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Epidemiology

Improved management of acute kidney injury in primary care using e-alerts and an educational outreach programme

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Abstract

Purpose. Acute kidney injury (AKI) detected in primary care is associated with increased morbidity and mortality. AKI electronic alerts (e-alerts) and educational programmes have recently been implemented but their contribution to improve AKI care is unknown. This project aimed to improve response to AKI detected in primary care and used a factorial design to evaluate the impact of the UK National Health Service (NHS) AKI e-alert and AKI educational outreach sessions on time to response to primary care AKI stages 2 and 3 between April and August 2016.

Methods. A total of 46 primary care practices were randomized into four groups. A 2 × 2 factorial design exposed each group to different combinations of two interventions. The primary outcome was 'time to repeat test' or hospitalization following AKI e-alert for stages 2 and 3. Yates algorithm was used to evaluate the impact of each intervention. Time to response and mortality pre- and post-intervention were analysed using Mann–Whitney *U* test and chi-square test respectively. The factorial design included two interventions: an AKI educational outreach programme and the NHS AKI e-alerts.

Results. 1807 (0.8%) primary care blood tests demonstrated AKI 1–3 (78.3% stage 1, 14.8% stage 2, 6.9% stage 3). There were 391 stage 2 and 3 events from 251 patients. E-alerts demonstrated a reduction in mean response time (–29 hours). Educational outreach had a smaller effect (–3 hours). Median response time to AKI 2 and 3 pre- and post-interventions was 27 hours versus 16 hours respectively ($P = 0.037$). Stage 2 and 3 event-related 30-day all-cause mortality decreased following the interventions (15.6% versus 3.9% $P = 0.036$).

Conclusion. AKI e-alerts in primary care hasten response to AKI 2 and 3 and reduce all-cause mortality. Educational outreach sessions further improve response time.

Key words: Acute kidney injury; algorithms; clinical alarms; educational; primary health care; quality improvement.

Introduction

Acute kidney injury (AKI) is associated with increased mortality, length of stay and healthcare costs (1–3). It is increasing in incidence across all specialities and disciplines (4). The National Confidential Enquiry into Patient Outcome and Death entitled 'Adding Insult to Injury' investigated deaths associated with AKI from UK hospitals and revealed suboptimal care for the majority of patients (5). AKI has few specific symptoms or signs. In the absence of specific treatments, early detection of AKI is important (6).

AKI in secondary care has been well studied (7–9). The introduction of care bundles using quality improvement (QI) methodology has demonstrated improvements in AKI outcomes in most cases (8,10). Whilst nearly two-thirds of AKI in hospital are community acquired (CA-AKI) (9), there is a paucity of literature surrounding the identification and management of AKI in primary care (11). Incidence of AKI detected by primary care (CA_p-AKI) and not admitted to hospital varies depending on AKI definition and algorithm used (12,13). Hobbs *et al.* (12) reported an incidence of AKI alerting in primary care of 7% using modified AKI criteria. This study may have overestimated AKI incidence because it excluded results from patients (irrespective of their AKI status) who were admitted to hospital at any time during the 6-month recruitment period and 2-year follow-up period. Barton *et al.* (13) reported that AKI was identified in 0.4 % of all primary care creatinine requests irrespective of subsequent hospitalization over a period of 12 months. When using the National Health Service (NHS) AKI algorithm, Sawhney *et al.* (14) demonstrated an incidence of 1.4% of AKI in primary care creatinine blood tests over a period of 12 months. This study also demonstrated that although short-term mortality was low (2.6% 30-day mortality for CA-AKI not admitted to hospital), long-term mortality of this group was high (46.2% 5-year mortality).

The potential role for medical alerts has been recognized for some time (15). AKI electronic alerts (e-alerts) offer the health care provider an immediate assessment of AKI severity based on Kidney Disease Improving Global Outcomes classification (16). Despite widespread adoption in secondary care environments, their impact on patient outcome, health resources and patient flow remains uncertain. Some research report improved outcomes (17) whereas others demonstrate no benefit (7). NHS England mandated that all acute hospitals embed an automated e-alert system into secondary care with a subsequent expansion of AKI e-alert reporting to primary care in 2016 (18). The NHS AKI e-alert is a computer-generated AKI warning system for AKI stages 1–3. The algorithm used to determine AKI is contained within Supplementary Figure S1. As a minimum, communication of this alert is required to be displayed on pathology results reporting systems. Additional methods of communication of the alert can be used but depend on local resources and systems.

