

Development of a rules-based framework for patient-facing interpretation of laboratory results

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Abstract

Objective

To describe development of a physician-informed, rules-based framework for contextual, patient-facing interpretation of routine laboratory testing. The framework was designed to address limitations of analyte-centric reporting by integrating biomarker relationships, prioritizing clinically meaningful signals, and clarifying overall urgency.

Materials and Methods

HealthRadar was developed as a modular interpretation framework that synthesizes multiple laboratory biomarkers into structured patient-facing summaries. Its architecture incorporates organ-system clustering, hierarchical prioritization of physiologic signals, severity-tier stratification, urgency-oriented communication, and structured narrative generation intended to reduce contradictory messaging. Iterative refinement was informed by physician review, usability observations, and repeated testing with representative laboratory profiles.

Results

The framework generated summaries designed to answer three patient-centered questions: “Am I OK right now?”, “What do these results mean together?”, and “What should I do next?” Outputs emphasized contextual interpretation and physiologic pattern synthesis rather than isolated abnormality flagging, while maintaining concise, non-alarmist communication. Preliminary physician and user feedback suggested that integrated summaries highlighted clinically meaningful patterns and relative urgency, while identifying opportunities to improve laboratory terminology explanation, reference-range context, and patient understanding.

Discussion

Contextual laboratory interpretation may help address an underdeveloped gap between raw result display and clinically coherent patient communication. A bounded, rules-based architecture offers transparency, auditability, and structured urgency framing in a patient-facing setting.

Conclusion

HealthRadar provides a conceptual model for severity-aware, patient-centered laboratory interpretation. Further evaluation is warranted to assess interpretive performance, patient comprehension, clinical utility, and integration into digital health workflows.

Introduction

The widespread adoption of electronic health records, patient portals, and direct-to-consumer laboratory testing has fundamentally changed how patients encounter medical information.^{1,2} Patients now routinely access laboratory results soon after processing, often before speaking with a healthcare professional.³ While this increased transparency may improve engagement and autonomy, it also exposes patients to complex clinical information that is frequently presented with little interpretation or context.⁴

Most conventional laboratory reporting systems remain fundamentally analyte-centric.⁴ Individual biomarkers are displayed alongside reference ranges, and abnormalities are typically highlighted in isolation using visual indicators such as bold text, arrows, or color changes.⁵ Although this approach reliably identifies values outside expected ranges, it does not reproduce the synthesis that occurs during clinical reasoning. Physicians rarely interpret laboratory abnormalities one analyte at a time. Clinical interpretation instead involves prioritizing physiologic signals, weighing abnormalities in context, and recognizing broader patterns across multiple biomarkers.⁶

As a result, patients are often left to interpret fragmented laboratory findings on their own. Mild or clinically insignificant abnormalities may generate disproportionate anxiety, while broader multi-marker patterns suggesting evolving disease processes may be difficult for non-clinician users to recognize.⁷ In many systems, explanatory comments remain generic, inconsistent, or disconnected from the overall laboratory profile. Conventional reporting structures also frequently fail to address the question many patients are trying to answer first: “Am I OK right now?” Many emerging approaches to automatically generated interpretation remain difficult to explain, insufficiently bounded for patient-facing use, or focused more on generating answers than on providing structured, clinically coherent communication.^{8,9}

HealthRadar was developed as a physician-informed framework intended to address these communication and contextualization gaps. Rather than functioning as a diagnostic system, it was designed as a structured interpretive communication layer that synthesizes laboratory relationships, prioritizes clinically meaningful physiologic signals, stratifies overall severity, and presents explanatory narratives using plain-language principles. The underlying design philosophy emphasized contextual interpretation, urgency clarification, contradiction reduction, and concise next-step guidance.

The objective of this manuscript is to describe the conceptual development and design principles underlying a rules-based framework for contextual, patient-facing interpretation of routine laboratory testing.

Methods

System overview

HealthRadar was developed as a modular, rules-based interpretation framework intended to synthesize routine laboratory biomarkers into structured patient-facing summaries. The prototype architecture incorporated sequential interpretive layers, including biomarker intake, organ-system clustering, hierarchical prioritization of physiologic signals, severity stratification, contextual narrative generation, and action-oriented output formatting.

Rather than treating laboratory values solely as isolated abnormalities, the framework evaluated relationships among biomarkers within broader physiologic domains, including metabolic, renal, hepatic, endocrine, and hematologic systems. Interpretive outputs were then generated using structured communication templates designed for non-clinician audiences.

