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Considering Work Systems and Processes in Assessing the Impact of a CDSS Intervention: Preliminary Results

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Abstract. The DetecIP project aims to implement multifactorial dynamic rules within a computerized decision support system (CDSS) for pharmaceutical analysis of orders to reduce the rate and severity of iatrogenic hyperkalemia and acute kidney injury. However, understanding the impact of this intervention (if any) requires that the way in which it influences the work systems and processes also be studied. This study presents the preliminary results of the analysis of the work contexts in which these rules will be implemented. A series of semi-structured interviews exploring the dimensions of the systems engineering initiative for patient safety (SEIPS) were conducted with healthcare professionals involved in the prevention and management of iatrogenic risks in five hospital units. Data were analyzed to identify current barriers and facilitators to the prevention and management of iatrogenic risks. Preliminary results from a geriatric unit and a cardiology unit reveal that, despite overall similarities in work processes, differences in the availability and location of physicians and clinical pharmacists influence how iatrogenic risks are managed. These contextual differences could influence the impact of the new CDSS rules once implemented.

Keywords. decision support systems, ergonomics, evaluation, system engineering

1. Introduction

Drug-induced (i.e., iatrogenic) hyperkaliemia and acute kidney injury (AKI) are frequent and represent a serious event in the poly-medicated elderly inpatient population [1,2]. Pharmaceutical analysis of orders by clinical pharmacists and the resulting pharmaceutical interventions represent an opportunity to identify drugs at iatrogenic risk and to propose either less risky therapeutic alternatives or actions to monitor iatrogenicity (e.g., blood analysis). Clinical pharmacists use computerized decision support systems (CDSS) to facilitate pharmaceutical analysis of orders and to identify unnoticed prescription errors [3,4]. These CDSSs automatically review medication lists for risks by comparing them to a set of knowledge rules. Hyperkalemia and AKI are essentially

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multifactorial (e.g., disease, age) with drug involvement [1,2]. Thus, it is necessary that these rules retrieve and take into account data of different natures from patient records. Yet, CDSS rules combining different types of factors have received little attention so far. The DetectIP project aims at developing multifactorial dynamic rules and implementing them within CDSSs for pharmaceutical analysis by hospital clinical pharmacists to decrease the iatrogenic risks of hyperkalemia and AKI in inpatients older than 65 years.

From a system engineering perspective, the outcome of implementing a new technology is not direct nor linear. It is mediated not only by the way it is used (if it is used at all) but also by its interactions with the other components of the work system in which it is implemented [5]. Yet research on the implementation of technology seldom considers the complexity of the work system in which they are intended to operate limiting the understanding of how the technology impacts and is impacted by other components of the work system [6,7]. Consequently, those interventions miss the system-level effect of the technology that in turn affects the success of the implementation. In short, ignoring how the implementation changes the work system prevents understanding the root causes of observed outcomes, generalizing them, and ultimately transferring implementation to other settings.

The DetectIP project evaluates the impact of the developed rules in five academic hospitals not only on the rates and severity of iatrogenic hyperkalemia and AKI events but also on the work systems and processes. For this purpose, DetectIP is organized into two phases: (1) analyzing work systems and processes before the implementation of the rules, (2) identifying the clinical impact of the implementation, the changes in the work systems and processes it caused along with the way the intervention has been changed by the work system. This paper reports some preliminary results of the first phase.

2. Methods

In each hospital participating in DetectIP, a clinical ward was selected whose data on the occurrence of hyperkalemia and AKI would be compared before and after the introduction of the new CDSS rules. The services were selected to vary the specialties as much as possible while ensuring that they accommodate patients older than 65 years.

Semi-structured interviews were conducted with representatives of professionals involved in the prevention and management of hyperkalemia and AKI: physicians (senior and resident), nurses, clinical pharmacists, medical biologists, with the possibility of other profiles being added if they were identified during the analysis. Interviews were conducted individually or with a group of representatives of the same profile, depending on their availability. The interview guide investigated the components of the work systems and processes as described by the systems engineering initiative for patient safety (SEIPS 2.0 [5]): persons, tasks, technology and tools used to perform them, internal environments where they are performed, work organization, external environment (e.g., policies), and the interaction between those elements. Interviews were recorded and transcribed.

Transcripts were analyzed by two researchers in ergonomics. In each unit, for each profile, the components of the work system were listed as well as their characteristics. The way in which these elements interact to give rise to the work process was also extracted in a narrative manner. The data were then merged for a given unit so that the entire processes of preventing and managing hyperkalemia and AKI could be described and current barriers and facilitators to AKI and hyperkaliemia prevention and management could be identified. Results are presented under the form of People Environment Tasks and Tools (PETT) scans [8].

3. Results

The study is still in progress: 27 interviews (average duration = 34min54s) were conducted with 35 professionals (10 senior physicians, 7 residents, 5 clinical pharmacists, 10 nurses and 4 medical biologists) from the five included wards. We present the results in two wards where data collection and analysis were completed.

Amiens hospital ward is a 22-bed cardiology unit where patients are often managed for heart failure whose treatments influence kaliemia and renal function. Therefore, clinicians monitor them on a daily basis. The department at the Kremlin-Bicêtre hospital is a 24-bed geriatric unit where patients are poly-medicated and often suffer from renal failure. Lab tests are usually performed every other day. Tables 1 and 2 present main identified barriers and facilitators to prevention and management of iatrogenic risks.

