NIHR | Collaboration for Leadership in Applied Health Research and Care Greater Manchester

# Primary Care Management of Acute Kidney Injury in NHS Bury CCG

Final Report

# Working in collaboration with:


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# Executive Summary

This report has been prepared by the project team from the National Institute of Health Research (NIHR) Collaboration for Leadership in Applied Health Research and Care (CLAHRC) Greater Manchester. The NIHR CLAHRC GM project team included facilitation, project management and research staff. The project's Steering Group consisted of managers based at NHS Bury Clinical Commissioning Group (CCG) and the NIHR CLAHRC GM project team, to support the delivery of, and to evaluate, an Acute Kidney Injury (AKI) management intervention in primary care.

## Background

AKI is common, harmful and costly and is a major barometer of patient safety across the NHS. To date, AKI initiatives have largely focused on improving management in secondary care. Recognising evidence that approximately two-thirds of episodes of AKI start in the community setting, efforts have broadened to address AKI in both secondary and primary care as well as across the interfaces of care. This report focuses on the implementation and evaluation of an intervention designed to enhance the primary care identification and management of patients who had had an episode of hospital care complicated by AKI and who had been discharged from Pennine Acute Hospitals NHS Trust (PAT).

## The Intervention

The design of the intervention and its evaluation was informed by joint working between NIHR CLAHRC GM and NHS Bury CCG. The intervention comprised: 1) audit and feedback, 2) educational events, and 3) development of a practice action plan. This work was aligned with NHS Bury CCG's Quality in Primary Care GP practice contract; general practices were incentivised to participate in these three activities. The records of active patients discharged from Pennine Acute Hospitals NHS Trust (PAT) with an episode of illness complicated by AKI for all general practices in the NHS Bury CCG area were audited over a three year period (April 2015-March 2018). The educational events raised awareness of AKI and shared best practice of its management. Participants were also provided with resource packs, and access to support, to facilitate development of action plans. In line with best practice, it was suggested that action planning focus on key post-discharge processes: a) Recording: AKI diagnosis to be Read coded in primary care, b) Medication Review: Patient to receive a medication review within one month of discharge, c) Monitoring of kidney function: Serum creatinine to be checked within three months, and d) Communication with patients: AKI to be communicated to the patient (and carer).

## The Audit

A clinical audit was conducted, to track changes in key indicators of processes of care for patients whose stay in PAT was complicated by AKI. The audit data demonstrated significant improvements in all four criteria measured, with diagnostic Read coding of AKI having increased by 22% from 28% in 2015/16, to 36% in 2016/17, and then to 50% in 2017/18.

Coding of AKI on primary care systems had a close association with significant improvements in downstream patient management to best practice, in terms of timely medication review, kidney function tests and written information being given to patients:

- *Medication Review*: For episodes of AKI that were Read coded, evidence of a medication having being conducted within 1 month of discharge increased from 23% in 2016/17 to 71% in 2017/18. In comparison, episodes that were not Read coded increased from 12% (2016/17) to 18% (2017/18).
- *Kidney function*: For episodes of AKI that were Read coded, evidence of a serum creatinine test have being taken within 3 months of discharge increased from 79% in 2016/17 to 90% in 2017/18. In comparison, episodes that were not Read coded decreased from 58% (2016/17) to 55% (2017/18).
- *Communication with patients about AKI*: For episodes of AKI that were Read coded, evidence of written information being given to patients increased from 15% in 2016/17 to 83% in 2017/18. In comparison, episodes that were not Read coded increased from 1% (2016/17) to 8% (2017/18).

# The Evaluation

We carried out a mixed methods evaluation, using quantitative and qualitative research, to investigate the potential impact of the improvement intervention and to understand AKI related working practises in primary care. The quantitative outcomes evaluation aimed to examine the effectiveness of the intervention, in particular, to assess changes in healthcare outcomes. The aim of the qualitative process evaluation was to explore and understand the process of implementing the intervention.

### The Outcome Evaluation

The outcomes assessed were unplanned readmission, length of stay, bed days, and mortality, for patients who had had a hospital admission complicated by AKI. We used Secondary Use Services (SUS) data from PAT. These data were complemented by indicators of mortality (in and out of hospital) within numerous time periods from discharge, derived from PAT records. Despite the improvements in primary care processes associated with the Bury intervention there was no effect on hospital and mortality outcomes on average in the two years following the start of the Bury intervention compared to other CCGs. Furthermore, there was no difference in outcomes between Bury GP practices that were high performers in terms of Read coding and medication reviews (above average levels in 2017-18) compared to other practices.

### The Process Evaluation

The process evaluation focussed on the experiences of people involved in implementing the processes of care. We interviewed GPs, pharmacists, practice managers and administrators. The educational events were generally well received by all types of participant. GPs did not generally think the content had added to their clinical knowledge, whereas pharmacists particularly appreciated the clinical material in the presentations and also the resources supplied. The project was generally seen as extending existing work, with the main changes being the increased recording of information, both through Read coding in the patient notes that they had had AKI and also recording the processes of care that were then put in place. The project highlighted the need for multidisciplinary working to manage patients with AKI. For pharmacists in particular, there were opportunities to expand their contribution in primary care; however, various challenges to doing this were also experienced. The standard of discharge summaries was generally good, but there were inconsistencies between trusts, and AKI was not always prominent and could be missed.

# Key Messages

- The audit data demonstrated improvements in all four criteria measured (Read coding, medication review, kidney function tests and written information given to patients) over the study period.
- Read coding of AKI in primary care is positively associated with improvements in downstream management.
- Despite the improvements in primary care processes associated with the intervention there was no measurable effect on hospital and mortality outcomes in the two years following the start of the Bury intervention. Although effects may emerge in the longer-term.
- Annotation of information on discharge summaries was noted to improve over the course of the study period; with greater diagnosis, medication information and blood result details. However, some information on discharge summaries could be interpreted as conflicting.

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# 1. Introduction

## 1.1. Background

### 1.1.1. Acute Kidney Injury

Acute Kidney Injury (AKI) is common, harmful and costly and is a major barometer of patient safety across the NHS.[1-4] It is a clinical syndrome characterised by a sudden reduction in kidney function that complicates episodes of acute illness.[2] As such, AKI is a marker of illness severity and is estimated to be associated with up to around one in five unplanned hospital admissions, with more than 60% of these episodes arising in the community.[5-7] AKI is associated with significantly worse health outcomes including higher risk of a further episode of AKI, of development or progression of chronic kidney disease up to end stage renal disease, and mortality, both in the immediate and longer term.[2,6,8] Hospital related care of patients with AKI is estimated to cost around 1% of the NHS budget.[3]

To date, AKI initiatives have largely focused on improving management in secondary care. Such initiatives were influenced particularly by the National Confidential Enquiry into Patient Death and Outcome 2009 Report on AKI, which indicated significant hospital failings in patient safety in terms of poor assessment of acute illness and delays in recognising AKI, with evidence to suggest that approximately one in five episodes of AKI were avoidable.[9]

Within NHS England's Patient Safety Domain, the Think Kidneys Programme was established to tackle the harm associated with AKI.[10] Recognising evidence that approximately two-thirds of episodes of AKI start in the community setting, efforts have broadened to address AKI in both secondary and primary care as well as across the interfaces of care.

During 2015-16, through the Commissioning for Quality and Innovation (CQUIN) framework, financial incentives were introduced to improve discharge care for patients who had a hospital admission complicated by AKI.[11] The stated CQUIN goal was 'to improve the follow up and recovery for individuals who have sustained AKI, reducing the risks of readmission, re-establishing medication for other long term conditions and improving follow up of episodes of AKI which is associated with increased cardiovascular risk in the long term.'[11] Its introduction aimed to improve 'information to GPs at the time of discharge' with the intentions of starting 'to develop the knowledge base of GPs on AKI' and also to 'positively impact on readmission rates for patients with AKI'.[11] Payments were made to hospital trusts for documentation of four key items on a patient's discharge summary:

1) Stage of AKI (a key aspect of AKI diagnosis)
2) Evidence of medicines review having been undertaken (a key aspect of AKI

treatment)
3) Type of blood tests required on discharge; for monitoring (a key aspect of post discharge care)
4) Frequency of blood tests required on discharge for monitoring (a key aspect of post discharge care).

Based on NICE recommendations[1,12] and the development of Think Kidneys guidance[13] for primary care, key elements of best practice include: a) raising awareness in people at risk of AKI (prevention); b) ensuring a timely response to an AKI Warning Stage Test Result (detection); c) managing AKI associated illness in the primary care setting (management); and d) implementing organisational structures and processes to help manage patients who have had an episode of care complicated by AKI (I.e. post-AKI care: prevention, detection and management).

