Street Art & Urban Creativity | Vol. 12, No. 7, 2026 | ISSN 2183-9956
Street Art & Urban Creativity. Scientific Journal

Closing the Loop on Critical Results

A Multidisciplinary Approach to Patient Safety

Nojoud Mohammed Alamoudi[1]*, Dawlat Ibrahim Hantool[2], Asma Munaji Alfadhli[3], Abdullah Ali Mohammed Al Zahrani[4], Abdulmajeed Abdullah Mohammed Qaysi[5], Najla Turki Almalki[6], Ohud Saeed Mohammed Alkathiri[7], Salwa Jaber Aljabry[8], Fahad Mohammed Abdulrahman Alharthi[9], Fatmah Mubark Aboalnass[10]

[1]Nurse Specialist, Jeddah Second Health Cluster, Ministry of Health, Jeddah, Saudi Arabia
[2]Pharmacy Technician, King Abdulaziz Hospital in Jeddah, Saudi Arabia
[3]Nursing Specialist, Rabigh General Hospital, Saudi Arabia
[4]Emergency Medicine Technician, Health Crisis and Disaster Management Center in Jeddah, Saudi Arabia
[5]Emergency Medical Specialist, Health Crisis and Disaster Management Center in Jeddah, Saudi Arabia
[6]Nursing Technician, Primary Health Care Center Al-Dar Al-Bayda, Saudi Arabia
[7]Laboratory Technician, King Salman Hospital, Saudi Arabia
[8]Nursing Specialist, Ministry of Health Branch in Riyadh Region, Compliance Department, First Compliance Office in West Riyadh, Saudi Arabia
[9]Laboratory Specialist, King Salman Hospital, Saudi Arabia
[10]Family Medicine Resident, King Abdulaziz Airport Primary Health Care Centers, Saudi Arabia
Corresponding author: nalamodi@moh.gov.sa

Abstract

Background. Critical results improve outcomes only when they reach someone who acts on them. Communication of critical results crosses laboratory medicine, radiology, nursing, medicine, pharmacy and health informatics, yet it is usually designed and audited one department at a time.

Aim. To map how urgent findings are communicated, acknowledged and acted on across disciplines, including escalation when the responsible clinician cannot be reached, and to synthesise evidence on failures and interventions.

Methods. Narrative review following SANRA. Key sources were appraised with AMSTAR 2, RoB 2, JBI checklists, MMAT or AACODS, according to design.

Findings. Laboratories usually notify within minutes, and radiology adherence to closed-loop policies can exceed 90%. Loss occurs after transmission. Systematic reviews report non-follow-up of 6.8% to 62% of ambulatory laboratory results and 1.0% to 35.7% of imaging results. Between 18% and over a third of electronic imaging alerts go unacknowledged, and physicians were unaware of 61.6% of potentially actionable results returning after discharge. Primary care physicians receive 56 to 77 notifications daily. Interventions with the best evidence are call centres with fallback to alternative caregivers, automated targeted notification, tiered closed-loop alert systems with mandatory acknowledgment, and tracking of follow-up recommendations. Time-triggered escalation and dedicated unit phones are promising low-cost fixes. Evidence on pharmacy, nursing, escalation design and patient outcomes is sparse.

Conclusion. Critical-result communication should be managed as one loop with one shared list, a named accountable recipient, tracked acknowledgment, timed escalation to a final responder, and loop-level measurement.

Keywords: critical results; critical values; closed-loop communication; escalation; patient safety; test result follow-up; interprofessional communication

1. Introduction

A critical result helps a patient only once someone has acted on it. A dangerously low potassium, a new pulmonary embolism on CT or a positive blood culture can be measured accurately and on time and still harm the patient if the message reaches the wrong person, sits unread in an inbox, or is acknowledged but never acted on. Most of the risk lies between steps that belong to different professions, not within any single step.

The evidence on missed results is consistent and sobering. A systematic review of 19 ambulatory studies found that 6.8% to 62% of laboratory results and 1.0% to 35.7% of imaging results lacked documented follow-up [1]. A companion review of 12 hospital studies found inpatient non-follow-up rates of 20.04% to 61.6%, and 1.0% to 75% in emergency departments. It flagged critical results and transitions between care settings as the most vulnerable areas [2]. Transitions are a particular weak point. In a prospective study of 2,644 discharged patients, 41% left hospital with results still pending, and physicians were unaware of 61.6% of the potentially actionable results that returned after discharge [3]. Electronic health records (EHRs) have not removed the problem; in some ways they have changed its shape. In a survey of 2,590 Veterans Affairs primary care practitioners, 69.6% reported receiving more alerts than they could effectively manage, and 29.8% reported personally missing results that delayed care [4].