The system was designed as an interpretive support framework and was not intended to establish diagnoses, replace physician judgment, or function as an autonomous clinical decision-making system. See **Figure 1**.

Core design principles

Urgency-first communication

A primary design objective was to clarify perceived urgency. Outputs were structured to address first whether laboratory findings appeared broadly reassuring, warranted routine follow-up, or suggested potentially urgent abnormalities requiring prompt clinical attention.

Contextual interpretation

The framework emphasized relationships among biomarkers and broader physiologic patterns rather than isolated deviations from reference ranges alone. It incorporated hierarchical prioritization strategies intended to identify the dominant clinically actionable signal within heterogeneous laboratory profiles. This approach was designed to better approximate clinician-style synthesis⁶ while remaining understandable to non-clinician users.

Plain-language explanatory outputs

Narrative summaries were intentionally designed using concise, patient-centered language intended to minimize unnecessary jargon and improve readability for general audiences.

Single-action guidance

Outputs were designed to provide one prioritized next-step recommendation in order to reduce information overload and improve usability.

Contradiction reduction

Structured output architecture was developed to minimize conflicting or internally inconsistent messaging between explanatory sections, reassurance statements, and follow-up recommendations. Please see **Table 1**.

Table 1. Core design principles of the HealthRadar framework

Principle	Purpose
Urgency-first communication	Clarify whether findings suggest reassurance, routine follow-up, or potentially urgent medical attention.
Contextual interpretation	Integrate related biomarkers into broader physiologic patterns rather than isolated abnormality reporting.
Plain-language reporting	Improve readability and comprehension for non-clinician users using concise patient-centered language.
Contradiction reduction	Maintain consistency between explanatory text, reassurance statements, and follow-up recommendations.
Single-action guidance	Reduce cognitive overload by prioritizing one clear next-step recommendation.
Balanced communication	Acknowledge reassuring findings when appropriate while still emphasizing clinically meaningful abnormalities.
Pattern prioritization	Emphasize the dominant physiologic signal within mixed laboratory profiles.
Explainable rules-based behavior	Support transparency, auditability, and predictable communication logic.

HealthRadar was designed to prioritize contextual interpretation, communication clarity, and patient-centered explanatory structure.

Severity stratification framework

Laboratory profiles were categorized into escalating interpretive tiers reflecting overall laboratory significance and potential urgency. Stratification incorporated the severity of individual abnormalities, relationships among biomarkers, and the broader physiologic context of the laboratory profile. Narrative outputs and recommended follow-up intensity were aligned with the resulting severity classification.

Organ-system contextualization

To reduce fragmented interpretation and better approximate clinician-style reasoning, laboratory biomarkers were grouped into broader physiologic domains representing commonly encountered clinical patterns, including metabolic, renal, hepatic, endocrine, and hematologic systems. Rather than treating abnormalities as isolated deviations from reference ranges, the framework evaluated relationships among biomarkers within and across these domains to generate context-aware interpretations.

The interpretive architecture emphasized contextual weighting of abnormalities according to physiologic coherence, severity, and potential clinical significance. Mild isolated abnormalities could therefore be deprioritized within an otherwise reassuring laboratory profile, whereas combinations of individually modest abnormalities pointing toward a coherent physiologic process could be elevated in interpretive importance. For example, mildly elevated fasting glucose, elevated triglycerides, reduced HDL cholesterol, and mildly abnormal hepatic transaminases could collectively support a broader metabolic-hepatic interpretation despite the limited severity of any single biomarker alone.

Individual biomarkers could also contribute to more than one physiologic interpretation depending on the surrounding laboratory context. This approach was intended to more closely reflect real-world clinical reasoning, in which laboratory findings are interpreted relationally rather than independently.⁶

When competing physiologic signals were present simultaneously, the framework applied hierarchical prioritization strategies intended to emphasize the most clinically actionable pattern. The system therefore sought to avoid fragmented or competing narratives by identifying a dominant physiologic signal while still acknowledging secondary abnormalities when appropriate.

Narrative output architecture

Patient-facing outputs were generated using a structured narrative framework composed of multiple coordinated communication sections. These sections were designed to maintain internal consistency while addressing distinct informational needs commonly encountered during patient review of laboratory results.