### 1.1.2. The Local Context

A set of nine primary care standards was developed for Greater Manchester, with the aim of addressing variation in care and improving outcomes.[14] NHS Bury CCG developed a Quality in Primary Care Contract (QIPC) i.e. a locally commissioned service, which focuses on five of these standards.[15] The Bury QIPC contract includes key performance indicators relating to the 'embedding a culture of medication safety' standard. One of the key performance indicators focuses on AKI and requires practices to:

1) Participate in an audit of diagnostic coding of AKI in general practice following hospital discharge
2) Attend an education training session
3) Develop and implement a practice level action plan to improve the management of AKI in primary care.

## 1.2.The Intervention

The intervention was designed to enhance primary care identification and management of patients who had had an episode of hospital care complicated by AKI and who had been discharged from Pennine Acute Hospitals NHS Trust (PAT) back to the community.

Previous research has shown that, whilst important, the introduction of guidelines or alerts alone are less effective in changing clinician behaviour or improving health outcomes, than when they are combined with feedback, education and support.[16,17] There is evidence that targeted audit and feedback interventions have the potential to support behaviour change and improve patient safety in primary care.[18,19,20] This approach is more effective when: there is a focus on areas of low baseline performance, education and feedback is provided by a supervisor or colleague, it is delivered in both verbal and written formats, and when it includes explicit targets and an action plan.[16,17,20] In order to build on this existing evidence base, it is recommended that the design and evaluation of future audit and feedback interventions should be informed by 'explicit use of theory, empirical evidence, and logic.'[16] The NIHR CLAHRC GM:Bury intervention was designed using this knowledge, and comprised: 1) a co-delivered educational element, 2) audit and feedback, and 3) ongoing practice support to design and deliver action plans. Table 1 below, based on the TIDieR[21] template for describing interventions, provides details of the intervention. The design of the intervention and its evaluation was informed by joint working between NIHR CLAHRC GM and NHS Bury CCG.

*Table 1 NHS Bury CCG primary care management of AKI intervention*

| Item number | Item |
|---|---|
| 1 | **BRIEF NAME**<br>Bury Primary Care Management of AKI Intervention. A primary care based intervention, aimed at improving the management of care for people who have had an episode of hospital care complicated by Acute Kidney Injury (AKI), implemented across one CCG area. |
| 2 | **WHY**<br>Patients who have had an episode of hospital care complicated by AKI are at higher risk of worse health outcomes, including a further episode(s) of AKI, increased mortality, increased development or progression of Chronic Kidney Disease (CKD) and high rates of hospital readmission. It is also known that around two thirds of cases of AKI occur in the community. Therefore, attention has focussed on improving the management of patients who have had an episode of hospital care complicated by AKI and been discharged. Following an episode of AKI, KDIGO guidelines advise testing kidney function after three months, whilst NICE recommends monitoring kidney function for two to three years; NICE also recommends that AKI risk is communicated with patients (and their carers) with a history of AKI. To date, evidence about the processes of identifying, recording and communicating AKI in primary care has been scarce, therefore, the development and evaluation of a primary care AKI management intervention was warranted. (See NICE 2013; 2014; KDIGO Acute Kidney Injury Work Group, 2012; Wonnacott et al 2014)<br><br>Evidence exists for the effectiveness of targeted audit and feedback interventions, but these have not been used in kidney health, therefore, using a targeted audit and feedback intervention was warranted.(See Ivers et al, 2012; Brehaut et al, 2016) |
| 3 and 4 | **WHAT**<br>As part of the NHS Bury CCG Quality in Primary Care GP practice contract, general practice teams were required to participate in an audit of AKI activity, attend an educational event and develop a practice level action plan.<br><br>1. **The clinical audit**<br>Procedure**:** A manual ‘pre-audit’ provided information about patients in Pennine Acute Hospitals NHS Trust (PAT), with a hospital admission |

complicated by AKI - that is, with a clinical diagnosis in chapter N17 of the International Classification of Diseases version 10 (ICD – 10) between April 2015 and March 2016. The records of all general practices in NHS Bury CCG were audited to ascertain how many cases of AKI had been recorded in practices. Practice teams were then tasked with reviewing/recording on their practice computer system, any cases that had not been recorded, using the relevant Read codes.

Following this, practice teams were expected to review/record (Read code), on their practice computer systems all cases of AKI that appeared on their patients' discharge summaries; regular audits were run to monitor the processes of care. The original plan was for NIHR CLAHRC GM and Vision (a provider of general practice computer systems) to feed data back to practices on a quarterly basis, using a new software tool. This would include the four processes of care outlined in point 3 below.

Materials: All practices in NHS Bury CCG use the Vision practice computer system. A copy of the 'pre-audit 'results was provided to each practice, with instructions on how to record the outstanding cases, including which Read codes to use.

**2. Educational events**

Procedure: The events consisted of presentations on: AKI and its importance, a case study of AKI, the audit data and a group session on action planning. These events raised awareness of AKI and shared best practice for its management.

Materials: Participants were provided with packs containing: the Read Codes for AKI, a practice action plan template and 'Think Kidneys' literature on AKI.

**3. Action planning**

Procedure: Development of a practice level action plan. In line with best practice, it was suggested that practice teams focused on the following key post-discharge processes:

a) Recording: AKI diagnosis to be Read coded in primary care
b) Medication review: Patient to receive a medication review within one month of discharge
c) Monitoring of kidney function: Serum creatinine to be checked within three months of discharge
d) Communication with patients: AKI risk to be communicated to the patient (and carer).

| | |
|---|---|
| 5 | **WHO**<br>The NIHR CLAHRC GM team conducted the audits and visited practices to present the results.<br>The NIHR CLAHRC GM team planned and facilitated the educational events. The presentations were given by the CCG leads, the NIHR CLAHRC GM team, and a local renal consultant.<br>General practitioners, practice nurses, practice managers, practice administrators, practice pharmacists, medicines optimisation technicians participated in all stages of the intervention. |
| 6 | **HOW**<br>The audits were carried out by the NIHR CLAHRC GM team accessing hospital records, and subsequently accessing primary care records. |
| 7 | **WHERE**<br>The list of patients with a clinical diagnosis of AKI was shared from PAT. The manual audit was being conducted in general practices across NHS Bury CCG. |
| 8 | **WHEN AND HOW MUCH**<br>The manual pre-audit was carried out once in summer 2016; two further audits were carried out in 2017 and 2018.<br>At least one representative from each practice attended a training event, during November and December 2016. Each practice developed one action plan, with a deadline of 31st March 2017. |
| 9 | **TAILORING**<br>Each practice was provided with their own audit results. Each practice developed and implemented their own action plan. |
| 10 | **MODIFICATIONS**<br>The Vision tool required further development, which was supported through an annual manual audit. Therefore the Vision tool was not used for audit/feedback activity. |

Practice support was organised around three types of activities, as described in Table 1:

1) Participation in the audit/feedback activity

Initially practice audit feedback was planned quarterly, using a tool on the Vision (practice computer system) Business Manager system. Unfortunately the tool was not ready for roll-out in the initial phases of this project, therefore the NIHR CLAHRC GM team shifted to annual feedback using a simplified manual audit process.

During the summers of 2016, 2017 and 2018, we conducted three manual audits (covering the periods April 2015 – March 2016, April 2016 – March 2017 and April 2017-March 2018) for patients registered with a GP practices in NHS Bury CCG and discharged from PAT after an admission complicated by AKI. We audited all patients who were still active and had AKI noted on their discharge summary from the hospital. Following the first audit, practices were asked to review and (where appropriate) Read code the patients identified through the audit. Subsequent audit and feedback visits aimed to sustain and enhance improved management of this patient population. The results of the audit are presented in section 2.2.

2) Multi-professional educational events

NIHR CLAHRC GM worked with NHS Bury CCG to run educational events during November and December 2016. Five events were delivered, with all 31 general practices represented. The total number of participants in the events was 82: 64 were practice staff (GPs, nurses, practice managers and administrators), 10 were pharmacists employed in practices, and 8 were CCG medicines optimisation pharmacists (5 of whom attended more than one event).

3) Development and implementation of a practice level action plan

Educational events, provision of resources, an initial audit/feedback visit, as well as access to further support if requested, supported NHS Bury CCG general practices to develop their own practice-level action plans. These aimed to improve management of patients who had had an episode of illness complicated by AKI, by focussing on the key processes of care (see section 2.1).