NHS England and the UK Renal Registry's 'Think Kidneys' programme aimed to improve the care of patients at risk of and with AKI; it has identified education as a key work stream. There is evidence that education can improve clinician's AKI knowledge and confidence to diagnose AKI in secondary care (19) but to our knowledge there is no evidence on the effectiveness of educational programmes in primary care AKI. Educational outreach programmes have demonstrated changes in behaviour and/or improved clinical practice in other areas (20).

The purpose of this project was to support phased implementation of AKI e-alerts with educational outreach visits aiming to improve response times to severe AKI detected in primary care. Factorial design QI methodology enabled this study to determine the effect of each intervention alone and in combination.

Objectives

The aims of this project were as follows:

(1) Reduce the response time for CA-AKI (stages 2 and 3) detected in primary care (CA_p-AKI).
(2) Engage primary care clinicians with AKI educational outreach session.

Methods

The project was performed using QI methodology in association with Haelo's Improvement Science for Leaders Programme. The project was conducted in collaboration with Salford Royal NHS Foundation Trust and NHS Salford Clinical Commissioning Group (SCCG). Ethical approval was not required.

The operational team consisted of one primary care physician, two renal consultants, one specialist trainee, one business information analyst, one biochemist and one service improvement manager from SCCG.

For the purposes of the factorial design, we elected to restrict the analysis to AKI 2 and 3 e-alerts because the NHS algorithm can misclassify stage 1 AKI episodes, particularly in primary care where the vast majority of e-alerts are based upon a baseline derived from the median creatinine from the preceding 365 days (21,22). AKI 2 and 3 are also associated with high mortality and morbidity even when detected in primary care (12,13).

There were 46 Salford primary care practices (258 729 registered patients in July 2015) assigned into four groups using a restricted randomization technique to ensure similar numbers of patients within each group (ranging from 62 013 to 68 738). A 2 × 2 factorial design was constructed using two interventions: an educational AKI outreach programme and an AKI e-alert to accompany blood tests taken in the community. All primary care practices in SCCG were included. Dialysis patients and patients <18 years old were excluded. Response time was defined as number of hours between an AKI alerting creatinine result stage 2 or 3 and a repeat blood test or admission to the local hospital. Events were excluded from analysis if no event had occurred at 14 days to avoid a definite time bias. Double counting the same AKI event was avoided by excluding CA_p-AKI within 48 hours of another CA_p-AKI in the same patient. In such circumstances, the first AKI event was included because the subsequent event was likely to represent the same AKI episode.

Baseline response times to CA_p-AKI 2 and 3 were analysed between January and October 2015. These baseline data were used to create each primary care practice group mean response time. The interventions were undertaken between October 2015 and May 2016 with the two groups exposed to e-alerts having their e-alerts switched on in March 2016. Educational outreach to the group that was exposed to both interventions was completed by the time the e-alert was switched on in March 2016. The data used in the factorial design analysis were acquired between April and August 2016. All groups had e-alerts switched on in August 2016. The follow-up period was from August 2016 until April 2017 (Fig. 1).

The e-alerts were accompanied by a regionally agreed CA_p-AKI e-alert pathway, guidance and definition sheet that was sent to all practices in SCCG (Supplementary Figure S2). All AKI 2 and 3 alerts were also telephoned to the primary care practice or out of hours practice by the biochemistry department at the time of identification.