Regulators recognise the stakes. For two decades, the Joint Commission's National Patient Safety Goal NPSG.02.03.01 required hospitals to define critical results, specify by whom and to whom they are reported, set an acceptable time from availability to reporting, and evaluate their own timeliness. In January 2026 the requirement moved into the new National Performance Goals chapter, which replaced the safety goals chapter for hospitals [5]. Accreditation standards for laboratories and radiology departments impose parallel duties, and most hospitals now have written critical-result policies. Yet the process is still usually designed and audited one department at a time. The laboratory measures how fast it phones, radiology audits its documentation of verbal reports, and nursing and medicine each work to their own expectations. No one owns the loop as a whole.

This narrative review takes the loop, rather than any single discipline, as its unit of analysis. Its objectives are to:

1. Map how urgent findings are detected, communicated, acknowledged and acted on across laboratory medicine, radiology, nursing, medicine, pharmacy and health informatics.
2. Synthesise and appraise the evidence on where the loop fails, including what happens when the responsible clinician cannot be reached.
3. Summarise interventions with evidence of benefit.
4. Propose an integrated, measurable framework, with explicit escalation, that hospitals can adapt.

2. METHODS

This is a narrative review written to the SANRA standard for narrative review articles [6]. It is not a systematic review, but its search and appraisal are reported transparently so readers can judge the weight of each claim.

Search. A search in November 2026 covered PubMed-indexed literature and grey literature: accreditation standards, professional society guidance and national quality programmes. Key terms combined critical result, critical value, panic value, actionable finding, test result follow-up, closed-loop communication, notification, escalation and read-back with laboratory, radiology, nursing, pharmacy and electronic health record. Reference lists of included reviews were hand-searched.

Selection. We prioritised four kinds of evidence:

- systematic reviews and meta-analyses;
- randomised and cluster-randomised trials;
- large multicentre or longitudinal studies with objective outcomes;
- standards that hospitals must meet.

Smaller single-site quality improvement reports were included where they illustrated a mechanism not captured elsewhere, especially escalation, nursing and pharmacy, where higher-

level evidence is scarce. English-language sources only.

Appraisal. Each key source was appraised with the tool designed for its type:

- AMSTAR 2 for systematic reviews [7];
- the Cochrane RoB 2 tool for randomised trials [8];
- JBI checklists for cross-sectional, cohort and quasi-experimental studies [9];
- the Mixed Methods Appraisal Tool (MMAT) for mixed or survey designs [10];
- the AACODS checklist for grey literature and standards [11].

Each source was then given an overall confidence rating of high, moderate or low, which is reported in the evidence table (Section 9).

Synthesis. Findings are organised around the steps of the communication loop rather than by discipline, because most failures happen at the handoffs between professions. Numbers quoted in the text were checked against the abstract or accessible text of each source..

3. Definitions and standards: one loop, many vocabularies

The concept dates to Lundberg's 1972 description of "panic values": laboratory results so far from normal that they signal immediate danger [12]. A Massachusetts consensus group later broadened the idea from values to test results, defining critical results as values or interpretations for which delayed reporting can cause serious adverse outcomes. The group published a "starter set" of results that most clinicians would agree are critical [13]. That shift matters for a multidisciplinary review, because an imaging diagnosis or a microbiology finding can be just as critical as a potassium level.

Vocabulary has not converged. Laboratories speak of critical values, panic values, alert values or critical limits. Radiology uses critical, urgent, non-routine and actionable findings. Clinicians in practice often mean any result they need to know about soon. Campbell and Horvath found wide heterogeneity in critical-result policies and terminology, and argued that harmonisation of definitions, thresholds, notification procedures and documentation is both necessary and feasible [14]. In Australasia, this led to a harmonised alert list that separates critical-risk from significant-risk results and is offered as a starter set for local adaptation [15]. Thresholds also differ widely between hospitals. A 2024 survey of web-posted lists at 26 US university hospitals compared current thresholds with national data from 1990 to 1993. Some limits had changed, while others, such as ionized calcium, had not [19].

