## Introduction

Acute kidney injury (AKI) is common and associated with poor outcomes. AKI management requires methodological delivery of basic elements of care but variations in standards of AKI care are commonplace. It has been suggested that strategies to address these gaps in care may translate into improved patient outcomes. We sought to test this hypothesis by evaluating the effectiveness, at the hospital level, of a package of measures to reduce harm associated with AKI.

## Methods

- **Study design:** Multi-centre, pragmatic, stepped-wedge cluster randomised trial (SWCRT), summarised in figure 1.
- **Study setting:** Five UK hospitals, including teaching and non-teaching centres. Differences between centres included size (range 593 to 2061 beds); number of emergency admissions (23k to 83k per annum); and pre-existing quality improvement infrastructure.
- **Intervention:** AKI alerts, a care bundle and an educational program, introduced sequentially at an organisation-level across fixed three month periods until all hospitals were exposed to the intervention.
- **Randomisation:** Hospitals were randomly allocated to the order in which they introduced the intervention.
- **Patients:** All patients with AKI aged ≥18 years hospitalised for >1 day. Chronic dialysis was the only exclusion criterion.
- **Data collection:** In 3 month periods, with a minimum of two pre-exposure (control), one transition and at least one post-implementation (intervention) periods per site. AKI episodes were identified as per a modified KDIGO definition using the NHS England AKI detection algorithm. Patient demographics, comorbidity and outcome data were collected from hospital episode statistics. A nested evaluation of the effect on processes of care was by case-note audit.
- **Outcome measures:** The primary outcome was 30-day mortality associated with AKI. Secondary endpoints included AKI incidence, AKI progression, hospital length of stay (LoS) and effects of the intervention on process of care.
- **Sample size:** With a trial duration of two years, 10,850 AKI episodes would be required to detect a decrease in mortality from 16% to 12.8% with 80% power.

## Results

24,091 AKI episodes were studied (unadjusted incidence 7.6 cases/100 admissions) in 20,719 patients. Patient details in control and intervention periods are shown in table 1.

<table>
<thead>
<tr>
<th>Number of admissions</th>
<th>Control</th>
<th>Intervention</th>
<th>Change in LoS (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>10,456</td>
<td>13,635</td>
<td>-0.09</td>
</tr>
<tr>
<td>% Male</td>
<td>53%</td>
<td>49%</td>
<td>0.007</td>
</tr>
<tr>
<td>Age</td>
<td>70.8±18</td>
<td>74.4±17</td>
<td>0.001</td>
</tr>
<tr>
<td>Charlson-Deyo score</td>
<td>Score 0: 10.4%</td>
<td>Score 1: 28.5%</td>
<td>Score 2: 43.3%</td>
</tr>
<tr>
<td>Ethanol</td>
<td>86.1%</td>
<td>85.5%</td>
<td>0.6</td>
</tr>
<tr>
<td>Death or discharge</td>
<td>33.4%</td>
<td>31.1%</td>
<td>0.001</td>
</tr>
<tr>
<td>% hospital acquired</td>
<td>93.4%</td>
<td>90.7%</td>
<td>0.001</td>
</tr>
<tr>
<td>% of patients &lt;65</td>
<td>85%</td>
<td>82%</td>
<td>0.001</td>
</tr>
</tbody>
</table>
| Table 1. Characteristics of patients in control and intervention periods. Note that hospitals contributed different proportions of patients to control and intervention periods due to SWCRT design so unadjusted differences between the groups may reflect centre differences, time and seasonal effects as well as intervention effects.

### Primary outcomes

- **Overall 30d mortality was 24.5%, with no difference between control and intervention periods (OR 1.07, 95% CI 0.93-1.24).**

### Secondary outcomes

- **Hospital length of stay (LoS) was reduced in the intervention period. Results from quartile regression analysis are shown in figure 2A.**

![Figure 2A](image)  
**Figure 2A. Quartile regression analysis of hospital length of stay (LoS) allowing comparison across the whole distribution, rather than only a comparison of means. Change in hospital length of stay is shown on the y-axis at different quantiles of the distribution, comparing the effect of the intervention against control period. The solid blue line represents the average change in hospital LoS in the intervention period. Results show significant reduction in LoS at 4th percentile with an effect size of 0.7 days (95% CI 0.2-1.0) and a trend for reduction in the 5th percentile.**

### Conclusions

A complex, hospital-wide intervention to reduce harm associated with AKI resulted in improvements in delivery of care, improved AKI detection, shorter duration of AKI and a modest reduction in LoS, but did not alter 30-day AKI mortality.

- **The effect of the intervention on LoS was not apparent in those with a short hospital stay, but became significant in those that stay in hospital for five days or longer. A similar effect was seen with AKI duration, possibly reflecting limited potential for improvement in those with very short LoS or AKI duration.**
- **Although modest on an individual patient level, the reduction in LoS has a potentially significant health economic impact in view of the large numbers of hospitalised patients who sustain AKI.**
- **Possible explanations for why the intervention did not affect 30d mortality include: lack of effect of intervention on this outcome; or that failure to achieve complete hospital-wide spread led to dilution of effect at an organisational level. Further insights into the fidelity of the intervention and the variation in improvement process measures between centres are currently being explored in a qualitative analysis.**
- **The increase in incidence of AKI during the intervention likely reflects better testing and detection of AKI. This is supported by the increase in AKI recognition seen in the audit of processes of care.**