Educational outreach was performed in half of the primary care practices within SCCG. These pre-defined structured sessions were carried out by a nephrology specialist trainee or a consultant nephrologist. Plan-Do-Study-Act (PDSA) cycles were used to develop and refine the peer learning event prior to the initiation of the educational outreach sessions. The PDSA cycles were undertaken with primary care physicians who were not participating in the interventions. The learning session was based on a structured brief overview of AKI in the community and a case of AKI from a patient registered

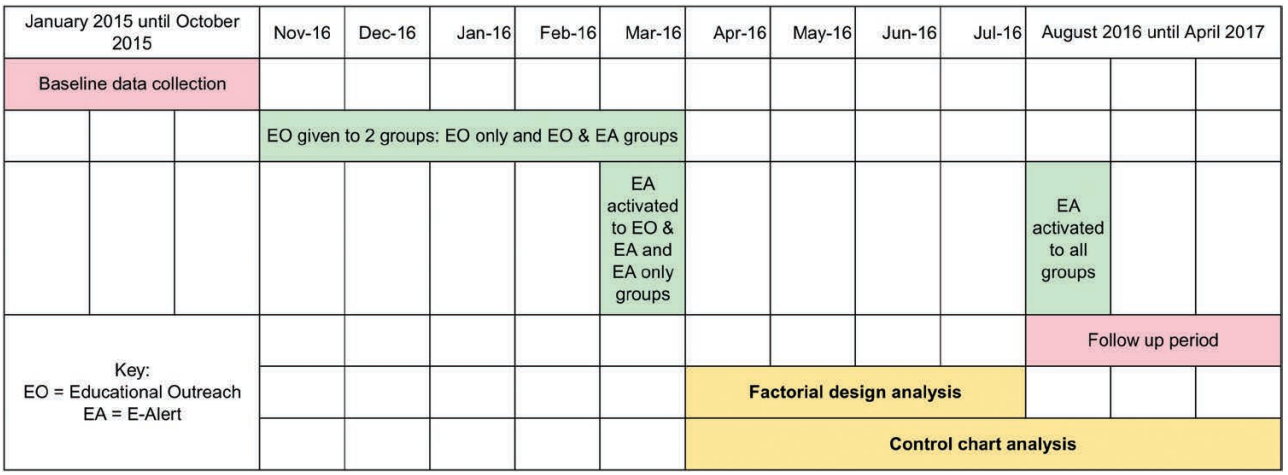

Figure 1. A Gantt chart that demonstrates the timelines of the interventions, follow-up period and analysis periods for Salford primary care practices and Salford patients who suffered acute kidney injury detected in primary care between January 2015 and April 2017

in that practice. It also included learning resources from Think Kidneys (23), pre-visit questionnaire, professional development certification and links to further resources. Following the 45-minute educational outreach session, all participants completed an evaluation of the learning event. PDSA methodology was also used to arrange the learning event and ensure engagement between primary care and nephrologist.

Measures

Process measure

It is the number of primary care practices engaged in AKI educational outreach.

Outcome measure

It is the response time to an AKI 2 or 3 creatinine measurement on a blood test performed by primary care in SCCG.

Data analysis

Demographic and admission data were retrieved from the patient administration system. Biochemistry data were garnered from the local telepath pathology system. These data were used to calculate the AKI response time. The relative effects of the interventions were calculated and visualized by the Yates algorithm and response plot (24) from the period after the completion of interventions to the full roll out of AKI e-alerts in August 2016. Mann–Whitney *U* test was used to compare median response times before any intervention (January to October 2015) and after the interventions (August 2016 to April 2017). Chi-square test was used to analyse 30-day all-cause mortality data before and after the interventions.

Response time data for AKI 2 and 3 events were ordered chronologically for each primary care practice group by date of test. These events were subgrouped into groups of four and response time was averaged for each subgroup to construct the X-bar and S control charts. X-bar charts display the changes in the mean outcome measure over time whilst S control charts display the SD (24). The baseline mean response time and control limits were frozen when the educational outreach had been completed and/or e-alert switched on. Data were tested for normality using Anderson–Darling normality test. Data were analysed using Microsoft Excel QI Charts software and IBM SPSS Version 23 (licensed to University of Manchester).

Results

Between January 2015 and April 2017, 0.74% (1807) of all community blood tests demonstrated CA_p-AKI 1–3. Of these 78.4% were AKI 1, 14.8% AKI 2 and 6.9% AKI 3. These AKI events were from 1260 patients. There were 391 AKI 2 and 3 events from 251 patients. AKI 2 or 3 tests from patients where another AKI 2 or 3 blood test had occurred within 48 hours were excluded (n = 65). The subsequent blood test was used as a response measure but not as another triggering AKI event. To avoid time bias, AKI 2 or 3 tests that did not have a repeat test within 14 days were also excluded (n = 92). Then, 234 CA_p-AKI 2 and 3 events were available for the final analysis.

