# Automated acute kidney injury alerts

Kianoush B. Kashani[1,2]

[1]Division of Pulmonary and Critical Care Medicine, Mayo Clinic, Rochester, Minnesota, USA; and [2]Division of Nephrology and Hypertension, Mayo Clinic, Rochester, Minnesota, USA

**Acute kidney injury (AKI) is one of the most common and probably one of the more consequential complications of critical illnesses. Recent information indicates that it is at least partially preventable; however, progress in its prevention, management, and treatment has been hindered by the scarcity of knowledge for effective interventions, inconsistencies in clinical practices, late identification of patients at risk for or with AKI, and limitations of access to best practices for prevention and management of AKI. Growing use of electronic health records has provided a platform for computer science to engage in data mining and processing, not only for early detection of AKI but also for the development of risk-stratification strategies and computer clinical decision–support (CDS) systems. Despite promising perspectives, the literature regarding the impact of AKI electronic alerts and CDS systems has been conflicting. Some studies have reported improvement in care processes and patient outcomes, whereas others have shown no effect on clinical outcomes and yet demonstrated an increase in the use of resources. These discrepancies are thought to be due to multiple factors that may be related to technology, human factors, modes of delivery of information to clinical providers, and level of expectations regarding the impact on patient outcomes. This review appraises the current body of knowledge and provides some outlines regarding research into and clinical aspects of CDS systems for AKI.**

*Kidney International* (2018) ■, ■–■; https://doi.org/10.1016/j.kint.2018.02.014

KEYWORDS: acute kidney injury; clinical decision support; e-alert; electronic alerts; electronic health records; sniffer



**Correspondence:** *Kianoush B. Kashani, Division of Nephrology and Hypertension, Mayo Clinic, 200 First Street SW, Rochester, Minnesota 55905, USA. E-mail: kashani.kianoush@mayo.edu*

**Received 3 January 2018; revised 2 February 2018; accepted 6 February 2018**

With increased awareness regarding the importance of acute kidney injury (AKI), one of the most common complications of critical illnesses and one with dire consequences, the necessity of using different approaches for its early recognition and management gains more momentum. In the past 2 decades, the use of automated surveillance tools that utilize electronic health records (EHRs) for timely and accurate recognition of AKI has dramatically increased in many developed countries. Despite this increasing use, reports of the impact of such tools on the processes of care and patient outcomes have been inconsistent.

An EHR is defined as "an electronic record of health-related information on an individual that is created, gathered, managed, and consulted by authorized health-care clinicians and staff."[1] In the United States, enactment of the American Recovery and Reinvestment Act and the Health Information Technology for Economic and Clinical Health Act and incentive programs for the Centers for Medicare and Medicaid Services for meaningful use of the EHRs have resulted in a substantial increase in its use.[2] The meaningful use incentive program devised by the Centers for Medicare and Medicaid Services to increase EHR utilization in order to improve quality, safety, and efficiency of health care; engage patients and their families; improve care coordination and population health while maintaining the privacy and security of patient health information. This program includes 3 distinct stages that focus on data capture and sharing, advancing clinical care processes, and improving outcome. Despite this progress, in the majority of health care systems, EHRs remain at very basic levels and lack the ability to communicate with other EHRs. These have hindered achieving the ultimate target of these programs (i.e., improvement in quality of clinical care processes and patients' outcomes).[2] On a positive note, judging based on the volume of publications in the field, there are considerable numbers of investigations and clinical programs with a primary focus on advancing capabilities of EHRs beyond basic holders of medical information.

In addition, other developed countries are implementing interventions to improve the use of EHRs. For example, in Canada, Health Infoway, a not-for-profit government-funded corporation, plans to implement an EHR system across Canada to improve processes of care and patient outcomes.[3] In the United Kingdom, the National Health Service provides considerable support for the National Programme for Information Technology to deliver the EHRs to all citizens covered by the National Health Service.[4] The EHR system in

the United Kingdom has been the source of many new advances and much knowledge, particularly related to AKI electronic alerts.[5,6] Finally, in Australia and New Zealand, the emphasis on using the EHR as the basis for improvement in the quality of care has resulted in funding for and the advent of HealthConnect (a change management strategy funded through the Commonwealth Government in order to leverage the existing eHealth projects and infrastructure and advance toward compliance with Australian National eHealth Transition Authority) to enhance the accessibility of medical records and patient safety and quality of care.[7]

This review article examines the current literature and discusses the potential path to improve the impact of electronic alerts and automated clinical decision support (CDS) systems on outcomes in patients with AKI through future research and development programs.

