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# Toward Laboratory Notification in Pediatric Emergency Departments

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**Abstract.** This study explores how patient's laboratory result are accessed in pediatric emergency departments. The rapid turnaround of laboratory results and their timely access by the medical team are crucial for effective patient management and care decision-making. This study revealed a systematic access prioritization to the Electronic Health Record, led by physicians, followed by nurses, and then other healthcare staff. Despite efforts to streamline access through computerized laboratory results, optimized laboratory turnaround time and integration of final results into the electronic health record remain key challenges. Delays in accessing analysis results issued by the central hospital laboratory are consistently experienced across various laboratory types, indicating broader systemic workflow issues rather than inefficiencies specific to individual laboratories.

**Keywords.** notification, clinical laboratory information systems, laboratory results, laboratory turnaround time, emergency department

## 1. Introduction

The delayed turnaround of laboratory results without direct notification to caregivers can potentially pose a critical patient safety concern in emergency departments (EDs). Timely access to laboratory results is crucial for accurate diagnosis and prompt initiation of appropriate treatment, especially in emergency situations where time is of essence. Furthermore, prolonged ED length of stay due to delayed consideration of laboratory results can contribute to overcrowding and increased workload for healthcare staff [1]. This can induce delays in patient care, compromised patient flow, and heightened stress levels among both patients and healthcare providers. Additionally, the lack of direct notification for abnormal test results can lead to communication gaps between healthcare providers, potentially resulting in missed opportunities for timely intervention or follow-up care. Although indirect notification are visible on screens within equipped EDs (e.g., TVs mounted on walls displaying each patient's laboratory results availability)

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, the transition from “waiting for results” to “results available” could be missed amidst complex interfaces, which is cluttered with various other pieces of patient-related information. Previous studies have shown that missed test results, particularly in ED settings, can significantly jeopardize patient care [2]. Emergency physicians have expressed concerns regarding directly notifying abnormal test results, citing potential patient anxiety, confusion, and lack of expertise to interpret results as primary concerns [3]. Furthermore, the implementation of expedited laboratory procedures and real-time notification systems has demonstrated a significant reduction in delays in diagnosing and isolating patients [4, 5]. These findings underscore the necessity for enhanced notification processes to address the emergency turnaround issue related to delayed laboratory results reading.

The aim of this study was threefold: (1) to identify the current laboratory workflow and turnaround time for laboratory results in a tertiary hospital, (2) to comprehend and quantify the various time intervals associated with laboratory notification for efficient decision-making by the clinical team, and (3) to offer insights for future notification process. The findings of this study informed the development of a smartphone mobile app designed to notify the clinical team promptly about laboratory results, with the ultimate goal of improving emergency turnaround time and ensuring timely patient care [6].

## 2. Methods

In the initial research phase, we meticulously mapped the patient onboarding sequence from ED triage to discharge or hospital admission, for a total of 4,711 unique patients. This mapping was informed by interviews with two clinicians from the pediatric ED to ensure accuracy. We then shifted focus to analyzing the result reading workflow using a time-based analytical approach with pandas (v2.2.2). By examining time-stamped data across different stages of the laboratory process, we identified variations in processing times and pinpointed stages with notable delays, particularly in result analysis and interpretation. To assess delays in accessing laboratory results, we used descriptive statistics via scipy (v1.13.0), and Pearson’s correlation, considering patient motives and urgency levels. This approach shed light on specific areas requiring further investigation, providing a quantitative basis for proposing targeted interventions to streamline information flow. Our comprehensive methodology aimed to dissect the complexities of laboratory workflows, yielding evidence-based future recommendations to enhance the notification process and ensure timely patient care delivery.

## 3. Results

Table 1 illustrates a concise overview of the key stages in the patient onboarding process within the institutional Electronic Health Record (EHR) and laboratory turnaround time, with each stage’s timestamp recorded.