Table 1. A shared vocabulary for urgent results across disciplines

Category	Typical owner	Examples	Expected mode	Time frame
Critical (life-threatening) result	Laboratory, radiology	Potassium far outside limits; tension pneumothorax; positive blood culture	Synchronous: direct call or page, with read-back	Minutes to 1 hour (set locally)
Urgent or significant result	Laboratory, radiology, pathology	New mass needing prompt work-up; rising troponin	Synchronous or tracked asynchronous message	Hours (set locally)
Actionable non-urgent finding	Radiology, pathology	Incidental pulmonary nodule needing follow-up imaging	Asynchronous, tracked to completion	Days to months
Drug critical limit	Laboratory with pharmacy	Toxic digoxin or lithium level; supratherapeutic INR	Synchronous; pharmacist involvement desirable	Minutes to hours (set locally)
Result pending at transition	Any	Culture finalised after discharge	Electronic notification to a named responsible clinician	By result type

Table 1 is a framework for local policy, not a standard. Time frames must be agreed by each institution's medical staff, as the Joint Commission requires [5].

The main standards converge on the same core requirements:

- Joint Commission NPSG.02.03.01, carried into the National Performance Goals from January 2026, requires written procedures that define critical results, by whom and to whom they are reported, and the acceptable time to report them, together with evaluation of timeliness [5].
- College of American Pathologists (CAP) checklist requires critical-result notification and read-back of verbally reported results [17].
- ISO 15189:2022, the international standard for medical laboratory accreditation, requires laboratories to have procedures for reporting critical results [18].
- American College of Radiology (ACR) practice parameter asks radiologists to expedite non-routine communication when urgent action may be needed. It advises documenting the date,

time, method and name of the person receiving the report. When the referring clinician cannot be reached, it may be appropriate to tell the patient directly [16].

All of these standards regulate the sender's side of the loop. None of them, on its own, requires that the receiver act, or says who owns the result once it has been delivered. That gap runs through the rest of this review.

4. The loop, discipline by discipline

Each profession reliably performs its own part of the loop. Results are lost in the handoffs between professions.

4.1. Laboratory medicine: fast to call, slower to reach the right person

Laboratories are usually quick to notify. A College of American Pathologists Q-Probes study of 3,545 inpatient and emergency department critical-result notifications in 121 laboratories found the following [20]:

- The median time from test completion to notifying someone was 5 minutes, with an interquartile range across institutions of 1.5 to 8 minutes.
- At the median facility, notification came 56.5 minutes after specimen collection, so calling time was a minor part of total turnaround.
- 89% of results were first called to a licensed caregiver, and 96% of calls included read-back.
- Only about half of institutions used a scripted call.

Speed in calling does not guarantee delivery. At a tertiary centre that relayed 42,648 critical values in eight months, a review of delayed calls found that 64% of delays were caused inside the laboratory [22]. The largest single cause was underused escalation protocols, at 48% of delays. Inability to identify or reach an appropriate provider caused 26%, and gaps in clinics' own escalation protocols caused 7%. Tightening the call-list colour timings from 30 and 60 minutes to 15 and 30 minutes cut calls taking more than 60 minutes from 3.4% to 1.3%. Such a simple change worked because it made escalation automatic rather than discretionary.

Verbal reporting adds a transcription risk. Across three organisations, read-back caught 29 errors in 822 outgoing calls (3.5%) at a cost of about 12.8 seconds per call. Calls to physicians had the highest error rate [21]. Read-back is cheap insurance, and the CAP checklist requires it [17].

4.2. Radiology: from "I called" to "the loop is closed"

Radiology's critical findings are often diagnoses rather than numbers, so they depend more on judgement and are harder to automate. Brigham and Women's Hospital provides the most complete longitudinal record. A four-year programme of policy, report audit and feedback raised adherence to its critical-results policy from 28.6% to 90.4% [26]. The researchers found that 9.6% of reviewed reports contained critical results, a heavy manual workload.

The hospital then built an alert notification system (ANCR) with three tiers:

- red alerts need closed-loop communication within 60 minutes;
- orange alerts within 3 hours;
- yellow alerts within 15 days.