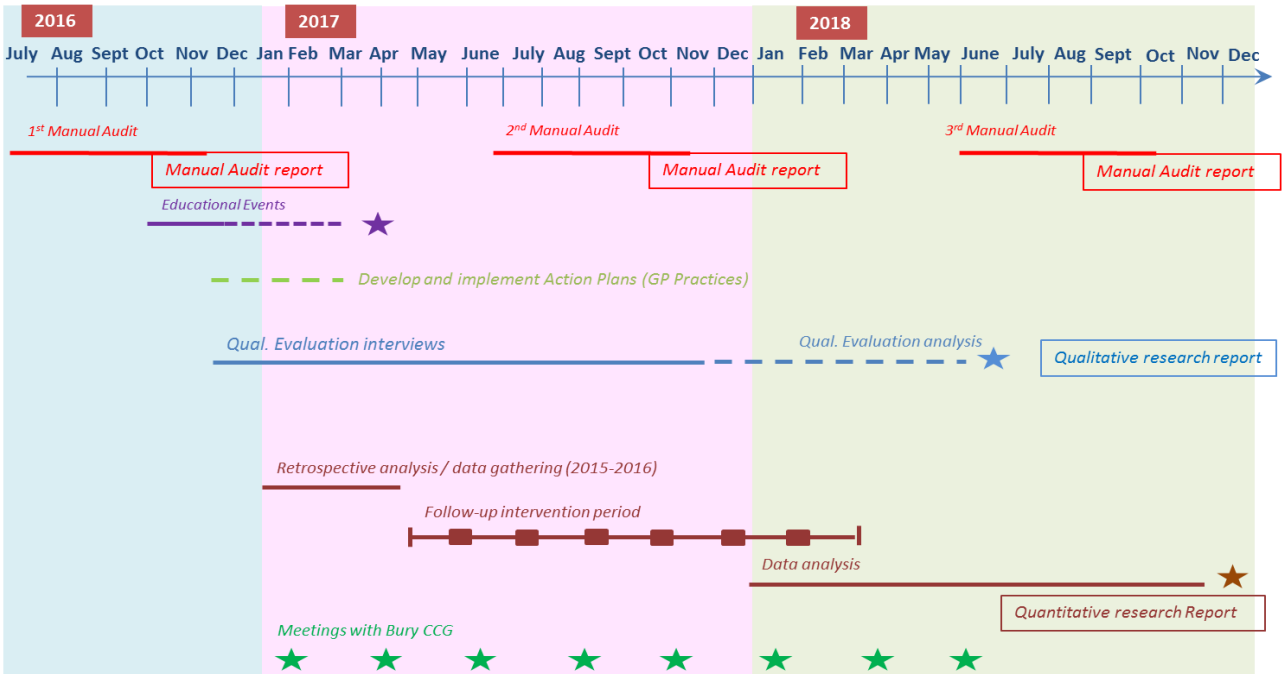
## 1.3.The Evaluation

NIHR CLAHRC GM also delivered a mixed method evaluation, using quantitative and qualitative research to investigate the potential impact of the improvement intervention and to understand AKI related working practises in primary care. The quantitative, outcomes evaluation aimed to examine the effectiveness of the intervention, in particular,

to assess changes in healthcare outcomes. The aim of the qualitative, process evaluation was to explore and understand the process of implementing the intervention.

Figure 1 shows the timeline for the intervention and evaluation. The audit data covers the three years from 1st April 2015 to 31st March 2018.

*Figure 1 Project timeline*



The following sections present the findings from the audit, outcome (quantitative) evaluation, and process (qualitative) evaluation.

# 2. The Audit

## 2.1. Audit Methods

A clinical audit covering three financial years (April 2015 - March 2016, April 2016 - March 2017, and April 2017 - March 2018) was conducted, to track changes in key indicators of processes of care for patients whose stay in PAT was complicated by AKI (that is, they had a clinical diagnosis of AKI as per the definition in Table 1). Aligned with national guidance including pilot indicators proposed by NICE[22], in consultation with Think Kidneys[23], (see Table 1 for details) we report on four key processes of care:

1. Recording, by Read coding on Vision, of AKI diagnosis in the electronic record of the patients registered at GP practices in Bury
2. Medication review undertaken within 1 month (31 days) of discharge from PAT
3. Serum creatinine check, to measure kidney function, undertaken within 3 months (93 days) of discharge from PAT
4. Written information about AKI given to patients.

Chi-square tests were applied for testing the association between the categorical variables of interest, with the exception of provision of written information, which used Fisher's Exact test (due to invalid assumption of a Chi-square test). Conclusions about each null hypothesis were made with 95% confidence (0.05 significance level). All analyses were performed using the statistical software Stata 15.

## 2.2. Audit Results

Each year, around 1500 patients were clinically coded with AKI and discharged from PAT (Table 2). Of these, approximately 60% were excluded from further analysis as the patients were no longer active on the system (left the practice or deceased); there was no discharge summary available on Vision, and/or no mention of AKI on the discharge summary. We audited 1669 patient records in total.

Due to the proportion of episodes of AKI *not* Read coded, we report the indicators on processes of care both as percentages of all the episodes of AKI and of the episodes Read coded, as illustrated in Table 3 and Appendix 1 in more detail. This also allows for a comparison of care for those patients Read coded and those not.

A number of Read codes were used in primary care which were reviewed and identified as inappropriate for the described measure/criteria. See Appendix 2 for the list of codes included and excluded in the audit.

*Table 2 Episodes of admissions to PAT complicated by AKI for patients registered with GP practices in NHS Bury CCG over 3 years (2015 to 2018)*

| **Episodes of admissions to PAT complicated by AKI** | **2015-2016** | **2016-2017** | **2017-2018** |
|---|---|---|---|
| Total episodes of admission complicated by AKI (PAT list) | 1,222 (100%) | 1,580 (100%) | 1,527 (100%) |
| Total episodes excluded from audit | 791 (65%) | 947 (60%) | 922 (60%) |
| – Patient no longer active / alive | 566 (46%) | 688 (44%) | 629 (41%) |
| – No discharge summary reported in Vision | 57 (5%) | 66 (4%) | 60 (4%) |
| – AKI not mentioned in the discharge summary | 168 (14%) | 193 (12%) | 233 (15%) |
| Total episodes included in the audit | 431 (35%) | 633 (40%) | 605 (40%) |

*Table 3 Indicators of post-discharge care for admissions complicated by AKI for patients registered with GP practices in NHS Bury CCG (2015 to 2018)*

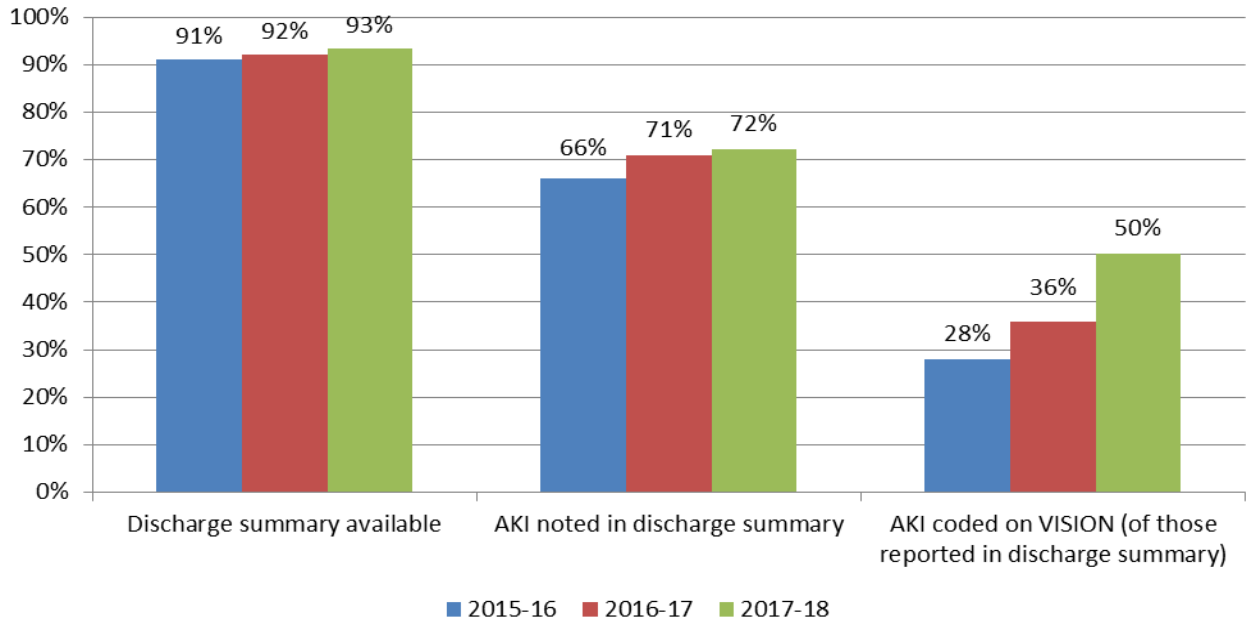
| Indicator | 2015-2016 | 2016-2017 | 2017-2018 |
|---|---|---|---|
| Episodes included in the audit | 431 | 633 | 605 |
| Episodes with AKI coded in Vision | 119 (28%) | 229 (36%) | 303 (50%) |
| Of the episodes coded in Vision: | | | |
| Medication review within one month | not collected* | 52 (23%) | 214 (71%) |
| Serum creatinine checked within 3 months | not collected* | 181 (79%) | 272 (90%) |
| Written information on AKI given to patient | not collected* | 35 (15%) | 251 (83%) |

* This data was not collected initially, as it was hoped the Vision tool would provide this information. However the manual audit was introduced as development of the Vision tool took longer than anticipated. It was not possible to collect the above data retrospectively as patients' data became inaccessible (from a governance perspective) if they were no longer registered at the practice or had deceased.