Our analysis focused on laboratory analyses conducted in-house at the hospital, specifically targeting those with results available within a 24-hour timeframe. Analyses such as bacterial cultures or serology, which require multiple days for processing or outsourced to external laboratories, were excluded from our study. We operated under the

**Table 1.** Patient Journey at the ED and Laboratory Turnaround

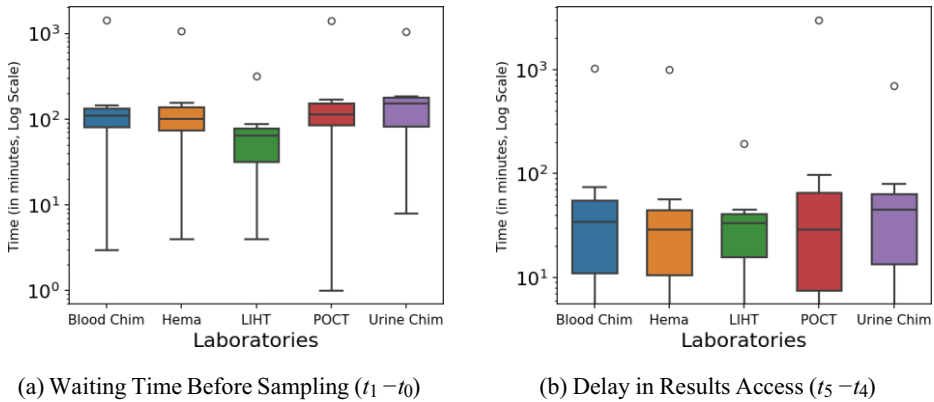
Time	Description
$t_0$	Patient triage upon ED arrival and enrollment in EHR system
$t_1$	Patient assessment and specimen collection
$t_2$	Receipt at laboratory and specimen processing
$t_3$	Start of analysis (e.g., microscopy, chemical assays, molecular testing, etc)
$t_4$	Results reported into the EHR system (manually or automatically)
$t_5$	Results reviewed and interpreted by caregivers
$t_6$	Clinical action based on the interpreted results
$t_7$	Laboratory results and any associated clinical actions are documented in the patient's EHR for future reference and continuity of care

assumption that the results of these longer analyses, while informative, were not relevant for immediate care during the patient's ED visit. Therefore, delays in notifying these results were presumed to not adversely affect the medical care provided by the caregivers. Our analysis centered on the laboratory outlined in Table 2.

We extracted 12 months of logs of laboratory analysis requests, spanning from February 2023 to January 2024, from the hospital data lake. This data lake serves as a centralized repository for ingesting, storing, and processing large volumes of data in its original form. This period includes patients who arrived before the first month of the study and departed after the last month, as their analysis were requested during the study period. We collected event times:  $t_{0..7}$  (Table 1), laboratory labels, role of the medical staff responsible for reading the analysis results (e.g., physician, nurse, medico-technical staff, medical students, and administrative clerks), urgency levels, reasons for visit, and patient IDs. Our dataset comprised 17,212 samples from December 2022 to February 2024, involving 4,711 unique patients. Figure 1a illustrates the patient waiting time before the sample was taken (i.e., for their first analysis after arriving at the ED). Mean waiting time before sampling ( $t_1 - t_0$ ) was 2 hours, 8 minutes, and 23 seconds, with a standard deviation of 1 hour, 47 minutes, and 50 seconds. The minimum waiting time was 1 minute, suggesting instances of immediate attention in urgent cases (e.g., POCT use). The quartile distribution further elucidated the range of waiting times, with the first quartile at 1 hour and 4 minutes, the median at 1 hour and 44 minutes, and the third quartile extending to 2 hours and 42 minutes. The maximum waiting time reached 23 hours and 44 minutes, highlighting extreme cases possibly influenced by operational bottlenecks or prioritization of more critical emergencies.