## CDS and electronic alerts

Electronic alerts are considered a subset of CDS systems. CDS is defined as a tool that "provides clinicians, staff, patients or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and healthcare."[8]

CDS systems, in addition to generating electronic alerts, can provide reminders, make recommendations based on clinical guidelines and the context of a clinical situation, generate data reports and summaries regarding the disease of interest, and assist with documentation and diagnostic approach. The intentions for the use of CDS systems are to improve quality of care processes, enhance patient safety, augment clinical care efficacy, and finally increase provider and patient satisfaction.[8] Considering the ever-growing volume of patient-specific data and disease-related knowledge, it seems rational to design and use these systems to improve quality of care. Use of CDS systems in clinical practice, however, has pros and cons (Table 1).

The primary purpose of a CDS system is to change provider behavior in order to improve quality of care that, in turn, leads to improvement in clinical outcomes. A work group of the 15th Acute Dialysis Quality Initiative described automatic alert and AKI CDS features that can affect the performance of such a tool (Figure 1).[9] These characteristics include technologic factors, human factors, and variables related to the delivery methods. Each of these components could affect the impact of a CDS system on the quality of care. Among critical technologic factors are the availability and sophistication of appropriate infrastructure and the clinical relevance of CDS system output. Human factors and methods of delivery can undoubtedly affect the compliance of clinical providers and, hence, the performance of CDS on the processes of care and patient outcomes.[10]

**Table 1 | Pros and cons of using clinical decision support systems within the clinical workflow**

| Pros | Cons |
|---|---|
| Provide relevant, evidence-based, in-time information | Threat of replacing clinical judgment |
| Standardization of practice | Variable user acceptance |
| Improve coding and documentation | Not user-friendly |
| Long-term cost saving | Cost of initiation and maintenance |
| Facilitate information gathering | Unknown legal and ethical issues |
| Provide platform for quality measures | Scarce knowledge of benefit |
| Facilitate teaching trainees | Inflexibility |

***CDS in all acute settings.*** Despite logical expectations for CDS to improve quality of care and patient outcomes in the acute setting, the current literature is not consistent in providing evidence of such results. In a systematic review of the topic in all acute clinical areas, authors identified 36 randomized clinical trials. They found that the process of care improved in 63% of the trials. CDS systems in these trials focused mainly on medication-dosing guidance, alerts, and reminders; management assistance through guidelines and algorithms; and diagnostic assistance. Patient outcomes were described in 64% of the studies, and only 15% of trials that had a focus on medication-dosing assistants showed a positive impact on clinical outcomes.[11] Of note, in just one-third of these studies was CDS incorporated into the clinical provider workflow, and in more than 60% of these investigations, data entry was done manually.

***AKI electronic alert.*** In the most recent systematic review, which included 6 randomized, quasirandomized, observational, and before-and-after studies, the authors found that use of automated AKI alerts or reminders without linking to a CDS system was not associated with any positive impact on the rate of death or use of renal replacement therapy. In this review, only a minority of studies showed improvement in the processes of care.[12]

The only randomized clinical trial of electronic alerts for AKI by Wilson *et al.*[13] showed no substantial improvement in the care of patients with AKI. The authors randomized 2393 patients with AKI to a standard-of-care (control) group or an AKI electronic alert (intervention) group. In that study, the clinical care providers, who mainly consisted of residents and advanced clinical practitioners, received a single alert regarding AKI development among patients admitted to intensive care units or general medical or surgical wards. The study not only showed no improvement in the processes of care and patient outcomes but also indicated a higher incidence of nephrology consultations and renal replacement therapy among the patients cared for in the general surgical unit. The factors that could have resulted in the observed negative results included, but were not limited to, the inclusion of patients who had a lower risk of AKI development and progress (those in general medical units), using only serum creatinine criterion for AKI detection, adding burden to the workflow of care providers (alarm fatigue),[10] not providing further decision-making support, alerting trainees and advanced care practitioners instead of intensive care physicians, and a lack of the interruptive nature of electronic alerts.[2,14] In comparison, Colpaert *et al.*[15] found that the