The prototype output structure included:

- a brief headline summarizing overall urgency or reassurance level
- a concise explanatory section describing the integrated meaning of the laboratory profile
- a context-specific interpretation section emphasizing physiologic relationships
- a reassurance section identifying stabilizing or favorable findings when appropriate
- a prioritized next-step recommendation

Narrative generation relied on modular text components selected according to severity tier, dominant physiologic pattern, and overall interpretation. Communication templates were iteratively refined to reduce contradictory phrasing and minimize abrupt shifts between reassuring and cautionary language.

Outputs were intentionally designed to avoid excessive diagnostic certainty, prescriptive treatment recommendations, or language likely to produce disproportionate alarm in the setting of low-risk abnormalities.

Severity communication strategy

A five-tier severity communication structure was developed to standardize urgency messaging across heterogeneous laboratory profiles. The framework ranged from reassuring interpretations with no significant active signal to outputs indicating that prompt medical evaluation may be warranted.

Severity assignment was intended primarily as a communication and prioritization tool rather than a diagnostic classification system. Output wording, explanatory detail, and follow-up recommendations were aligned with the overall severity tier to maintain consistency throughout the generated narrative.

The framework also incorporated escalation logic for selected high-impact laboratory abnormalities that warranted increased clinical attention regardless of the broader contextual profile. This strategy was intended to reduce the risk that potentially important findings would be underemphasized within otherwise mixed laboratory results.

Patient-centered communication principles

The communication framework was informed by principles derived from physician-patient interaction, health literacy considerations, and cognitive load reduction strategies.^{1,2,5,7} Particular emphasis was placed on reducing ambiguity, minimizing conflicting messages, and presenting laboratory findings in a manner understandable to individuals without formal clinical training.

Several recurring communication objectives guided iterative development:

1. prioritize overall contextual meaning over isolated numeric abnormalities
2. reduce unnecessary alarm associated with minor laboratory deviations
3. distinguish routine follow-up from potentially urgent findings
4. provide concise and actionable next-step guidance
5. avoid excessive medical jargon where simpler language could preserve meaning
6. maintain a calm, clinician-like explanatory tone

The framework was also designed to acknowledge reassuring findings where appropriate in order to provide balanced interpretation rather than exclusively focusing on abnormal values.

Prototype implementation

The prototype framework was implemented using a modular architecture with integrated rule processing and structured output generation. Laboratory inputs were normalized and processed through sequential interpretive layers responsible for contextualization, prioritization, severity assignment, and narrative assembly.

The modular structure allowed iterative refinement of communication logic, physiologic grouping behavior, and explanatory text generation without requiring reconstruction of the broader interpretive

framework. This design also supported expansion into additional biomarker domains, adaptation of communication strategies for different audiences or clinical settings, and future incorporation of longitudinal trend interpretation and patient-specific baseline contextualization.

As of May 2026, the prototype framework had processed approximately 170 laboratory profiles, including both synthetic edge-testing cases and real-world user-entered laboratory data. Synthetic cases were used during development to evaluate escalation behavior, contradiction reduction, and handling of mixed physiologic abnormalities, while real-world usage provided early observations regarding interpretability, usability, and communication clarity. In addition, 37 preliminary user survey responses were collected during iterative testing. Early feedback consistently emphasized the importance of contextual explanation, understandable laboratory terminology, and clear urgency communication, while also suggesting that integrated physiologic summaries were perceived as more useful than isolated abnormality reporting alone.

Iterative refinement process

Development of the framework involved repeated iterative testing using representative laboratory profiles spanning normal findings, isolated abnormalities, mixed physiologic patterns, and higher-severity laboratory presentations. Outputs were repeatedly reviewed and revised to improve coherence, case-specific accuracy, readability, and communication consistency.

Particular attention was devoted to identifying situations in which generated narratives:

- overemphasized low-risk abnormalities
- produced contradictory reassurance and urgency statements
- failed to identify clinically coherent multi-marker patterns
- generated excessive explanatory complexity
- implied unsupported diagnostic certainty

Refinement was informed by physician review and informal usability observations obtained during repeated prototype testing. Feedback focused primarily on interpretability, communication quality, physiologic coherence, and prioritization of clinically meaningful findings.

Preliminary evaluation approach

Initial framework evaluation focused on qualitative assessment of interpretive coherence, communication consistency, and perceived clinical usefulness rather than formal diagnostic performance metrics. Prototype outputs were compared informally against conventional laboratory reporting structures to assess whether integrated summaries more effectively communicated overall physiologic context and relative urgency.

