolysis and contamination rates by collector group
Storage and transport	Delay; temperature excursion; loss; security breach	Health security, health assistants	Secured routes; packaging to international standards; transport time logging	Proportion of specimens exceeding stability time
Reception and analysis	Unreported rejection; QC failure under shortage	Medical laboratories	Documented acceptance criteria; QC and EQA; contingency reagents	Rejection rate and feedback closure rate
Reporting and communication	Misrouted result; unreported critical value; downtime error	Secretarial services, nursing, laboratories	Result-routing rules; critical value read-back; downtime reconciliation	Critical result communication time
Interpretation and action	Over-interpretation of compromised results	Direct patient care, laboratories	Specimen quality comments; laboratory-clinician consultation	Proportion of results acted on with quality flags

Note. Synthesized by the author from the literature reviewed; indicators are consistent with the quality-

indicator approach described by Sciacovelli et al. (2016, 2023).

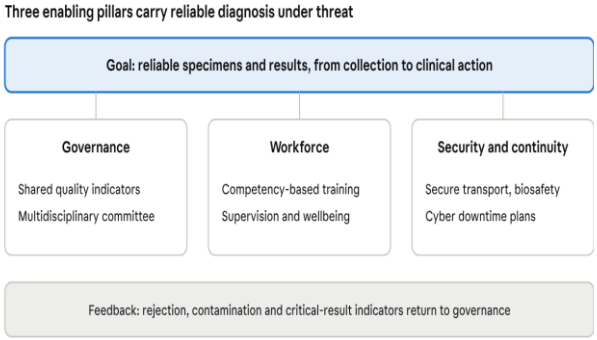


Figure 3. Integrated governance model linking enabling conditions to chain performance.

11. Enabling Conditions and Implications

11.1 Governance and shared quality indicators

The evidence reviewed suggests that reliability under threat depends on governance that spans professional boundaries. Quality indicators for the pre- and post-analytical phases exist but are unevenly adopted, and the fact that they are typically owned by laboratories limits visibility of problems arising on wards and in administrative units (Cadamuro et al., 2019; Sciacovelli et al., 2023). Shared indicators, reviewed by multidisciplinary quality committees that include nursing, secretarial, and security representatives, would convert laboratory data into collective accountability. National preparedness frameworks should likewise treat specimen referral, transport security, and laboratory information continuity as linked capacities (Kandel et al., 2020; WHO, 2018). The call for a new public health order in Africa, which stresses local diagnostic and manufacturing capacity, reflects the same logic at continental scale (Nkengasong & Tessema, 2020).

11.2 Workforce, training, and wellbeing

Competency-based training and supervision for all specimen-handling and information-handling roles are the most direct way to reduce preventable error. Training should be interprofessional and scenario-based, including downtime and surge simulations. Workforce wellbeing should be treated as a diagnostic safety issue, given links between burnout and patient safety (Hall et al., 2016), and protective measures for staff physical safety are equally essential (Haar et al., 2021).

11.3 Research agenda

Four gaps stand out. First, empirical studies of specimen error in conflict and disaster settings are scarce. Second, the contribution of administrative staff to result reliability is largely unmeasured. Third, the effects of task-shifting on preanalytical quality need controlled evaluation. Fourth, the cost-effectiveness of integrated quality indicators and interprofessional training in unstable settings is unknown.

12. Limitations

As a narrative review, this work did not follow a systematic search protocol, formal risk-of-bias appraisal, or quantitative synthesis, so selection bias is possible. Direct empirical evidence from high-threat environments is limited, and several inferences, particularly concerning secretarial services and wellbeing, are extrapolated from other settings. The conceptual model and matrices are proposals for testing and not validated instruments.

13. Conclusion

Securing the diagnostic chain requires recognizing that specimen integrity and result reliability are collective products. Health security creates the conditions for work, health assistants and nurses safeguard the specimen at its most vulnerable point, secretarial services preserve identity and information, laboratories verify and analyse, and clinicians interpret and act. In high-threat environments each role is simultaneously more essential and more fragile. Shared governance, common quality indicators, interprofessional training, and protection of the workforce offer a practical route to maintaining reliable diagnosis when conditions are least favourable.

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