### 2.2.1. AKI Recording in Primary Care

Figure 2 shows the total number of active episodes with a discharge summary uploaded onto Vision, the number of active episodes with AKI noted on the discharge summary, and then those which had been Read coded on practice systems. A comparison between the three manual audits (2015-16 vs 2016-17 vs 2017-18) is included, which demonstrates a statistically significant ($p<0.05$) trend over time, with an increase from 28% (2015-16) to 36% (2016-17) and 50% (2017-18) in the percentage of episodes Read coded of those with AKI reported on the discharge summary.

*Figure 2 Percentage of episodes of admissions complicated by AKI with discharge summary available, AKI noted in discharge summary and AKI Read coded, NHS Bury CCG (2015-16, 2016-17 and 2017-18)*

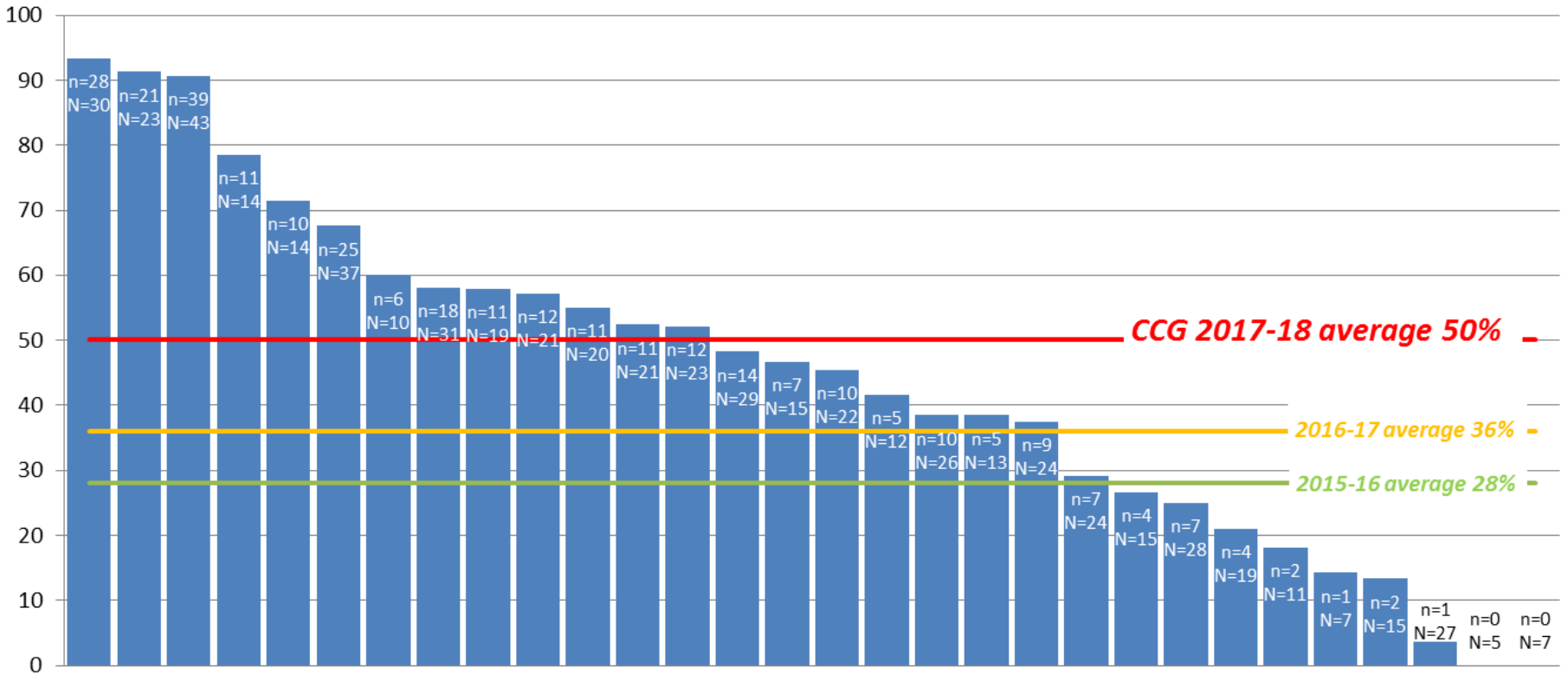



Note: Percentages calculated out of the total number of episodes of admission complicated by AKI for patients still active in the GP practice register at the time of the audit.

Figure 3 shows the number of active episodes with AKI on discharge summary and then Read coded in general practice, ranking individual anonymised practices by proportion of patients coded. In 2017-18, 50% of the episodes of AKI were Read coded overall in NHS Bury CCG. However, there is variation across the 30 GP practices audited, from 0% of AKI episodes Read coded through to 93%. The comparison between the three audits is also indicated on Figure 3.

The coding achievement of each individual practice, as well as achievement of the other indicators, has been made available to each GP practice through individual practice reports, as well as our key strategic contacts at the CCG.

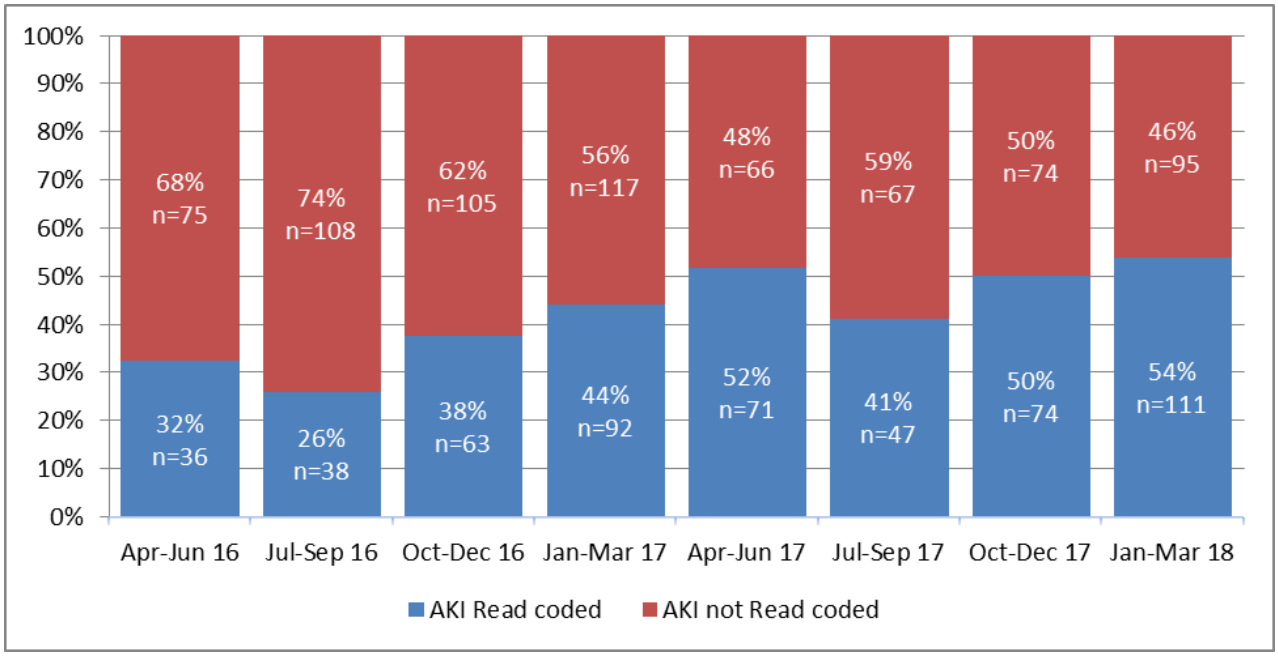
*Figure 3 Percentage of episodes with AKI on discharge summary and Read coded by GP practice, NHS Bury CCG (April 2017 – March 2018)*




Note: n= number of episodes with AKI noted in discharge summary and Read coded, N= total number of episodes with AKI noted in discharge summary. The overall level of coding across the CCG is shown in green (2015-6), amber (2016-7) and red (2017-8).

Figure 4 summarises the change in coding for all episodes in the 30 practices across NHS Bury CCG over time, and shows the number of active episodes with AKI noted on the discharge summary comparing those Read coded versus not Read coded in general practice. There was a significant increase in the number of episodes of AKI Read coded in Vision compared to those not coded over time ($p<0.05$).