Preliminary physician feedback emphasized several recurring themes, including:

- improved visibility of multi-marker physiologic patterns
- reduction in fragmented interpretation
- enhanced contextual explanation for non-clinician users
- clearer prioritization of follow-up urgency

Informal patient-oriented usability feedback similarly suggested that users valued contextual synthesis, explicit reference ranges, and concise next-step guidance, while also identifying opportunities for improved explanation of laboratory terminology and contextual interpretation principles.

Ethical and clinical considerations

The framework was designed as an informational and educational support tool rather than a diagnostic platform. Outputs were not intended to replace physician evaluation, establish definitive diagnoses, or direct treatment decisions.

Communication strategies intentionally emphasized appropriate clinical follow-up, contextual interpretation, and acknowledgment of uncertainty where applicable. The framework was developed with awareness of the potential psychological impact of automated medical interpretation and therefore prioritized balanced language, bounded next-step guidance, and avoidance of unnecessarily alarmist phrasing.

No protected health information or directly identifiable patient data were collected or used in the prototype observations described in this manuscript.

Results

Prototype output structure

The prototype framework generated structured patient-facing summaries designed to contextualize routine laboratory findings using narrative physiologic interpretation rather than isolated analyte reporting alone. Outputs were consistently organized into coordinated communication sections that included:

- an overall urgency-oriented headline
- a concise summary interpretation
- context-specific explanatory text
- reassurance statements when appropriate
- a prioritized follow-up recommendation

The generated narratives were designed to address three primary patient concerns commonly encountered during laboratory review:

1. "Am I OK right now?"

2. "What do these results mean together?"
3. "What should I do next?"

Across representative laboratory profiles, the framework consistently prioritized coordinated physiologic interpretation over isolated statistical abnormalities. Output behavior emphasized coherence, severity-aligned communication, and minimization of internally contradictory messaging.

Integrated pattern recognition behavior

The framework consistently combined related laboratory abnormalities into coherent physiologic interpretations rather than treating each abnormal value as an unrelated event. In many cases, patterns that appeared fragmented in conventional laboratory reporting became substantially more understandable when interpreted collectively.

For example, mildly elevated fasting glucose, elevated triglycerides, reduced high-density lipoprotein cholesterol, increased waist circumference, and mildly abnormal hepatic transaminases could be synthesized into a single metabolic-hepatic interpretation associated with insulin resistance and early metabolic dysfunction. Individually, these abnormalities might appear modest or nonspecific. Viewed together, however, they may point toward a recognizable physiologic pattern commonly encountered in clinical practice.

The framework also demonstrated hierarchical prioritization behavior when multiple abnormal physiologic domains were present simultaneously. Rather than generating competing narratives for every abnormal value, the system attempted to identify the dominant clinically actionable signal while still acknowledging secondary findings. This approach reduced fragmentation and produced more coherent overall interpretations.

During iterative testing, the overall synthesis model also reduced several communication patterns commonly observed in analyte-centric reporting systems, including:

- disproportionate emphasis on low-risk isolated abnormalities
- failure to recognize clinically coherent multi-marker patterns
- internally conflicting reassurance and urgency statements
- excessive focus on statistical abnormality rather than physiologic significance

Overall, the framework generated narratives that more closely resembled clinician-style laboratory interpretation by emphasizing physiologic relationships, contextual weighting, and prioritized explanatory synthesis rather than isolated abnormality flagging alone.

Illustrative laboratory profiles

Case 1: Early metabolic dysfunction pattern

Representative laboratory profile:

- mildly elevated fasting glucose
- elevated triglycerides
- reduced HDL cholesterol
- mildly elevated alanine aminotransferase

Conventional laboratory reporting would typically display these abnormalities independently with limited contextual interpretation.¹ In contrast, the prototype framework generated an integrated narrative describing an early metabolic pattern associated with insulin resistance and possible hepatic metabolic stress.

The patient-facing output emphasized that the abnormalities appeared interconnected rather than isolated, while also clarifying that the findings did not necessarily indicate immediate danger or established advanced disease.

The corresponding follow-up recommendation emphasized routine clinical follow-up and lifestyle-focused risk reduction rather than urgent evaluation.