Policy adherence rose from 91.3% to 95.0%, and use of the system grew ninefold. About 41% of alerts went through a non-interruptive channel, which cut unnecessary pages [27]. A time-series analysis confirmed fewer critical results lacking documented communication, without overuse of the alert system for normal reports [28].

Transmission is not the same as receipt or action. At a Veterans Affairs clinic, clinicians did not acknowledge over one-third of electronic imaging alerts (368 of 1,017), and 45 studies were completely lost to follow-up at four weeks [29]. A larger follow-up study reviewed 1,196 critical imaging alerts generated from 123,638 outpatient studies [30]:

- 18.1% of alerts were never acknowledged;
- 7.7% lacked timely follow-up, a similar rate whether or not the alert had been opened (7.3% vs 9.7%);
- alerts were more likely to go unacknowledged when the orderer was a trainee (odds ratio 5.58) and when more than one clinician was alerted (odds ratio 2.02).

Alerting two clinicians, intended as a safeguard, appears to have spread responsibility so thinly that each assumed the other would act.

The newest work extends the loop to non-urgent but actionable recommendations. In a

controlled comparison of 7.5 million reports from two hospitals, a package of radiologist education, closed-loop tracking, safety-net staff and feedback reports produced three changes at the study site [31]:

- the actionable share of follow-up recommendations rose from 5.5% to 42.3%;
- 84.7% of actionable recommendations were completed or scheduled, against 59.6% at the control site;
- recommendations for additional imaging fell by 44%.

4.3. Nursing: the human relay

Nurses are often the first to receive a critical result and the people most likely to see the patient within minutes. In an early computerised system that paged nurses directly, 76% of alerts reached the primary nurse, and in 67% of cases the nurse had not previously known of the result [32]. This makes nursing the natural first responder. It also makes the nurse a relay point: the result must still pass to a prescriber, which adds a second verbal handoff with its own risk of error and delay.

Small changes in unit workflow make a difference. In a hospital where about 25% of critical-value calls had to be escalated because no one on the unit took them, provider education cut escalations to 18%, but the gain did not last. A dedicated critical-results phone in each area brought a sustained fall to 9% to 14% [23]. Assigning a dedicated person to receive results did not help. The authors attribute the phone's success to simplifying and standardising where calls are answered. Nursing policy should therefore specify:

- who answers the call;
- read-back and documentation;
- a maximum time to inform the responsible prescriber;
- what the nurse may start under protocol while waiting, such as repeat glucose or cardiac monitoring;
- when the nurse must escalate up the medical chain without waiting to be told.

4.4. Physicians: acknowledgment is not action

The physician's step turns information into treatment, and it is where volume overwhelms vigilance. Primary care practitioners in one Veterans Affairs system received a mean of 56.4 new-information alerts per day and spent about 49 minutes a day processing them [33]. In commercial EHRs, primary care physicians received 76.9 notifications per day [34]. Unsurprisingly, 29.8% of surveyed practitioners reported personally missing results that delayed care [4].

Automation can speed the physician's response when it is targeted. In a randomised trial, automatically paging the covering physician about critical laboratory conditions shortened the median time to appropriate treatment by 38%, from 1.6 to 1.0 hours. The trial found no significant difference in adverse events [25].

Responsibility at transitions is the weakest link. In the discharge cohort described earlier, physicians were unaware of 61.6% of potentially actionable results that returned after discharge [3]. A cluster-randomised trial of automated email to the responsible physicians raised awareness among inpatient attendings from 38% to 76% (adjusted odds ratio 6.30) and among primary care physicians from 33% to 57%. The trend for actionable results (59% vs 29%) was not statistically significant [35]. Policy must name one accountable clinician per result, and that responsibility must transfer explicitly at shift change, handover and discharge.

4.5. Pharmacy: an under-used safety net

Many critical results concern drugs: toxic levels, supratherapeutic INR, and electrolyte disturbances caused or treated by medications. A 2026 analysis of notification lists from 417 US hospitals found that 411 kept drug critical limits, covering 111 drugs, with wide variation in thresholds and no national standard [36]. Kuperman's trial rules combined laboratory values with active medications, showing that drug-aware alerting is technically feasible [25].

