

Conception and Development of a Targeted Alert System : Multisystem Considerations

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Abstract. Alerting systems have a strong potential to improve quality of care in hospital by ensuring that clinicians provide more effective and timely care to their patients. Many systems have been implemented but often fail to unleash their full potential due to the problem of alert fatigue. As an attempt to reduce this fatigue we have developed a targeted alerting system ensuring only the concerned clinicians receives the alerts. The conception of the system went through several steps going from the identification of the requirement, the prototyping and implementation into several systems. The results present the different parameters taken into consideration and developed frontends. We finally discuss the important considerations of alerting system, such as the necessity of a governance. The system still needs a formal evaluation to validate that it responds to its promises before being deployed more largely.

Keywords. Alert, Alarm fatigue; Alarm safety, Clinical decision support system, mobile

1. Introduction

Medical alert is a clinical decision support systems that has raise increasing interest in recent years. By helping clinicians provide more targeted and timely care to their patients it improves quality of care. Alert systems can be used to automatically detect and alert clinicians about abnormal laboratory test results, for example, allowing the clinician to react before the patient's condition deteriorates. Medical alerts have the potential to improve patient outcomes by providing clinicians with timely and relevant notifications about their patients' health [1]. For instance, an alert system may also be used to detect a decrease in a patient's blood pressure, alerting the clinician so that they can take immediate action to prevent any further decline. Similarly, an alert system may be used to detect a high level of creatinine in a patient's blood, alerting the clinician to change management plans (e.g., change medications if needed or increase hydration) to avoid further kidney damage [2].

Despite the potential benefits of medical alert systems, there are several barriers that limit their deployment in healthcare. The most significant barrier is that clinicians are often overwhelmed with the sheer number of alerts they receive, which can lead to alert fatigue. This is caused by the fact that traditional alert systems are often configured to produce alerts without targeting a specific user, resulting in many alerts for everyone.

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Many of these alerts may be irrelevant to most receivers, and lead to a lower responsiveness to alerts overall. In addition, many alert systems are binary (e.g., a result has arrived in the system) but may not have nuances to allow for distinctions between very abnormal findings, somewhat abnormal findings and normal findings. Lastly, many alert systems lack the ability to customize the content of the alert message, making it difficult for the clinician to quickly identify the most urgent matter [3]. In order to effectively address these barriers, a new medical alert system trigger has been developed in our hospital, which in its pilot version is specifically designed to detect and alert clinicians of abnormal laboratory test results. This system is designed to be highly customizable and to consider the specificity of each care unit. It is also designed to reduce alert fatigue by only sending alerts to the clinician in charge when the results of the laboratory tests are above or under a given threshold. Furthermore, the alert message is designed to be concise and easy to read, so that the clinician can quickly identify the most important information.

The purpose of this article is to present the design of a new medical alert system, which is triggered by abnormal laboratory test results. The system is designed to be highly customizable and tailored to target specific members of the patient's medical team.

2. Methodology

To design the alerting system, we went through the following steps: Identification of the goal of the medical alert system, identification of the stakeholders, conduct of a business analysis of the medical alert system. This analysis included the identification of the user needs, the system objectives, the operational requirements, the required features, the system design and the implementation plan. We developed a system design based on business analysis including consideration of the system architecture, the user interface, the data architecture, the security measures and the system integration. We developed a prototype of the system to test the system design and to identify any potential problems or issues. Then we developed a testing plan to test the system and to ensure that it fulfills the requirements of the medical alert system. Finally, we implemented the system once the system design and the testing plan were developed and approved.

3. Results

The goal of the medical alert system is to provide timely and accurate alerts to the clinician in charge of a patient. The stakeholders of the medical alert system include the healthcare professionals (doctor and nurse team), the IT professionals and the software developers.

During the business analysis, we began by identifying all the parameters and attributes that needed to be considered for each alert. These are presented in Table 1. Attributes of the alerts included the level of urgency of the alert (low, medium, high), the need for a recall and the targeted receiver(s). The level of urgency of the alert defines the communication method for the alert: low urgency alerts can wait for the user to open the patient's chart, for example, whereas high urgency alerts need to reach the receiver even when they are not using a computer, such as a smartphone notification. Parameters to define were the thresholds for each laboratory result, for each level of urgency. Other considerations include the text in the alert, its duration of validity (which may be longer

in ambulatory care, and shorter during a hospital stay for example). For alerts with recalls, we also needed to define whether it was a duration of alert or a specific action that would turn the alert and its recalls off.

Table 1. parameter considered for the parametrization of the alerts

Alert parameter	Description	Possible values
Name	Name of the alert	Free text
Description	Description of the alert	Free text
Category	Category of the alert	Clinical / admin / pathways
Urgency	Urgency of the alert	Low / medium / high
Color	Color of the alert	Grey, Yellow, Red
Trigger	What triggers the alert	Threshold
Termination	What switches the alert from active to inactive?	Prescription of anti-Xa HNF activity for heparin alert
Mobile	Is the alert displayed on mobile device	True/false
Displayed information	Information to interpret the result	Free text
Display duration	Duration of display of the alert	Number
Authorized people	Authorized people to handle the alert	Identities of the active directory
Targeted people		Clinician /nurses / ...
	Unit receiving the alert	Unit

The desired process was mapped using business process modeling notation (BPMN) to ensure that all the possibilities were considered. At the start of the shift, doctors identify which patients they will manage (in-patients); for out-patients, the consultation calendar defines the doctor in charge. For this paper, we will focus on in-patients with lab results.