Demographic and comorbidity data of patients who suffered CA_p-AKI 2 and 3 are presented in Supplementary Table S1; the data are grouped by intervention. Patients were well matched for recognized risk factors for AKI apart from age that was higher in the group exposed to education only.

There were 47 AKI 2 and 3 events during the factorial analysis period and prior to the full roll out of e-alerts in August 2016. Response time during this period decreased compared with the response time of 47 consecutive alerts prior to the intervention phase. Median response time was 49 hours versus 16 hours respectively (P = 0.031).

The relative effects of the interventions to the mean response time were calculated by the Yates algorithm. The results are presented in Table 1 and depicted graphically in the response plot in Fig. 2. The interaction between the two factors was important. The e-alert reduced the mean response time to repeat blood test or hospital admission by 29 hours without education and by 37 hours in conjunction with education. Educational outreach alone made a modest impact (3 hours).

The X-bar chart for the primary care practice group that was exposed to both the e-alert and the educational outreach extended to April 2017 demonstrates a significant shift in mean response time to AKI (Fig. 3) because there are >8 data points beneath the mean. The control charts for the other intervention groups during the same period showed only common cause variation (Supplementary Figures 3–5).

There was a significant reduction in median response time to AKI after the e-alerts were rolled out to all four groups in August 2016 compared with before any intervention was carried out that

Table 1. 2 × 2 factorial design matrix and Yates algorithm calculating the interactions of acute kidney injury (AKI) intervention factors on AKI detected in primary care response times for the time period from April until August 2016 in Salford

	Interventions (+/–)			
Primary care practice group	Electronic alert (A)	Education outreach (O)	A × O	Mean hours to response
1	–	–	+	68
2	+	–	–	47
3	–	+	–	73
4	+	+	+	35
Effect (hours)	–29	–3	–8	

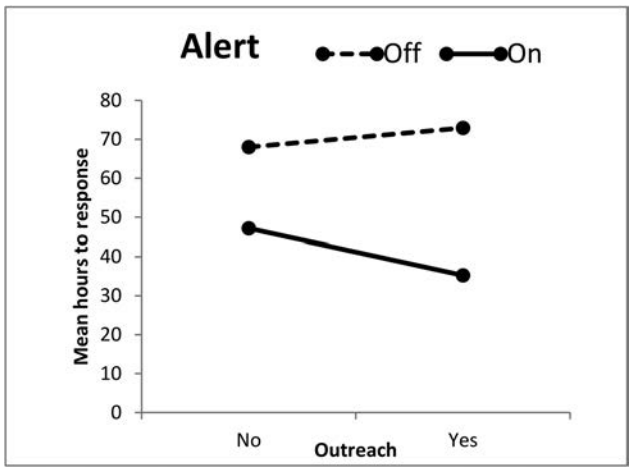

Figure 2. Response plot demonstrating the interaction of the electronic-alert and educational outreach on acute kidney injury detected in primary care response time for Salford primary care patients between April and August 2016

is before October 2015 (27.0 hours versus 16 hours respectively, $P = 0.037$). The 30-day all-cause mortality for all AKI over whole study period was 8.3%. There was a significant reduction in 30-day all-cause mortality for AKI 2 and 3 when it was compared before any interventions and after interventions were completed (15.6% versus 3.9% respectively, $P = 0.036$). These results are displayed in Table 2.

Engagement of primary care practices with AKI educational outreach required numerous PDSA cycles. A total of 17 out of 20 (85%) of the practices agreed to engage with the educational event. A variety of primary care clinicians, including GPs, practice nurses and advanced nurse practitioners, attended the outreach sessions. Ninety-one per cent of participants found inclusion of shared AKI cases useful and provided a framework for learning and 100% of participants expressed a wish for repeat nephrology-based educational sessions.