Case 2: Renal function abnormality

Representative laboratory profile:

- elevated serum creatinine
- reduced estimated glomerular filtration rate
- otherwise limited laboratory abnormalities

The framework generated a renal-focused contextual interpretation emphasizing decreased kidney filtration function and recommending prompt clinical review proportional to overall severity tier.

Unlike conventional isolated flagging of creatinine abnormalities alone, the output prioritized physiologic interpretation and overall urgency communication. Narrative generation was also structured to distinguish routine monitoring situations from findings potentially requiring more immediate medical evaluation.

Case 3: Mixed hepatic-metabolic pattern

Representative laboratory profile:

- elevated alanine aminotransferase

- elevated aspartate aminotransferase
- elevated triglycerides
- elevated body mass index

The framework interpreted this constellation as a likely interconnected metabolic-hepatic pattern rather than as isolated liver enzyme abnormalities alone. Generated outputs emphasized the possibility of metabolic-associated hepatic stress while avoiding unsupported diagnostic certainty.

Narratives also acknowledged reassuring findings when present in order to provide balanced interpretation rather than exclusively focusing on abnormalities.

Case 4: High-impact laboratory abnormality

Representative laboratory profile:

- markedly abnormal electrolyte value
- concurrent secondary laboratory abnormalities

In higher-severity laboratory presentations, the framework escalated urgency-oriented communication and generated outputs emphasizing the potential need for prompt medical attention. The narrative structure intentionally shifted from routine follow-up framing toward immediate clinical evaluation language while preserving concise and non-alarmist communication style.

This escalation behavior was intended to reduce the likelihood that potentially important abnormalities would be minimized within otherwise mixed laboratory profiles. Please see **Table 2**.

Table 2. Illustrative comparison of conventional laboratory reporting and contextual interpretation

Representative case	Conventional laboratory reporting	HealthRadar contextual interpretation
Early metabolic dysfunction pattern	Multiple isolated abnormalities displayed independently (mildly elevated fasting glucose, elevated triglycerides, reduced HDL cholesterol, mildly elevated ALT).	Integrated narrative describing an early metabolic pattern associated with insulin resistance and possible hepatic metabolic stress, with routine follow-up guidance.
Renal function abnormality	Elevated creatinine and reduced eGFR flagged individually with limited interpretation.	Renal-focused explanation emphasizing reduced kidney filtration function, severity-aligned assessment, and urgency-aligned follow-up recommendations.
Mixed hepatic-metabolic pattern	Elevated liver enzymes and metabolic abnormalities	Integrated interpretation emphasizing a likely

	reported separately without synthesis.	interconnected metabolic-hepatic pattern while avoiding unsupported diagnostic certainty.
High-impact laboratory abnormality	Critical laboratory abnormality displayed using visual flags and standard warning language.	Escalated urgency-oriented communication emphasizing prompt medical attention while maintaining concise and non-alarmist explanatory tone.
Predominantly reassuring profile with minor abnormalities	Minor abnormalities highlighted despite otherwise reassuring findings.	Balanced communication acknowledging reassuring overall findings while considering low-risk abnormalities appropriately.

Illustrative examples are representative conceptual scenarios used to demonstrate differences between isolated analyte-centric reporting and contextual patient-facing interpretation. Communication consistency observations

Iterative testing demonstrated that structured narrative generation reduced several common communication inconsistencies observed during early prototype development. Specifically, refinement efforts reduced instances in which:

- reassuring statements conflicted with urgency recommendations
- isolated abnormalities were overemphasized despite reassuring overall profiles
- physiologically related abnormalities were described independently without related synthesis
- outputs implied unsupported diagnostic certainty

The final prototype architecture consistently aligned explanatory tone, reassurance language, and follow-up recommendations with overall severity categorization.

Preliminary physician review observations

Physician review suggested that the patient-facing summaries were perceived as more clinically coherent than conventional analyte-centric laboratory reporting approaches. Reviewers noted that contextualized narratives more effectively highlighted clinically meaningful physiologic patterns while reducing fragmentation of interpretation.

Several reviewers also observed that the framework's emphasis on overall physiologic meaning more closely resembled clinician-style reasoning than traditional reference-range reporting structures.

Feedback additionally suggested that the communication structure may improve usability for non-clinician audiences by prioritizing urgency clarification and concise explanatory framing before more detailed laboratory discussion.