The arrival of a laboratory result triggers the alert: it appears in the medical chart for low urgencies, whereas for urgent, critical results, the doctor is also notified directly on the Bedside app. In specific cases of high risk, the alert is designed with a recall system, if a certain action is not performed. In the case of highly overdosed heparin, it is the prescription of the next anti-Xa activity lab that switches the system off: in our system, each change of dose of heparin (except for the stop) is accompanied by the prescription of the monitoring anti-Xa lab. If no lab is prescribed after an hour, the recall system kicks in, and even alerts the supervising physician, to help ensure that the overdosed heparin is addressed.

In order to make this process actionable, the system is composed of four components that must work altogether. First a rule-based engine, developed with Java Springboot, that can be parametrized, responsible to trigger Kafka event will be consumed in several endpoints; a mobile application, developed in angular, enabling doctor to identify their patients and that receive push notifications; an alert panel in the EHR summarizing the alerts, and finally a header highlighting the most important information. All communications between the components are done using Kafka messages as well as through API structured following FHIR data model.

3.1. The EHR header

All notifications for a given patient are visible in the header of the EHR. The color of the number indicates the highest degree of urgency for a given category of alerts, whereas the number represents the total number of notifications for the patient. In this example we see three categories of alerts, the first of which is the current alerts (left), with at least one important (yellow) alert. The second category indicates that the patient

is in a clinical pathway with one information alert (not urgent, grey). Finally, the third category indicates an urgent administrative alert (e.g., no insurance coverage).



Figure 1. Header displayed on the EHR

3.2. The EHR alert panel

A panel has been developed in our EHR to gather all alerts for a given patient in one place. It opens when the header is clicked, and shows all alerts, sorted by degree of urgency (which is also color-coded). In this panel, users can view the alerts, but also indicate when the alert is addressed: in this case, the alert is moved to the history of sections alerts, at the bottom of the panel. This history is designed for all the times users click “too quickly” on an alert to close it and did not take time to read it!

3.3. The Bedside mobility app

The development of a mobile application was a prerequisite for the good functioning of the system and is the communication channel for targeted urgent alerts. It allows the doctors to define the patients they will manage during their shift, and presents the alerts, which can be seen by clicking on the patient. In this view, the user can choose to hide the alert or not. As mentioned above, alerts can all be found in the EHR panel of the patient’s chart.

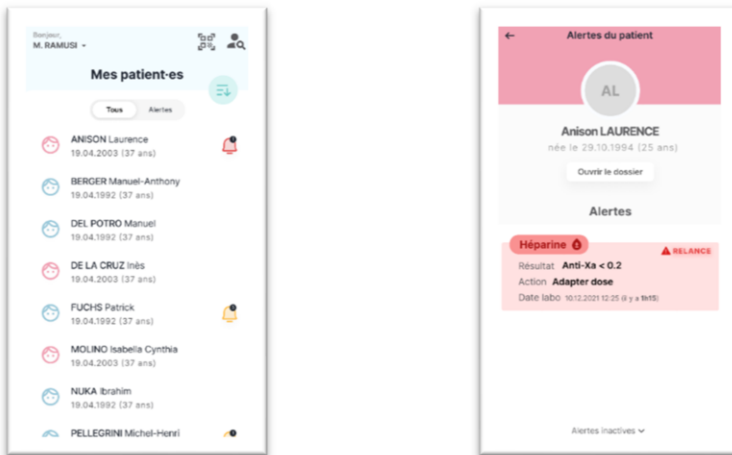


Figure 2. On the left, screen for the doctor to select the patients managed during a shift. On the right, display of an urgent alert (red) about a lab result (blood drop icon)

4. Discussion

Governance for alerts at an institutional level is required to maintain coherence in the system. Closely related alerts (e.g., for different laboratory results) can share many processes, thereby facilitating their implementation. In this case, it is more about getting

the different medical specialties to agree on common thresholds for the institution, or to define division-level thresholds. Governance may need to intervene to reach this consensus [4]. There are often several thresholds to define: besides the upper (and/or lower) threshold of normality, there may also be a threshold for critical values. This exists in the HL7 codes for laboratory results (OBX-8).

However, when individual alerts require specific processes (e.g., recall system for anti-Xa activity for heparin), additional developments are required. In these cases, besides validating the need for these specificities, the governance also defines the priority of the developments. It also has a role in the choice of the solution, which should be the most generalizable for other future alerts, besides addressing safety issues.

Alert fatigue in healthcare is a growing problem which is caused by many alerts being generated in the healthcare system. These alerts are often not targeted, and clinicians are bombarded by a high volume of alerts, leading to alert fatigue. Alert fatigue is a state in which clinicians become desensitized to alerts, leading to them missing important alerts or ignoring them altogether [5]. This can have dangerous consequences, as important alerts could be missed and lead to patient harm. Reducing alert fatigue in healthcare is an important issue that needs to be addressed in order to ensure patient safety. In our project, the identification of the clinician in charge is a key factor to ensure that the right person receives the relevant information at the right time.

5. Conclusion

Alert systems have a strong potential to improve care by ensuring that clinicians provide more targeted and timely care to their patients. One of the strong barriers to these systems are the fatigue induced by alerts. As an attempt to respond to this challenge, we designed a system with several urgency levels and subsequent communication channels, targeting the clinician in charge with messages to help prioritize tasks. Its adoption as well as efficiency must still be evaluated in practice. The pilot system for laboratory results will be generalized to other types of information (e.g., vital signs, administrative data, or clinical itineraries) in the future development of the alert system.

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