Discussion

Summary

This factorial design project is the first to demonstrate that the combination of AKI educational outreach and e-alerts reduces response time to CA_p-AKI 2 and 3. Analysis of the factorial design demonstrates that the e-alert has a greater impact on reducing response time than the educational outreach but the interaction of interventions had the greatest impact. Educational outreach alone only has a modest impact on AKI response times in primary care. Furthermore, in our study population, the mortality of patients with CA_p-AKI 2 and 3 decreased following the completion of the roll out of e-alerts in all groups.

Interpretation

There has been no previous study to evaluate the effectiveness of AKI e-alerts in primary care. Analysis of their ability to improve outcomes and care in secondary care institutions is mixed (7,19). It is plausible that e-alert may be more useful in primary care because CA_p-AKI is much less frequently encountered than AKI in hospital (11) particularly for AKI 2 and 3 which are potentially life-threatening conditions that require immediate response. Furthermore, the educational outreach intervention improved response to AKI e-alerts 2 and 3 highlighting the importance of education but also created links between primary and secondary care to support response to AKI in the community. This study provides evidence supporting the use of AKI e-alerts in primary care.

In this project, AKI 2 and 3 were also reported by the biochemistry technician to the primary care practice even if the result was received out of normal working hours. This represents <200 phone calls per year and has not disrupted the biochemistry laboratory work patterns. Other significantly abnormal blood tests results that require urgent attention are already phoned through to primary care providers and no new systems or processes were required. We suggest that this practice to support AKI e-alerts should be the standard practice.

Educational outreach was welcomed by primary care clinicians and repeat visits were encouraged. Primary care clinicians also used the opportunity to clarify other nephrology-related queries. Work is ongoing to develop a more balanced clinical partnership between primary and secondary care and explore new ways of working together.

Limitations

There are limitations to this study. Firstly, despite the study being carried out over 26 months, we could only analyse 234 AKI 2 and 3 events. CA_p-AKI of advanced stages (2 and 3) is a rare but serious event. Despite this small number, a significant all-cause mortality and response time improvement was seen. This study was not powered to investigate a mortality difference and there were only a small number of deaths. The mortality rates were vastly different before and after the factorial design experiment. Although no other major changes in AKI care were occurring locally during this time period, national AKI awareness campaigns may have biased the results. There was also no control group as part of the mortality analysis. For these reasons, the authors would advise caution in interpretation of the mortality difference. Secondly, the intervention period for educational outreach was spread over time. Thirdly, this project did not include AKI 1. We would expect that primary care clinicians would use clinical judgement to decide whether a patient's results represent