Peer-reviewed evaluations of pharmacists as formal recipients or co-recipients of critical results are scarce. This is a clear evidence gap. Practical roles that teams should test and report include:

- pharmacists as co-recipients of drug-level and INR critical results;
- protocol-driven dose holds or adjustments, such as holding an anticoagulant or nephrotoxin;
- a second check on the prescriber's response.

4.6. Health informatics: plumbing for the loop

Informatics supplies routing, tracking, acknowledgment and audit. The CDC Laboratory Medicine Best Practices review found five call-centre studies and four automated-notification studies with credible evidence [24]:

- centralised call centres were rated an evidence-based best practice for timeliness and accuracy (odds ratio 22.1);
- automated notification also favoured the intervention (standardised mean difference 0.42), but the evidence was judged insufficient for a recommendation.

Automation transmits; it does not guarantee acknowledgment or action [29,30]. Effective designs share four features:

- tiered urgency, with interruptive channels reserved for true emergencies [27];
- mandatory acknowledgment;
- time-triggered automatic escalation when acknowledgment does not arrive;
- dashboards that make open loops visible [27,28].

In Saudi Arabia, the Ministry of National Guard Health Affairs has introduced an electronic critical-result notification system (Takeed), announced for all its facilities, with clinician acknowledgment by interactive voice response or the system itself [37]. Published outcome evaluations of such regional systems would strengthen the evidence base considerably.

5. Where the loop breaks, and how escalation should work

The failures reviewed above cluster at six points, each matched to a countermeasure with at least some evidence of benefit (Table 2). Most occur after the result has left the department that produced it.

Table 2. Failure modes across the loop.

Loop step	Typical failure	Key evidence	Countermeasure
Detect and classify	Thresholds and categories vary between hospitals and disciplines	[14,15,19,36]	Harmonised, medical-staff-approved lists reviewed on a schedule
Communicate	Responsible clinician not identified or not reached; transcription error	[21,22,23]	Up-to-date on-call directory; dedicated unit phone; read-back
Acknowledge	Electronic alert never opened	[29,30]	Mandatory acknowledgment with time-triggered escalation
Act	Result seen but no timely action; responsibility spread across several recipients	[3,30]	One named accountable clinician; follow-up tracking
Transition	Result returns after shift change, transfer or discharge	[2,3,35]	Explicit transfer of responsibility; automated notification after discharge
Overload	Alert volume exceeds what a clinician can process	[4,33,34]	Tiered urgency; non-interruptive channel for lower tiers; inbox redesign

5.1. The unreachable clinician

Every critical-results policy eventually meets the clinician who does not answer. The evidence points to three lessons.

1. Make escalation the default, not the exception. In the tertiary-centre review described above, underused escalation protocols caused nearly half of all delays. Automatic escalation timers fixed much of the problem [22]. Callers should not have to judge whether "enough" time has passed.
2. Escalate to a role, not a person. Call centres earned their evidence rating partly because they go on to alternative caregivers when the first contact fails [24]. This needs a live directory of who is covering each patient at each hour.
3. Define the end of the line. Policies need a final tier that always answers, such as a senior physician, a duty manager or a house supervisor. For outpatients, they need a route to the patient. ACR guidance accepts direct communication with the patient when the referring clinician cannot be reached [16].

Escalation also flows sideways. A radiologist or pathologist unable to reach the ordering team should be able to call the covering physician directly. A nurse who cannot reach the prescriber should escalate up the medical chain under protocol, not wait.

Figure 1 sets out a tiered escalation ladder built on these principles. The time intervals shown are illustrative. Each institution must set and approve its own [5].