*Figure 4 Percentage of episodes with AKI on discharge summary and Read coded by quarter, NHS Bury CCG (2016-17 – 2017-18)*

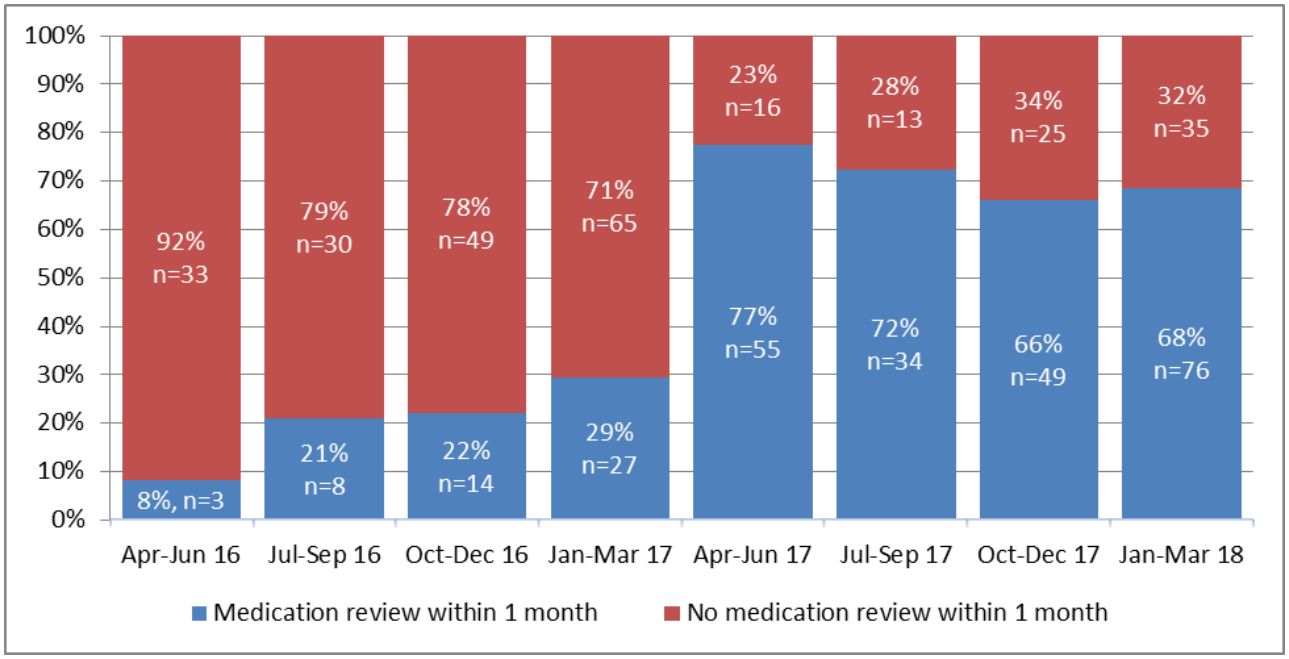



### 2.2.2. Medication Review

Figure 5 shows the number of active episodes with AKI noted on the discharge summary, and then Read coded with AKI in general practice, who had a medication review within 1 month of discharge. The percentage has significantly increased ($p<0.05$) over the course of the audit period, rising from 8% at the beginning of the 2016 financial year to 68% at the end of the 2018 financial year.

Patients who were Read coded with an AKI diagnosis were more likely to have a medication review within 1 month of discharge than those who were not Read coded ($p<0.05$); in 2017-8, overall 18% of episodes had a medication review within 1 month where AKI was *not* Read coded, whereas the figure was 71% for those who were Read coded (Appendix 1).

*Figure 5 Percentage of episodes with AKI Read coded who had a medication review within 1 month of discharge, NHS Bury CCG (2016-17 – 2017-18)*

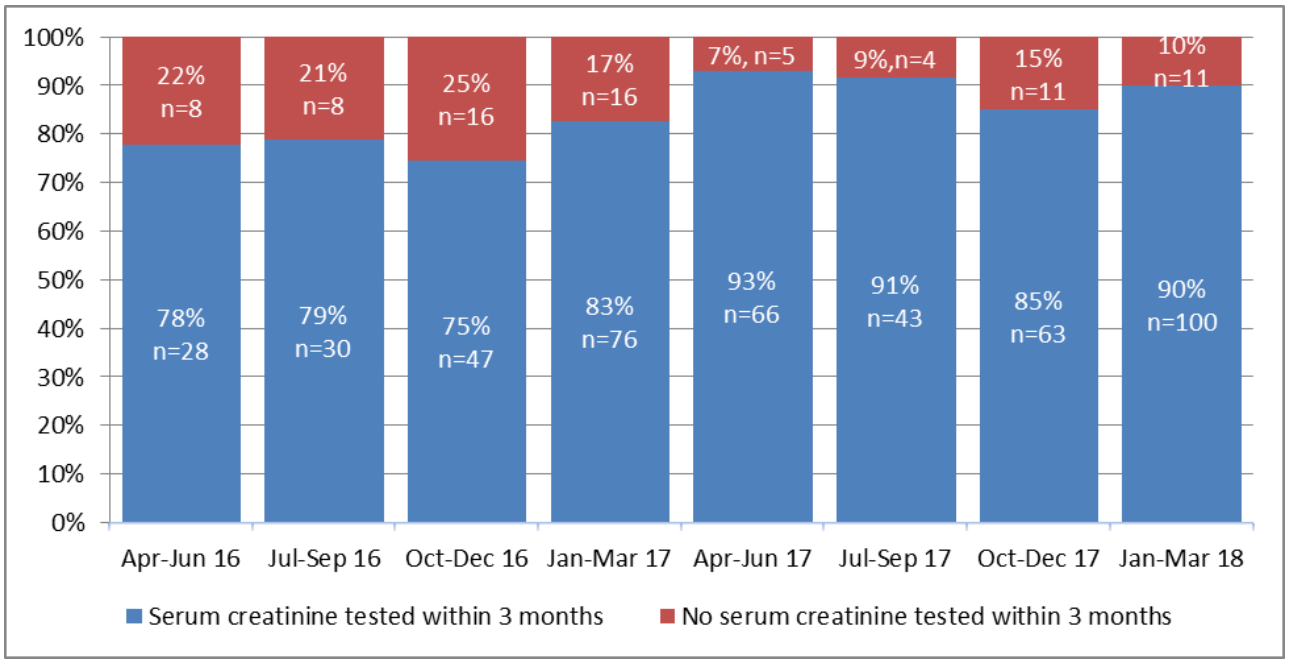



### 2.2.3. Kidney Function

The current guidelines[2] recommend that a serum creatinine check is carried out within 3 months of an AKI event. In this audit we have counted from date of discharge as this is the first opportunity for primary care teams to be aware/act. Figure 6 shows the number of active episodes with AKI noted on the discharge summary, and then Read coded with AKI in general practice, where a serum creatinine check was performed within 3 months of discharge. There was a significant difference ($p<0.05$) in the number of AKI episodes coded in Vision when the patient had serum creatinine tested within 3 months compared to those when serum creatinine was not tested within 3 months (by audit quarter).

Again there seems to be a notable difference (significance $p<0.05$) between those Read coded with an AKI diagnosis and not coded; in 2017-18, 55% of episodes *not* Read coded had a serum creatinine tested within 3 months of discharge, compared with 90% of episodes Read coded (Appendix 1).

*Figure 6 Percentage of episodes with AKI Read coded who had serum creatinine tested within 3 months of discharge by quarter, NHS Bury CCG (2016-17 – 2017-18)*