Table 1. PETT scan for Amiens' hospital cardiology ward listing main facilitators to and barriers against iatrogenic AKI/hyperkaliemia prevention or management.

	Facilitators	Barriers
People (Physicians, residents, nurses, biologists, pharmacists)	Professionals know in person and trust the pharmacist. The ward pharmacist knows the ward's constrains and habits and adapts her intervention. Medical biologists call nurses in case of severe abnormal results.	The pharmacist is in the ward 2 days a week; when off duty, clinicians do not accept messages from outside-the-unit pharmacists. Iatrogenic cut-offs differ between physicians and residents. Residents are on the front line of prescription.
Tools (Electronic health record (EHR), online medication knowledge base, pharmacist CDSS, telephone)	EHR gathers the needed information. Pharmacist always puts a note in the EHR in case of iatrogenic risk. Residents use medication knowledge bases to check dosages and interaction. Physicians and pharmacists are always reachable by phone.	EHR does not alert about new/abnormal results for patient. Pharmacist does not use the CDSS because she already knows well the rules.
Tasks (Transmission, medical round, counter-visit, debriefing, pharmaceutical analysis, lab analysis)	Physicians and residents try to optimize the order. Nurses inform residents of changes in lab results and seek their input before administering any medications that may affect kaliemia/AKI to affected patients. Physicians conduct rounds with residents thrice a week; on other days, debriefs or counter-visits are organized. Physicians/residents tell nurses of order changes. When outside the unit, physicians remotely check orders and lab results and call residents if necessary. The pharmacist performs a pharmaceutical analysis, put an note in the EHR and discuss it with residents.	If changes are not communicated and explained to nurses, they may backtrack thinking it was a mistake.
Environment (Offices, patient's room, corridor)	Residents share their office with the pharmacist: she can intervene face-to-face and hear about patients' condition.	Clinical staff is often interrupted. Physicians' offices are off the ward.

Table 2. PETT scan for Kremlin-Bicêtre hospital geriatrics ward listing main facilitators to and barriers against iatrogenic AKI/hyperkaliemia prevention or management.

	Facilitators	Barriers
People (Physicians, residents, nurses, biologists, pharmacists)	Medical biologists call nurses in case of severe abnormal results (not AKI).	The pharmacist works part time. High turnover rate: unexperienced/temp nurses do not know the unit's habits. Nurses are not trained to identify AKI. Physicians seldom call the pharmacists about iatrogenic.
Tools (EHR, online medication knowledge base, pharmacist CDSS, telephone)	EHR gathers the needed information. Residents use medication knowledge bases to check dosages and interaction. Physicians access the EHR and can prescribe from home. Nurses text physicians to inform them and ask them questions. At least one physician is always reachable.	EHR does not alert about results. It does not alert nurses of order changes. Pharmacist's interface makes pharmaceutical analysis difficult. Pharmacist does not use the CDSS because of usability/usefulness issues. Pharmaceutical interventions notes are not visible in the EHR. Nurses seldom carry their phone with them, leading to missing medical biologists' calls.
Tasks (Transmission, medical round, debriefing, pharmaceutical analysis, lab analysis)	Physicians and residents try to optimize the order. Residents organize the round based on lab results. Nurses inform residents of significant changes in lab results and seek their input before administering to affected patients any medications that may affect kaliemia/AKI. Nurses question odd prescriptions and monitor lab results (mainly kaliemia). Physicians conduct rounds with residents twice a week. On other days, residents debrief with the physicians. Physicians/residents tell nurses about order changes for immediate action. Physicians remotely check lab results and prescriptions and call residents if necessary. The pharmacist performs a pharmaceutical analysis for key patients, put a note in the EHR and calls physicians if they do not respond it within one day.	Debriefing does not allow for questioning the prescription as much as the round with the physician.
Environment (Offices, patient's room, corridor)	Residents and physicians' offices are next to each other in the unit. Making the round in the corridor facilitates communication with nurses.	Clinical staff is often interrupted. The pharmacist is not in the ward: only experienced staff know her.

4. Discussion

Prevention and management of iatrogenic risks operate broadly in the same way in both units. People compare the lab test results with the medication list to optimize it and manage the iatrogenic risk. Pharmacists perform pharmaceutical analyses of orders relatively similarly without using the pharmacist CDSS. In both wards, a series of organizational, technical, and human elements facilitate the risk management.

Nevertheless, differences exist. In the cardiology unit, because physicians' offices are off the ward, residents, pharmacists, and nurses form a team that manages iatrogenic risk relatively autonomously under the direction of the residents but nevertheless under the active control of physicians. Residents share their office with the pharmacist which facilitates their cooperation. In the geriatric unit, physicians work in contact with residents, leaving them less autonomy, but the pharmacist is outside the ward, which hinders their cooperation. Local processes induce different modes of pharmaceutical interventions: mainly by face-to-face supplemented by EHR in cardiology, by EHR/telephone in geriatrics. Yet, literature has shown that the location of the clinical pharmacists and the way they deliver their interventions impact the number of interventions and their acceptance [9]. Therefore, implementing new rules in the pharmacist CDSS will likely not have the same effect in cardiology and geriatrics units.

The next step of the DetectIP project is to introduce new multifactorial dynamic rules in the pharmacist CDSS. We will investigate their influence on the work systems and processes to understand their impact (if any) on the hyperkalemia and AKI rates.

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