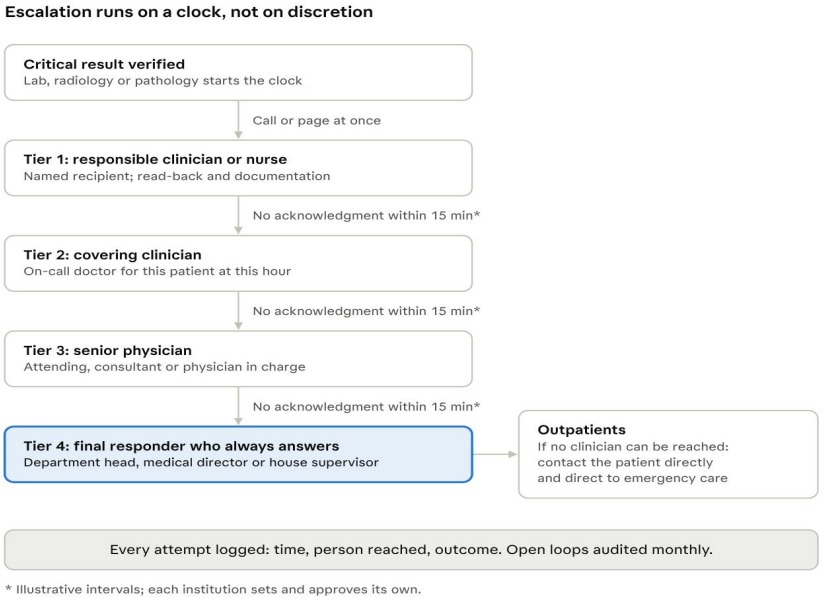


Figure 1. Time-triggered escalation ladder for critical results (illustrative intervals)
Each tier is triggered automatically by a missing acknowledgment, not by the caller's judgement. The final tier must always answer.

5.2. Escalation without blame

Escalation fails socially as well as technically. Staff may hesitate to page a senior physician at night or to go around a colleague who has not answered. Policies should state that escalation according to the protocol is expected behaviour, and that it is audited as a system measure rather than treated as a complaint about an individual. The data support this framing. At the hospital where about a quarter of calls needed escalation, the most effective fix changed the system (a dedicated phone), not individual behaviour [23].

6. What works: interventions and the strength of their evidence

The strongest evidence supports changing systems rather than exhorting individuals. Table 3 ranks the main interventions by the quality of the evidence behind them.

Table 3. Interventions to close the loop

Intervention	Loop step	Best evidence	Main effect	Confidence
Centralised call centre with fallback to alternative caregivers	Communicate	Systematic review and meta-analysis (5 studies) [24]	Faster, more accurate reporting (OR 22.1)	Moderate
Automated paging of the responsible physician	Communicate, act	Randomised trial [25]	Median time to treatment 1.6 h to 1.0 h; no difference in adverse events	Moderate
Automated email for tests pending at discharge	Transition	Cluster-randomised trial [35]	Attending awareness 38% to 76%	Moderate
Tiered closed-loop alert system with acknowledgment	Communicate, acknowledge	Longitudinal before–after and time series [27,28]	Policy adherence 91.3% to 95.0%; fewer undocumented critical results	Moderate
Written policy with audit and feedback	All steps	Four-year before–after [26]	Adherence 28.6% to 90.4%	Low to moderate
Closed-loop tracking of follow-up recommendations, safety-net staff, feedback	Act	Controlled before–after, 7.5 million reports [31]	Completion 84.7% vs 59.6% at control site	Moderate
Read-back of verbal results	Communicate	Multisite observational [21]	3.5% of calls had an error caught by read-back	Low to moderate
Automatic escalation timers	Escalate	Single-site before–after [22]	Calls over 60 min fell from 3.4% to 1.3%	Low
Dedicated critical-results phone per unit	Communicate	Single-site quality improvement [23]	Escalated calls fell from about 25% to 9–14%	Low
Electronic alert without acknowledgment tracking	Communicate	Cohort studies [29,30]	18% to over a third of alerts unacknowledged	Moderate (documents a gap)

dence ratings are drawn from the appraisals in Section 9.

Four patterns stand out.

1. Redundancy works best when it is designed. Ad hoc redundancy can backfire. Call centres succeed because they move to a defined alternative caregiver [24], whereas copying a second clinician on an alert made non-acknowledgment more likely [30].
2. Interventions that close the loop beat those that only transmit. Systems that require acknowledgment and track the result to an action improved adherence [27,28,31]. Transmission alone left a stubborn residue of missed results [29,30].
3. Small workflow fixes can matter as much as large IT projects. A recalibrated call list and a dedicated phone each produced gains at very low cost, and the phone's gains were sustained [22,23].
4. Patient outcomes are rarely measured. Most studies report process measures such as time to notification, adherence or awareness. The one randomised trial that measured adverse events found no significant difference [25], and the CDC review assessed timeliness and accuracy rather than harm [24]. Process gains are necessary but are not proof of benefit.