### 2.2.4. Communication with Patients about AKI

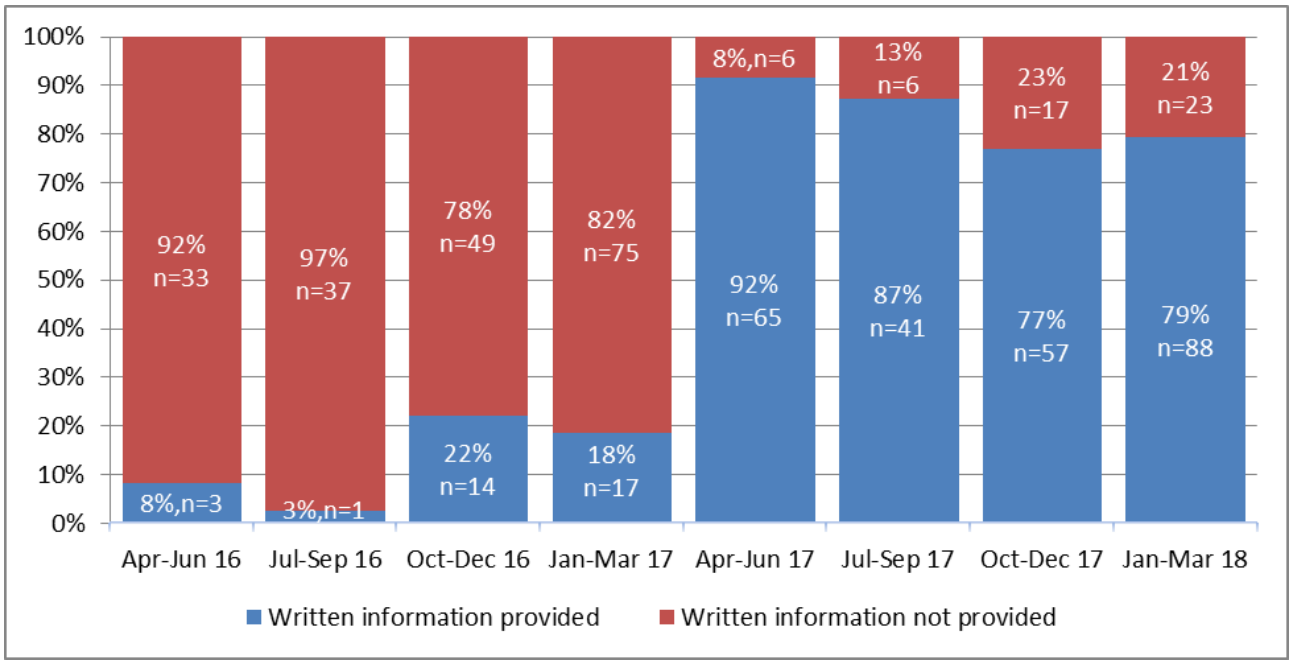
Finally, best practice guidance recommends that all patients who have had AKI receive written information about it. NICE Quality Standards recommend that AKI risk is communicated with patients (and their carers) who have pre-existing chronic kidney disease (CKD), a past history of AKI, or cognitive impairment and who may be reliant on a carer during episodes of acute illness.[12] Resource development takes into account a current knowledge gap concerning the importance of AKI and kidney health, with evidence that only about half the population know that the kidneys produce urine and that just over 10% are aware that the kidneys have a role in processing medicines.[24] Patient accessible information about AKI can be obtained via the Think Kidneys website[10] and the Patient Info website[25]. We also provided Bury practices with printed resources to facilitate this activity.

Figure 7 shows the number of active episodes with AKI noted on the discharge summary, and then Read coded with AKI in general practice, who received written information about AKI. There was a notable increase in the percentage of patients Read coded as having received written information over the course of this study (which was statistically significant $p<0.05$), rising from 15% in 2016-17 to 83% in 2017-18 (Appendix 1).

Furthermore there was a marked difference ($p<0.05$) between the patients Read coded with an AKI diagnosis and those not coded; in 2017-18 8% of episodes *not*

Read coded with AKI were given written information, compared to 83% of those Read coded (Appendix 1).

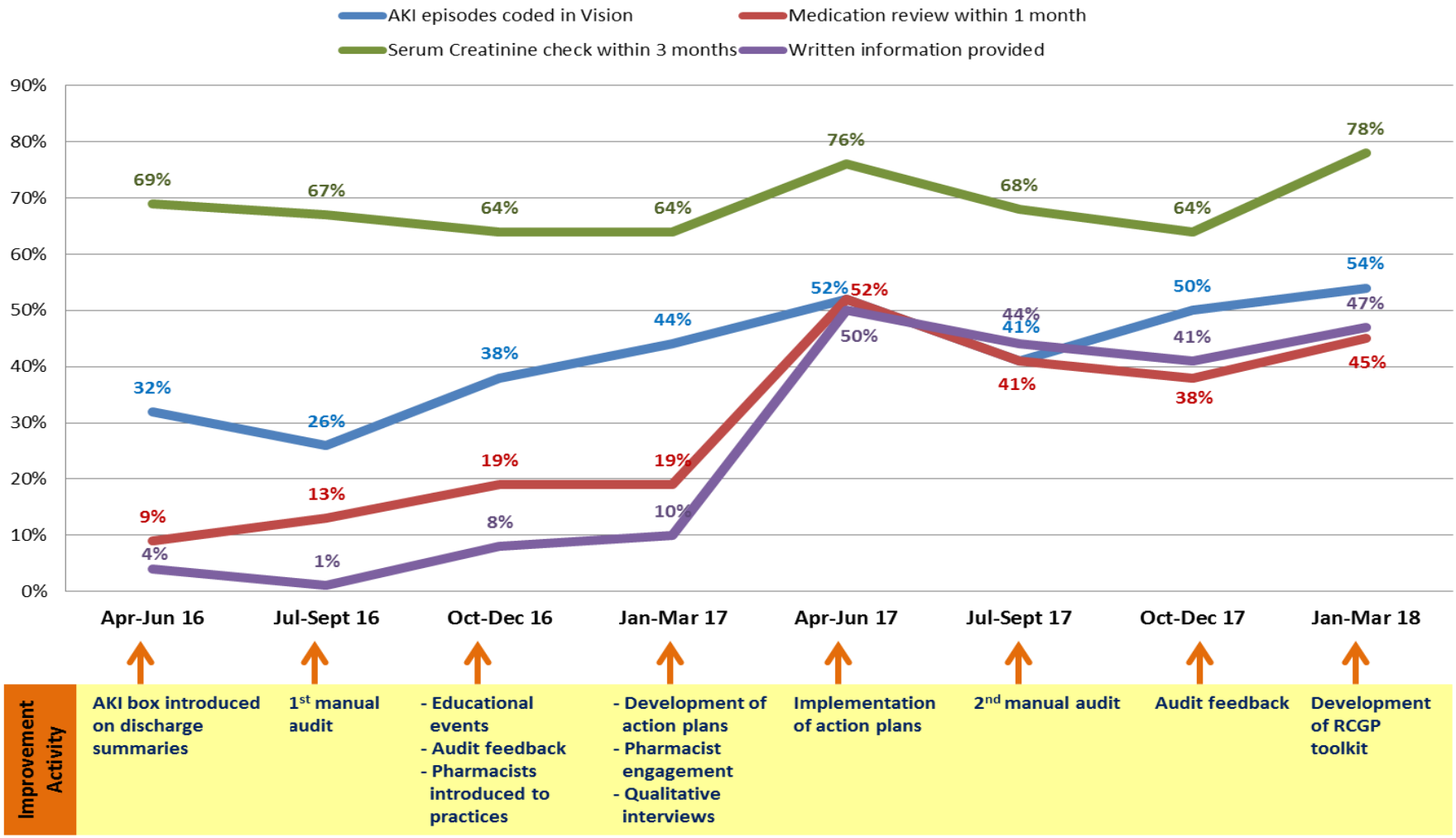
*Figure 7 Percentage of episodes with AKI Read coded who had received written information about AKI by quarter, NHS Bury CCG (2016-17 – 2017-18)*




### 2.2.5. Progression of Improvement Over Time

Figure 8 shows the trends in the four criteria measured, documented alongside when various interventions were delivered along the timeline. Please also refer to Appendix 1. There were a number of shifts around the period of the educational events, audit feedback action plan completion and pharmacist engagement. So far, there is evidence that the improvements have been sustained.

*Figure 8 Percentage of episodes with AKI on discharge summary who had the key indicators per quarter, NHS Bury CCG (April 2016 – March 2018)*



### 2.2.6. Additional Audit Data for 2017 - 2018

Whilst this project was underway some significant changes were introduced to the PAT discharge summaries (mostly from mid-2016). We were able to capture these indicators in the final manual audit (2017-18):

1.1 At the end of the discharge summary, a section was added for clinicians to indicate if the patient had had AKI whilst in hospital, using tick boxes to indicate: “Yes AKI” or “ No AKI”
2.1 A new section also allowed clinicians to state if a medication change had occurred
3.1 Results of blood tests were indicated in the discharge summary.

Table 4 summarises the additional data collected in the final (2017-18) audit period at the request of the CCG, exploring discharge summary details. Although the AKI box was completed on many (91%) of the discharge notices reviewed, fewer (53%) contained AKI notes at the front of the document. Stage of AKI and indication of medication review was often included, whereas the serum creatinine value at discharge was less frequently noted.

*Table 4 Additional audit data collated in 2017-8 around discharge summary details*

| Additional Data | 2017-18 | |
|---|---|---|
| | Number | Percentage |
| AKI noted at the front of the discharge summary | 447 | 53%[1] |
| AKI Box completed (back of discharge summary) | 766 | 91%[1] |
| "Yes AKI" | 520 | 68% |
| "No AKI" | 246 | 32% |
| Stage on discharge summary | 529 | 87%[2] |
| Stage 1 | 373 | 71% |
| Stage 2 | 108 | 20% |
| Stage 3 | 48 | 9% |
| Medication change in hospital noted on the discharge summary | 746 | 89%[1] |
| Last serum creatinine value provided on discharge summary | 276 | 33%[2] |

[1] Denominator n=838 episodes with a discharge summary available
[2] Denominator n=605 episodes with AKI mentioned in the discharge summary

## 2.3.Key Audit Summary Points

- The audit data demonstrates significant improvements in all four criteria measured, which was supported statistically.
- Read coding of AKI on practice systems appears to have a positive impact on the improvement of management of this patient population (based on the measures as defined in Section 2.1). Coding of AKI in primary care systems had a close association with improvements in downstream patient management to best practice in terms of: timely medication review, kidney function tests and written information being given to patients.
- The results show improvement of these measures from April 2017, around the time of education sessions, audit data feedback, completion of action plans, and pharmacist engagement.
- The audit noted improved annotation of information on discharge summaries over the course of the study period; with greater diagnosis, medication information and blood result details. However, from meetings with practices, it was apparent some information on discharge summaries could be interpreted as conflicting, and lacking a clear plan of action for ongoing care, which may benefit from further refinement.