Prototype adaptability

The modular architecture demonstrated flexibility for expansion into additional biomarker domains and communication strategies. During development, iterative modifications were implemented without requiring redesign of the broader interpretive framework.

The architecture also supported multiple communication intensities, ranging from reassuring wellness-oriented summaries to narratives emphasizing potentially urgent laboratory abnormalities requiring prompt medical attention.

Discussion

The present work describes the conceptual development of a physician-informed, rules-based framework designed to generate contextual patient-facing interpretations of routine laboratory testing. The prototype demonstrated the ability to synthesize multiple laboratory biomarkers into coherent physiologic narratives while prioritizing urgency clarification, explanatory clarity, and internal consistency. Rather than functioning as a diagnostic engine, the framework was designed to approximate several core features of clinician-style laboratory interpretation: identifying meaningful patterns, distinguishing signal from noise, and aligning explanatory language with the overall significance of the laboratory profile.⁶

The rapid expansion of patient access to laboratory data has created an increasingly important communication challenge within modern healthcare systems. Conventional laboratory reporting reliably identifies analytes outside statistical reference ranges, but most reporting environments remain fundamentally data-centric rather than interpretation-centric. Laboratory portals are effective at displaying results. They are much less effective at helping patients understand which findings matter most, how abnormalities relate to one another, or whether the overall picture is reassuring, requires follow-up, or may warrant more urgent attention.

This distinction is clinically meaningful. Physicians rarely interpret laboratory findings as isolated deviations from reference ranges alone. Clinical reasoning more often involves synthesis of multiple signals into broader physiologic interpretations that account for severity, coherence, and clinical significance.⁶ Mild elevations in fasting glucose, triglycerides, hepatic transaminases, and waist circumference, for example, may collectively suggest evolving metabolic dysfunction despite the absence of dramatically abnormal individual values.¹⁰ Conversely, isolated minor abnormalities may be clinically unimportant when viewed within an otherwise reassuring laboratory profile. Conventional reporting systems frequently lack mechanisms to distinguish between these situations in a way that is both meaningful and accessible to patients.

The framework described in this manuscript was developed in part to address this gap between data presentation and interpretation. A central design objective was to shift emphasis away from isolated abnormality flagging and toward integrated physiologic explanation. This approach was intended to

better align automated laboratory communication with the way clinicians commonly interpret results during real-world patient encounters. **Figures 2 and 3** illustrate the difference between conventional analyte-centric presentation and the structured contextual interpretation approach described here.

Another major design objective was urgency clarification. Patients reviewing laboratory data are often trying to determine whether findings suggest immediate danger, routine follow-up needs, or a more substantial medical concern.^{3,11} Conventional laboratory interfaces frequently provide little direct assistance in answering that question.⁴ The framework therefore incorporated severity-aligned communication structures intended to clarify overall urgency before presenting more detailed explanatory information.

Importantly, the communication framework also emphasized reduction of unnecessary alarm. Patients now routinely encounter abnormal laboratory flags before speaking with a clinician, often without adequate context regarding whether findings are minor, expected, or potentially serious.¹² Early prototype feedback also suggested that many users seek not only interpretation of abnormal values, but broader understanding of what laboratory tests measure, how findings relate physiologically, and how urgency should be interpreted in context. The prototype attempted to address this problem through balanced language, contextual interpretation, and inclusion of reassuring findings when appropriate. Concise next-step guidance was similarly intended to reduce cognitive overload and improve usability for non-clinician audiences.

A less obvious but important design objective involved reduction of internally conflicting communication. During early prototype development, automated medical narratives could produce psychologically discordant outputs in which reassuring language, abnormal findings, and follow-up recommendations conveyed inconsistent levels of concern. Patients may interpret such mixed signals as uncertainty or hidden danger. The framework therefore incorporated contradiction-reduction strategies intended to align explanatory tone, urgency signaling, reassurance language, and recommended next steps into a coherent communication structure. This approach extended beyond simple text generation and functioned more as a severity-aware communication architecture designed to produce clinically and psychologically coherent narratives.

The prototype architecture also highlights several potential advantages of deterministic, rules-based interpretive systems within healthcare communication environments. Unlike less bounded approaches to automated medical explanation, a rules-based framework can offer greater transparency, auditability, and explainability. Narrative behavior can be reviewed by clinicians, tested against representative laboratory profiles, and refined to improve consistency without relying on open-ended conversational generation. These characteristics may be particularly valuable in patient-facing medical communication contexts, where interpretability, traceability, and constrained output behavior are important considerations.