**Table 2.** Detailed Laboratory Analysis Categories and Descriptions

Analysis Category	Description
POCT	Point of Care Testing: Immediate testing at or near the site of patient care to facilitate quick clinical decisions.
HEMA	Hematology: Analysis of blood and its components to diagnose conditions such as anemia and clotting disorders.
Blood chemistry	Tests for chemical components in the blood to evaluate organ function.
Urine chemistry	Chemical analysis of urine to detect and diagnose urinary tract and kidney disorders, as well as metabolic diseases like diabetes.
LIHT	Laboratory of immunohematology and transfusion: Specializes in immunohematology and transfusion, focusing on blood typing, compatibility testing, and preparation of blood and blood components for transfusion.



**Figure 1.** Analysis of Patient Waiting Time and Delay in Results Access

Our findings delineated a consistent pattern in the order of result review (Table 1  $t_5$ ), with physicians being the first recipients (62.33%), followed closely by nurses (34.49%), and subsequently, other healthcare staff (3.18%). A notable aspect of our analysis focused on the streaming nature of laboratory result reporting. Specifically, results are dispatched sequentially as individual tests are completed, rather than waiting the conclusion of all tests associated with a given sample. Our study confirms that this practice of result streaming is common across all examined laboratory types. Additionally, our analysis revealed that approximately 9.75 of laboratory analyses were only reviewed after patient discharge. However, as illustrated in Figure 1b, the temporal dynamics of result access by the clinical team did not exhibit a significant correlation with the specific laboratory type (correlation coefficient  $r(\text{amount of sample})$ ,  $r(15528) = .03$ ,  $p < .05$ ). This absence of correlation extends to the relationship between the delay in result access and the patients' reasons for ED visit, ( $r(15528) = .04$ ,  $p < .001$ ), as well as between result access urgency and the patients' clinical urgency level, ( $r(15528) = -.05$ ,  $p < .001$ ).

#### 4. Discussion

This study shed light on the operational dynamics of clinical teams and laboratory processing. The main finding was that physicians were the first to review laboratory results, followed by nurses and other healthcare professionals. This hierarchy in result access reflects a structured approach to patient care, with physicians leading the initial interpretation of laboratory results and treatment decisions, while being supported by nurses and other care team members. This prioritization emphasizes the pivotal role of physicians in the early stages of patient assessment and treatment decision-making. Our study highlighted the practice of streaming laboratory results, where outcomes for different tests from the same sample are reported as they become available, rather than waiting for all tests to be completed. This approach ensures timely delivery of critical data reach the medical staff, potentially expediting decision-making processes even before the completion of all laboratory analyses. Despite the widespread use of result

streaming across all laboratory types examined, no significant correlation between the timeliness of laboratory processing and subsequent result access was found. Interestingly, a substantial portion of analyses were reviewed only after patient had been discharged home. However, this delay in result access did not seem to impact immediate clinical decisions or patient outcomes. We also observed visual indicators on an LCD screen in the medical situation room, signaling the availability of laboratory results to all caregivers, albeit without detailed values. This hints at the potential for technological advancements to improve result dissemination in a more personalized manner, possibly through smartphones. Nevertheless, the absence of smartphones among non-physician staff in the ED and reliance on individual account IDs for result access through the EHR may lead to delays in information sharing within the care team. Our study specifically examined laboratory result access within a single pediatric ED. While our findings offer valuable insights into the workflow and access prioritization in this setting, further research is necessary to determine if these results can be generalized to other EDs. Given that most EDs also use EHRs for patient management, it is reasonable to expect they might face similar challenges in laboratory result access and prioritization. Thus, while our findings are based on a pediatric ED, they likely have broader implications for emergency care settings using EHR systems.

## 5. Conclusions

This study underscores consistent delays in reading laboratory results across various analysis types, indicating a universal challenge in ED settings. Systemic factors within the ED workflow, rather than specific operational dynamics, influence result access timing. Future investigations will benefit from examining the integration of notification apps with existing healthcare systems to optimize the efficiency of result dissemination and improve patient care outcomes.

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