# 3. The Outcome Evaluation

The outcome evaluation aimed to assess changes in health care outcomes; unplanned readmission, length of stay and mortality, for patients who had had a hospital admission complicated by AKI. Assessing the effect is important to understand whether the management of patients in primary care could impact on patient outcomes as well as lead to potential cost-savings in secondary care.

## 3.1. Outcome Evaluation Methods

**Data Sources**

We used Secondary Use Services (SUS) data from PAT, obtained via a data sharing agreement between PAT and NIHR CLAHRC GM. SUS contains records of all admissions to hospital. Data are available at individual patient and admission spell level and contain anonymised patient identifiers as well as detailed information on the admission episode and patient socio-demographics. These data were complemented by indicators of mortality (in and out of hospital) within numerous time periods from discharge, derived from PAT records.

### Sample Restrictions

To be consistent with the audit implementation we identified records with an AKI diagnosis using the ICD10 code N17.9. Admissions were restricted to those discharged alive. For consistency, in terms of examining rates of readmission, we used the first AKI admission over the study period for each patient as the index case[26].

### Sample Period

Data cover the time period from 1st April 2014 to 31st August 2018, with 1st April 2014 to 31st March 2016 serving as a two-year 'pre-intervention' period, and April 2016 to March 2018 serving as a combined 'implementation plus post-intervention period' upon which to evaluate the impact of the intervention. Data from 1st April 2018 to 31st August 2018 were used to identify readmissions within 90 days (and the subsequent length of stay for a period of up to two months) of patients discharged up to the 31st of March 2018. The two-year pre-intervention time period was selected to improve precision and to control for seasonality and trends over time. The post-intervention period was defined as starting from the day one of the QIPC contract (1st of April 2016).

### Outcomes Measured

The health outcomes were calculated at the patient level and aggregated at the GP practice – quarter level and include:

1. Hospital unplanned readmission within 7, 30, 60 and 90 days from discharge after an admission including an AKI complication, as a measure of improved management in primary care. The 90-day period accounts for the time required for patients to be added to a care planning register and to have had a 3 month review. Readmissions were identified by tracking the patient through the anonymised identifier, and unplanned readmission identified as admissions with any emergency code in the admission methods.

2. Mortality within 7, 30, 60 and 90 days after an AKI episode.

3. Average length of stay at first readmission within 90 days and total number of bed days across all readmissions within 90 days from discharge, as proxies of the severity and financial consequences of the readmission. Length of stay was calculated as the difference between date of discharge and date of admission plus one.

We focus on the results for length of stay, number of bed days and readmission and mortality within 30 and 90 days, as these are the outcomes with the most clinical relevance.

## Methods of Analysis

### *Risk-adjustment*

Consistent with previous studies[27,28], risk-adjusted outcomes were computed by comparing observed rates of mortality and readmission and observed average length of stay and bed days to their expected levels. Predicted outcomes for each patient were first calculated using patient-level logistic models (for mortality and readmissions) and ordinary least squares regressions (for length of stay and bed days), based on patient demographics and comorbidities that were hypothesised to affect outcomes. The included variables were: if the patient is of white ethnicity, age, gender, if the admission was from his/her home, if the discharge was to his/her place of residence, the primary diagnosis group[29] and his/her comorbidities (data not shown). Individual-level risk-adjusted outcomes were then calculated as the difference between observed and predicted outcomes and aggregated to the GP-practice-quarter level.

### *Difference in Difference Estimation of the Intervention Effects*

We assessed the effect of the intervention on health care outcomes using a controlled before-and-after study design and a difference-in-difference (DiD) identification strategy[30].

The DiD methodology consists of identifying the change in outcomes over time in a 'treatment group' (those exposed to the intervention) over and above the changes over time observed in a 'comparator group' (those not exposed to the intervention). Changes in outcomes in the comparator group are assumed to reflect outcome changes that would have occurred in the treatment group had the intervention not been implemented. The sample for this study consisted of patients discharged from PAT, with patients registered with a GP practice in NHS Bury CCG constituting the intervention group and patients registered with GP practices in Oldham, HMR and North Manchester CCGs forming the comparator group. As patients from both groups are treated at the same hospital trust, differences in outcomes can be attributed to differences in primary care treatment.

Intervention effects were therefore calculated as the difference in outcomes for GP practices in Bury between the pre and post-intervention period, net of this same difference for GP practices in Oldham, HMR and North Manchester. These were estimated via multivariable analysis. Risk-adjusted outcomes were regressed on a binary variable identifying whether or not a GP practice was situated in NHS Bury CCG and was observed after the start of the intervention (1st of April 2016). The size and significance of the coefficient associated with NHS Bury CCG GP practice in the post-intervention period indicate the effect of the intervention on health outcomes.

### *Lagged Dependent Variable (LDV) Estimation*

The validity of the difference-in-difference method relies on the assumption of parallel trends in health care outcomes in the pre-intervention period between intervention (Bury) and comparator (non-Bury) GP practices. We tested the assumption and when it was not supported, we used the best available alternative[31]. The Lagged Dependent Variable approach controls for values of the outcomes in all pre-intervention periods and therefore does not rely on the assumption of parallel trends.

### *Differences in the Effect of the Intervention by Process Performance*

After assessing the average impact of the intervention, we then examined whether the effect of the intervention differed between 'high performing' practices and other practices. We identified high performance as above average levels of diagnostic coding and provision of a medication review within one month of discharge, as shown by the 2017-18 audit.

## 3.2. Outcome Evaluation Results

### Admissions to PAT Complicated by AKI

Table 5 presents the numbers and percentages of AKI and non-AKI admissions to PAT for patients registered with GP practices in Bury, HMR, Oldham and North Manchester over the financial years 2014/15 to 2017/18. Both the volumes and the relative percentages of admissions with an episode of AKI increased over time in the four CCGs, except in 2017/18 when there is a mild reduction in volumes and percentages in Bury and North Manchester, and in percentages in HMR.

*Table 5 Admissions to PAT with and without a diagnosis of AKI (1st of April 2014 to 31st of March 2018), by CCG and financial year percentage in italics*