Patient-facing laboratory interpretation also involves distinctive trust requirements. In this setting, the value of an automated communication system may depend not only on the accuracy of its outputs, but

also on whether its interpretive boundaries are understandable, its narrative behavior is reviewable, and its recommendations remain appropriately constrained.¹³ Structured interpretive frameworks may therefore offer practical advantages in sensitive healthcare communication environments where transparency, consistency, and clinician acceptance are important.¹⁴

The present work should also be interpreted within several important limitations. The framework remains an early-stage prototype and has not undergone formal prospective clinical validation. The observations described in this manuscript are primarily conceptual and qualitative rather than outcome-based. Formal studies evaluating patient comprehension, effects on health-related anxiety, clinical appropriateness, interobserver agreement, and real-world workflow integration have not yet been completed.

In addition, the prototype currently relies on structured laboratory inputs and limited background variables rather than comprehensive individualized clinical histories. Human clinical reasoning incorporates substantially broader information than laboratory data alone, including symptoms, medications, imaging findings, prior diagnoses, longitudinal trends, and social determinants of health. Consequently, the framework should not be interpreted as a substitute for physician evaluation or clinical judgment.

The rules-based architecture itself also imposes limitations. Although deterministic systems may improve interpretability and communication consistency, they may be less flexible in atypical or highly complex clinical scenarios.¹⁵ Severity categorization and contextual interpretation also depend on design assumptions that may evolve with additional clinical review, expansion of supported laboratory patterns, and prospective testing.

Despite these limitations, the present framework suggests that contextual patient-facing laboratory interpretation represents an important and underdeveloped area within digital health communication. As direct-access testing, remote monitoring, telehealth, and asynchronous care models continue to expand, the need for understandable, bounded, and clinically coherent laboratory communication is likely to increase.

Future directions

Future development of contextual laboratory interpretation systems may extend substantially beyond single-timepoint explanatory reporting. One important direction involves incorporation of longitudinal trend analysis and patient-specific baseline contextualization. Future interpretive architectures may therefore benefit from temporal pattern recognition, individualized baseline comparisons, and narrative synthesis of evolving physiologic trajectories.

Additional development may involve expansion of hierarchical physiologic prioritization strategies across broader biomarker domains and more complex multi-system laboratory profiles. Future frameworks may ultimately incorporate layered interpretive architectures that combine rules-based prioritization,

contextual weighting, and carefully constrained adaptive methods while maintaining clinician oversight and explainable outputs.

Another important direction involves prospective evaluation of patient comprehension, emotional response, and healthcare utilization effects associated with contextual laboratory interpretation. Although the present work focused primarily on conceptual framework development, future studies should examine whether integrated explanatory narratives improve patient understanding, reduce unnecessary anxiety associated with isolated abnormality reporting, or influence follow-up adherence and clinical workflow efficiency.

Broader integration opportunities may also emerge within telehealth, asynchronous care delivery, remote monitoring, and patient portal environments. As patients increasingly encounter laboratory information outside traditional face-to-face clinical interactions, the need for understandable, severity-aware explanatory communication is likely to grow. Future contextual interpretation systems may therefore function not as replacements for clinicians, but as structured communication layers intended to improve patient understanding while preserving appropriate clinical oversight and escalation pathways.

Conclusions

A physician-informed, rules-based framework for contextual patient-facing laboratory interpretation was developed and demonstrated the ability to generate integrated physiologic narratives aligned with overall laboratory significance and urgency. By emphasizing pattern synthesis, urgency clarification, and patient-centered communication principles, the framework sought to narrow the gap between conventional laboratory reporting and clinician-style interpretation. Although additional validation is required, structured contextual interpretation systems may represent a promising approach for improving patient understanding of laboratory testing within increasingly digital healthcare environments.

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Author contributions

Both authors contributed equally to the overall conception, drafting, reviewing, and revising of this manuscript.