Evidence from the Gulf region is mostly descriptive. A Saudi tertiary laboratory accredited by the Central Board for Accreditation of Healthcare Institutions (CBAHI) described its critical-value profile, including call-centre notification for outpatients [38]. Health systems in the region have also introduced electronic notification platforms [37]. Formal before-and-after or controlled evaluations from these settings are a priority for future work.

7. An integrated framework

7.1. One loop, owned end to end

We propose that hospitals manage critical results as one multidisciplinary process with six steps: detect, classify, communicate, acknowledge, act and audit. Escalation branches from the acknowledgment step and appears as its own stage in Figure 2. The framework is a synthesis of the evidence above, not a tested intervention. Its value lies in assigning an owner to every step and every handoff.

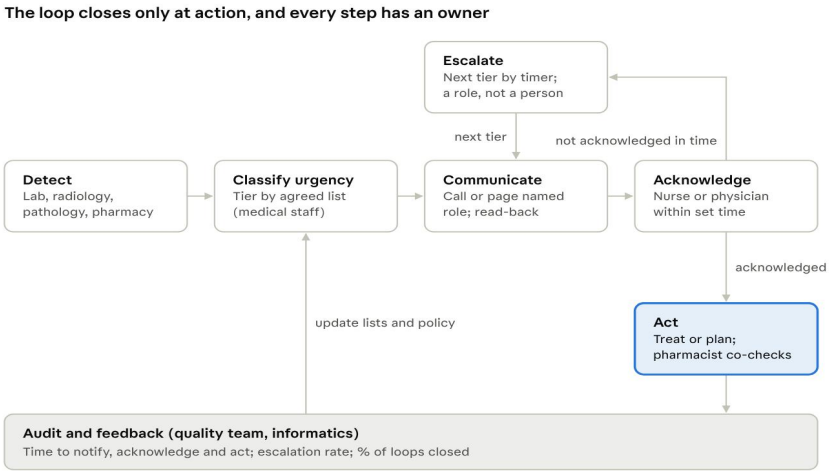


Figure 2. The integrated critical-results loop with an owner at each step Acknowledgment either leads to action or triggers escalation to the next tier. Audit feeds back into the agreed list and policy.

Four governance features make it work:

• A single multidisciplinary committee owns the policy. Its members come from laboratory medicine, radiology, nursing, medicine, pharmacy and informatics, so no discipline writes rules that another must follow without consultation [13,14].

• A single list of critical results with tiers and times, approved by the medical staff, covers laboratory, imaging, pathology and drug levels [5,15].

• One accountable clinician per result is named at every moment, including after shift change and discharge [3,35].

• Pharmacy has an explicit role, at a minimum as co-recipient of drug-level and anticoagulation results.

7.2. Measuring the whole loop

Most hospitals measure only the first step: the laboratory's time to call. A loop-level dashboard should report measures across every step (Table 4).

Table 4. Suggested loop-level measures

Step	Measure	Basis
Communicate	% of critical results notified within the policy time; % with documented read-back	Timeliness: Joint Commission [5]; read-back: CAP [17]
Acknowledge	Median time to acknowledgment; % unacknowledged at the policy limit	[27,29,30]
Escalate	% of results needing escalation, and the tier reached	[22,23]
Act	Time to first appropriate order; % of loops with documented action	[25,26]
Transition	% of results pending at discharge acknowledged by the named clinician	[35]
Follow-up	% of actionable imaging recommendations completed on time	[31]
Balancing	Interruptive alerts per clinician per day; staff time spent on calls	[33,34]

Where possible, these measures should be linked to patient outcomes, such as deterioration or rapid-response calls after a critical result. This is the evidence the field most lacks.

7.3. Gaps and future research

- Outcomes. Few studies link loop performance to harm. Trials and stepped-wedge evaluations should include patient outcomes, not only process times.
- Pharmacy and nursing. These are the least-studied disciplines, even though they sit closest to the patient and the drug.
- Escalation. No study has compared escalation designs, such as interval length, the number of tiers or role-based against person-based routing.
- Low- and middle-income and Gulf settings. Most evidence comes from US academic centres. Regional reports are largely descriptive [37,38].
- Patients as part of the loop. Patient portals that release results directly may add a safety net or may add confusion. Their effect on loop closure is unknown.
- Artificial intelligence. Natural-language processing that flags follow-up recommendations is promising but needs prospective evaluation against the closed-loop measures above.