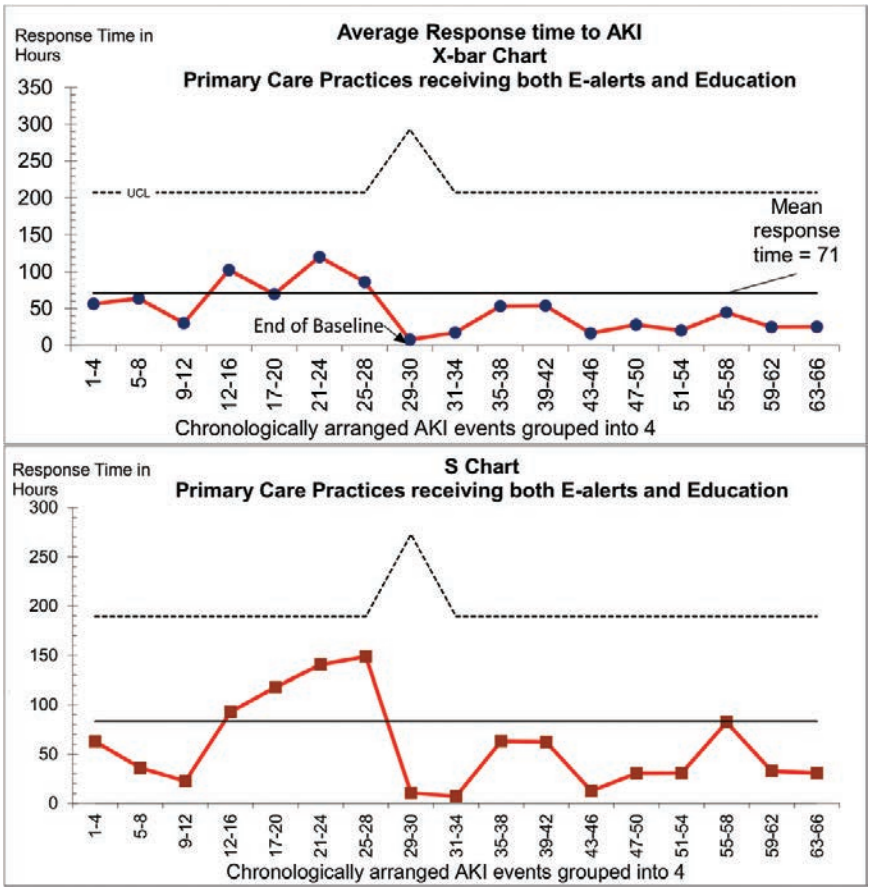

Figure 3. Control charts. X-bar (mean) control chart demonstrating mean time to acute kidney injury (AKI) response for the combined intervention group from January 2016 until April 2017. Baseline data represent time up until March 2016 when the e-alerts were switched on. These data were used to create baseline mean response time (horizontal line). Each data point constitutes the mean response time from four chronologically occurring AKI detected in primary care events in this Salford primary care practice subgroup. This graph demonstrates a significant shift in response time following introduction of the interventions because there are >8 consecutive data points below the horizontal line. S chart demonstrating the SD of each subgroup. If all results are below the upper control limit (+3σ), then the X-bar chart can be accurately interpreted. The horizontal line represents average SD

Table 2. A comparison between acute kidney injury detected in primary care (CA_p-AKI) response time and mortality of all CA_p-AKI in Salford between the time before any interventions had occurred (January to October 2015) and after all interventions had been completed (August 2016 to April 2017)

	Count	Median time to admission/repeat blood test (hours)	30-day all-cause mortality
Before any interventions	90	27.0	15.6%
After interventions	51	16.0 *P* = 0.037	3.9% *P* = 0.036

normal creatinine variation, particularly in the context of chronic kidney disease, and respond appropriately. Due to resource limitations, a study to evaluate the response to CA_p-AKI 1 is outside of the scope of this study. A fourth limitation is that hospital admission data were only collected at Salford Royal NHS Hospital. It is conceivable that some patients had their AKI diagnosed at the Salford laboratory and then attended an out of area, alternative hospital.

Another limitation is that 3 out of 20 primary care groups who were assigned educational outreach did not engage in the process despite different PDSAs and methodologies. This study was analysed on an intention-to-treat basis. Educational outreach did not therefore reach all intended primary care clinicians in the CCG although this study was designed to encourage dissemination of the learning amongst the non-attenders. Finally, some clinicians work in more than one primary care practice and may have inadvertently contaminated the practice groups who were assigned different interventions. National awareness schemes and local secondary care initiatives are ongoing and may also have reduced response time; however, the control group demonstrated no reduction in response time over the study period.

Upon discovery of an AKI 2 or 3 e-alert, the biochemistry department phoned the abnormal result to the primary care practice as advised (but not necessitated) by the NHS 'Think Kidneys' programme (25). It is therefore difficult to ascertain whether the e-alert or the phone call reduced the response times and all-cause mortality of primary care patients with AKI 2 and 3.

Conclusion

This study demonstrates that AKI e-alerts reduce time to response in CA_p-AKI 2 and 3 and this effect is enhanced when they are accompanied with educational outreach sessions. Furthermore, in our study

population, we observed a decrease in all-cause mortality of patients with CA_p-AKI 2 and 3 after the implementation of AKI alerts. This reduction may be explained by a reduction in the response time that a primary care clinician takes to respond to AKI 2 or 3. Improved AKI awareness and knowledge after an AKI educational outreach session may also be contributing to the management of AKI in the community.

Supplementary Material

Supplementary data are available at *Family Practice* online.

Declaration

Funding: This project received a small grant from Salford Clinical Commissioning Group Innovation Fund.

Ethical approval: Ethical approval was not required.

Conflict of interest: The authors declare no conflicts of interest. The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported and that no important aspects of the study have been omitted.

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