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Conflicts of interest

The authors declare no competing interests

References

1. Giardina TD, Modi V, Parrish DE, et al.. The patient portal and abnormal test results: An exploratory study of patient experiences. *Patient Exp J*. Spring 2015;2(1):148-154.
2. Zhang Z, Citardi D, Xing A, et al. Patient Challenges and Needs in Comprehending Laboratory Test Results: Mixed Methods Study. *J Med Internet Res*. Dec 7 2020;22(12):e18725. doi:10.2196/18725
3. Steitz BD, Turer RW, Lin CT, et al. Perspectives of Patients About Immediate Access to Test Results Through an Online Patient Portal. *JAMA Netw Open*. Mar 1 2023;6(3):e233572. doi:10.1001/jamanetworkopen.2023.3572
4. Fraccaro P, Vigo M, Balatsoukas P, et al. Presentation of laboratory test results in patient portals: influence of interface design on risk interpretation and visual search behaviour. *BMC Med Inform Decis Mak*. Feb 12 2018;18(1):11. doi:10.1186/s12911-018-0589-7
5. van der Mee FAM, Schaper F, Jansen J, et al. Enhancing Patient Understanding of Laboratory Test Results: Systematic Review of Presentation Formats and Their Impact on Perception, Decision, Action, and Memory. *J Med Internet Res*. Aug 12 2024;26:e53993. doi:10.2196/53993
6. Torsvik T, Lillebo B, Hertzum M. How Do Experienced Physicians Access and Evaluate Laboratory Test Results for the Chronic Patient? A Qualitative Analysis. *Appl Clin Inform*. Apr 2018;9(2):403-410. doi:10.1055/s-0038-1653967
7. Lustria MLA, Aliche O, Killian MO, et al. Enhancing patient engagement and understanding: is providing direct access to laboratory results through patient portals adequate? *JAMIA Open*. Apr 2025;8(2):oaf009. doi:10.1093/jamiaopen/oaf009
8. Cadamuro J, Cabitza F, Debeljak Z, et al. Potentials and pitfalls of ChatGPT and natural-language artificial intelligence models for the understanding of laboratory medicine test results. An assessment by the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Working Group on Artificial Intelligence (WG-AI). *Clin Chem Lab Med*. Jun 27 2023;61(7):1158-1166. doi:10.1515/cclm-2023-0355
9. Ojeda Meixueiro VH, Perez-Campos Mayoral L, Hernandez Huerta MT, et al. Relevance of a Customized Version of ChatGPT Explaining Laboratory Test Results in Patient Education. *J Med Educ Curric Dev*. Jan-Dec 2024;11:23821205241260239. doi:10.1177/23821205241260239
10. Habibullah M, Jemmieh K, Ouda A, et al. Metabolic-associated fatty liver disease: a selective review of pathogenesis, diagnostic approaches, and therapeutic strategies. *Front Med (Lausanne)*. 2024;11:1291501. doi:10.3389/fmed.2024.1291501
11. Scherer AM, Witteman HO, Solomon J, et al. Improving the Understanding of Test Results by Substituting (Not Adding) Goal Ranges: Web-Based Between-Subjects Experiment. *J Med Internet Res*. Oct 19 2018;20(10):e11027. doi:10.2196/11027
12. Zikmund-Fisher BJ, Scherer AM, et al. Effect of Harm Anchors in Visual Displays of Test Results on Patient Perceptions of Urgency About Near-Normal Values: Experimental Study. *J Med Internet Res*. Mar 26 2018;20(3):e98. doi:10.2196/jmir.8889
13. Wong KKL, Han Y, Cai Y, et al. From Trust in Automation to Trust in AI in Healthcare: A 30-Year Longitudinal Review and an Interdisciplinary Framework. *Bioengineering (Basel)*. Oct 1 2025;12(10):doi:10.3390/bioengineering12101070
14. Pillay TS. Increasing the Impact and Value of Laboratory Medicine Through Effective and AI-Assisted Communication. *EJIFCC*. Mar 2025;36(1):12-25.

15. Thayer JG, Franklin A, Miller JM, et al. A scoping review of rule-based clinical decision support malfunctions. *J Am Med Inform Assoc.* Oct 1 2024;31(10):2405-2413.
doi:10.1093/jamia/ocae187

Tables and Figures

Table 1. Core design principles of the HealthRadar framework

Table 2. Illustrative comparison of conventional laboratory reporting and contextual interpretation

Figure 1. HealthRadar conceptual workflow for contextual laboratory interpretation

Figure 2. Illustrative comparison between conventional analyte-centric laboratory reporting and contextual patient-facing interpretation.

Figure 3. Representative side-by-side comparison of conventional laboratory reporting and HealthRadar-generated patient interpretation using the same synthetic laboratory profile.