7.4. Limitations

This is a narrative review. Its search was not exhaustive, and its selection and appraisal involve judgement. The evidence base is dominated by single-centre, before–after studies from high-income settings, many from a small number of institutions, which limits generalisability. Several effect sizes come from process measures whose link to patient benefit is assumed rather than shown.

8. CONCLUSION

Communicating a critical result is not an event inside one department. It is a chain of handoffs that crosses laboratory medicine, radiology, nursing, medicine, pharmacy and informatics. The evidence shows that laboratories and radiologists usually transmit quickly, and that results are lost afterwards: in unacknowledged alerts, in responsibility spread across several recipients, at shift changes and discharges, and when no one is reachable.

The most effective remedies are systemic:

- one shared definition and list of critical results;
- a named accountable recipient for every result;
- acknowledgment that is required and tracked;
- escalation that runs on a timer to a final responder who always answers;
- measurement of the whole loop rather than its first step.

Closing the loop is a shared responsibility, and it should be designed, owned and audited as one.

9. Evidence appraisal

The evidence base is moderate at best. There are two randomised trials (one cluster-

randomised) and three systematic reviews. Most other sources are single-centre before–after studies.

Table 5. Appraisal of key sources (confidence = confidence in the finding as used in this review)

Ref	Source	Design and size	Tool	Main limitations	Confidence
[1]	Callen 2012	Systematic review, 19 studies (ambulatory)	AMSTAR 2	English only, 1995–2010; heterogeneous definitions; no pooling	Moderate
[2]	Callen 2011	Systematic review, 12 studies (hospital)	AMSTAR 2	1990–2010; heterogeneous; few outcome data	Moderate
[24]	Liebow 2012	Systematic review and meta-analysis, 9 studies	AMSTAR 2	Few studies, mostly before–after, inpatient only	Moderate (call centres); low (automation)
[25]	Kuperman 1999	RCT, 192 alerting situations	RoB 2	Single centre; unblinded; pager era; underpowered for adverse events	Moderate
[35]	Dalal 2014	Cluster RCT, 441 patients	RoB 2	Self-reported awareness outcome; survey non-response; single network	Moderate
[3]	Roy 2005	Prospective cohort, 2,644 discharges	JBI cohort	Two academic centres; no link to harm	Moderate
[20]	Valenstein 2008	Multicentre cross-sectional, 121 laboratories	JBI cross-sectional	Voluntary participants; self-collected data	Moderate
[29]	Singh 2007	Prospective cohort, 1,017 alerts	JBI cohort	Single VA system; no pre-implementation comparison	Moderate
[30]	Singh 2009	Cohort, 1,196 alerts	JBI cohort	Single VA facility; follow-up judged by chart review	Moderate
[27]	Lacson 2014	Before–after, 4 years	JBI quasi-experimental	Single centre; no control; high baseline	Moderate
[28]	Lacson 2016	Interrupted time series	JBI quasi-experimental	Single centre	Moderate
[26]	Anthony 2011	Before–after with feedback	JBI quasi-experimental	Single centre; small early samples	Low to moderate
[31]	Abbasi 2025	Controlled before–after, 7.5 million reports	JBI quasi-experimental	Sequential bundle; one health system	Moderate
[4]	Singh 2013	Survey, 2,590 respondents (51.8%)	MMAT	Self-report; VA only	Moderate
[33]	Murphy 2012	Log analysis and time–motion study	JBI cross-sectional	Single VA facility	Moderate
[36]	Kuang 2026	Document analysis, 417 hospitals	JBI cross-sectional	Posted policies only; US only	Moderate
[21]	Barenfanger 2004	Observational, 822 calls, 3 sites	JBI cross-sectional	Short period; error definition not standardised	Low to moderate
[22]	Hopkins 2021	Quality improvement, before–after	JBI quasi-experimental	Single site; one-month delay audit	Low
[23]	Guarner 2025	Quality improvement, PDSA cycles	JBI quasi-experimental	Single hospital; no control	Low
[32]	Tate 1995	System evaluation	JBI cross-sectional	Old; single site	Low
[5,16–18]	Joint Commission, ACR, CAP, ISO	Standards and practice parameters	AACODS	Statements of requirement, not evidence of effect	High (as requirements)
[13,14]	Hanna 2005; Campbell 2014	Consensus recommendations; review	AACODS; SANRA	Expert opinion	Moderate

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