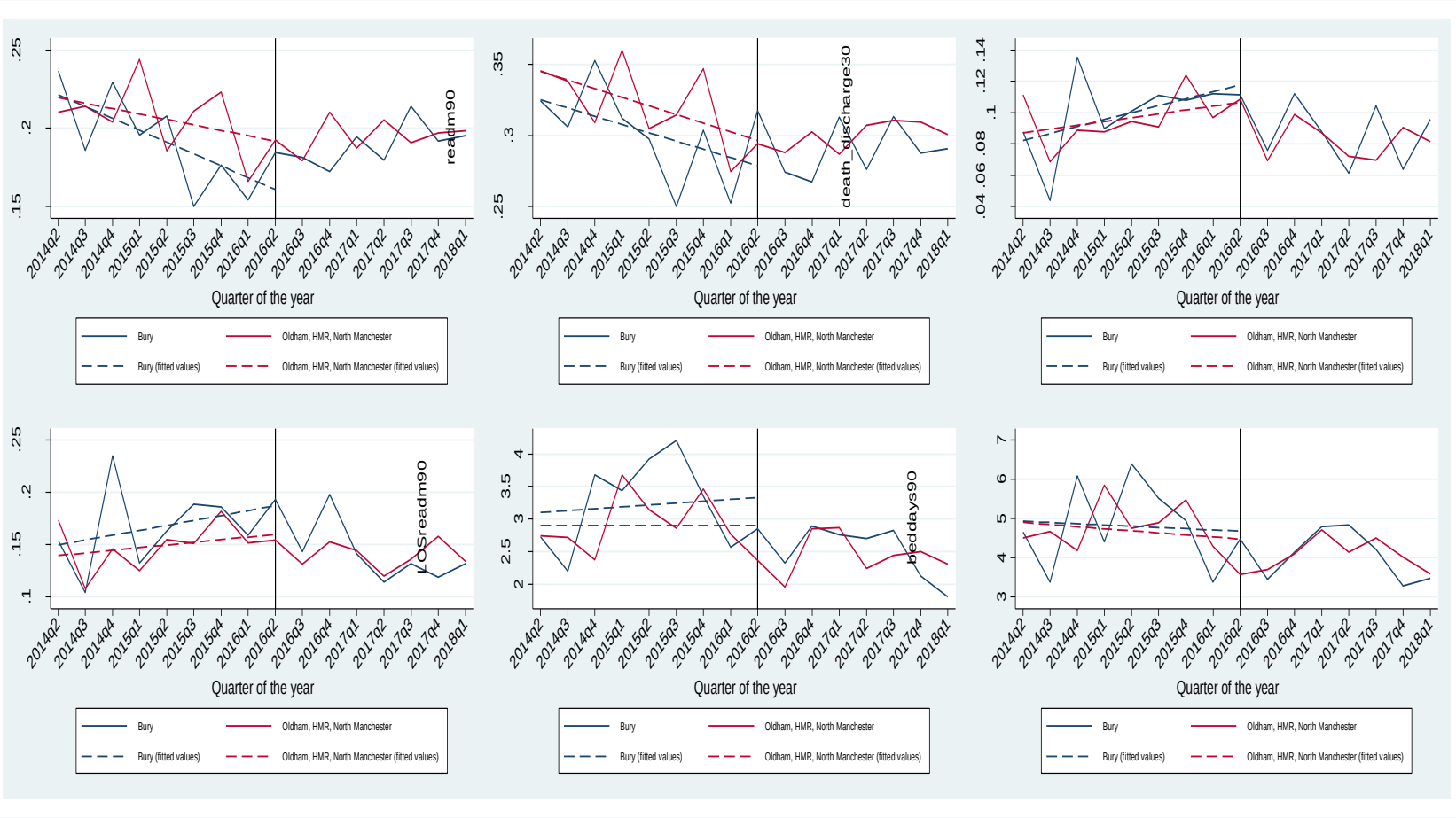
| | 2014/15 | 2015/16 | 2016/17 | 2017/18 |
|---|---|---|---|---|
| **Bury** | | | | |
| Without AKI | 36,960 | 35,417 | 36,248 | 37,349 |
| | *96.99* | *96.52* | *95.76* | *96.13* |
| With AKI | 1,147 | 1,276 | 1,606 | 1,502 |
| | *3.01* | *3.48* | *4.24* | *3.87* |
| **Total** | 38,107 | 36,693 | 37,854 | 38,851 |
| | *100.00* | *100.00* | *100.00* | *100.00* |
| **HMR** | | | | |
| Without AKI | 53,164 | 49,865 | 48,193 | 52,576 |
| | *97.12* | *96.48* | *95.94* | *96.09* |
| With AKI | 1,574 | 1,819 | 2,040 | 2,138 |
| | *2.88* | *3.52* | *4.06* | *3.91* |
| **Total** | 54,738 | 51,684 | 50,233 | 54,714 |
| | *100.00* | *100.00* | *100.00* | *100.00* |
| **Oldham** | | | | |
| Without AKI | 57,165 | 54,986 | 54,207 | 56,733 |
| | *97.62* | *97.11* | *96.75* | *96.72* |
| With AKI | 1,391 | 1,637 | 1,821 | 1,923 |
| | *2.38* | *2.89* | *3.25* | *3.28* |
| **Total** | 58,556 | 56,623 | 56,028 | 58,656 |
| | *100.00* | *100.00* | *100.00* | *100.00* |
| **North MCR** | | | | |
| Without AKI | 33,792 | 30,640 | 29,326 | 28,962 |
| | *97.27* | *96.54* | *96.08* | *96.48* |
| With AKI | 948 | 1,099 | 1,198 | 1,056 |
| | *2.73* | *3.46* | *3.92* | *3.52* |
| **Total** | 34,740 | 31,739 | 30,524 | 30,018 |
| | *100.00* | *100.00* | *100.00* | *100.00* |

The rates of readmission within 90 days in Bury decreased from 32% in 2014/15 to 29% in 2017/18. Table 6 presents the main causes for readmission (within 90 days) classified according to the primary diagnosis[29]. Pneumonia and urinary tract infections were the most common, followed by acute and unspecified renal failure, congestive heart failure, septicaemia & shock, and COPD and bronchiectasis.

*Table 6 Main causes of unplanned readmission following an inpatient stay with a first AKI complication (1st of April 2014 to 31st of March 2018)*

| Primary diagnosis group | Frequency | Percentage |
|---|---|---|
| Pneumonia (excluding TB/STD) | 529 | 12.16 |
| Urinary tract infections | 323 | 7.43 |
| Acute and unspecified renal failure | 216 | 4.97 |
| Congestive heart failure; non hypertensive | 214 | 4.92 |
| Septicaemia (except in labour), Shock | 156 | 3.59 |
| COPD & bronchiectasis | 150 | 3.45 |
| Skin and subcutaneous tissue infections | 102 | 2.35 |
| Acute bronchitis | 96 | 2.21 |
| Intestinal infection | 91 | 2.09 |
| Fluid and electrolyte disorders | 87 | 2.00 |
| Other connective tissue disease | 79 | 1.82 |
| Gastrointestinal haemorrhage | 69 | 1.59 |
| Cardiac dysrhythmias | 68 | 1.56 |
| Acute cerebrovascular disease | 64 | 1.47 |
| Aspiration pneumonitis; food/vomitus | 63 | 1.45 |
| Superficial injury; contusion | 59 | 1.36 |
| Acute myocardial infarction | 58 | 1.33 |
| Genitourinary symptoms & ill-defined conditions | 58 | 1.33 |
| Complication of device; implant; or graft | 58 | 1.33 |
| Diabetes mellitus with complications | 55 | 1.26 |
| Complication of surgical procedures or medical care | 55 | 1.26 |
| Organic mental disorders | 54 | 1.24 |
| Allergic reactions, aftercare & screening, R codes | 53 | 1.22 |
| Fracture of neck of femur (hip) | 52 | 1.20 |
| Skin disorders | 50 | 1.15 |
| Other circulatory disease | 1490 | 34.26 |
| **Total** | **4,349** | **100** |

*Figure 9 Readmission, mortality, length of stay and number of bed days following an inpatient stay with AKI (1st of April 2014 to 31st of March 2018), Bury and Control by quarter*




*Note: readm30 and readm90 are the outcome measures readmission within 30 and 90 days; death_discharge30 and death_discharge90 are the outcome measures mortality within 30 and 90 days; LOSreadm90 is the outcome measure readmission length of stay; beddays90 is the outcome measure bed days within 90 days.

### Effects of the Bury Intervention

Figure 9 presents the average outcomes across GP practices in Bury and HMR, Oldham and North Manchester, by quarter, across the whole study period. The vertical axes represent the average probability of readmission or mortality (from 0 to 1) and the average number of days at first readmission or in the 90 days following discharge. The dashed line represents the linear outcome trends over the pre-intervention in the Bury and comparator groups. The graphs suggest that there was a reduction (i.e. an improvement) in outcome measures over time in all CCGs, and that it was happening at a different pace (non-parallel trend) in the pre-intervention period, except for readmission within 90 days from discharge. Table 7 reports the mean outcomes in the Bury and comparator groups before and after the intervention, and the impact of the Bury intervention, estimated using either difference-in-difference or lagged dependent variable regressions, depending on whether the pre-intervention trends were found to be parallel.

*Table 7 Effect of Bury intervention on readmission, mortality, length of stay and number of bed days*

| Outcome | Period | Mean outcomes | | Parallel trends | Effect‡ | 95% Confidence interval |
|---|---|---|---|---|---|---|
| | | Bury | Control | | | |
| Readmission within 30 days | Pre | 0.15 | 0.17 | Non-parallel | -0.011 | [-0.032; 0.010] |
| *(Probability: 0 to 1)* | Post | 0.16 | 0.16 | | | |
| Readmission within 90 days | Pre | 0.24 | 0.26 | Parallel | 0.014 | [-0.024; 0.052] |
| *(Probability: 0 to 1)* | Post | 0.25 | 0.25 | | | |
| Mortality within 30 days | Pre | 0.08 | 0.08 | Non parallel | 0.007 | [-0.010; 0.023] |
| *(Probability: 0 to 1)* | Post | 0.07 | 0.07 | | | |
| Mortality within 90 days | Pre | 0.13 | 0.12 | Non parallel | 0.002 | [-0.019; 0.024] |
| *(Probability: 0 to 1)* | Post | 0.12 | 0.12 | | | |
| Readmission length of stay | Pre | 2.53 | 2.37 | Non parallel | 0.007 | [-0.311; 0.325] |
| *(Number of days)* | Post | 2.12 | 2.04 | | | |
| Bed days within 90 days | Pre | 3.76 | 3.9 | Non parallel | 0.108 | [-0.473; 0.689] |
| *(Number of days)* | Post | 3.42 | 3.35 | | | |

We report estimation results from the lagged dependent variable estimation if the parallel trends assumption fails. GP-practice clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. The total number of observations is 2,234. Outcomes relate to the first admission complicated by AKI in the time period covered by the analysis. Readmission indicates unplanned readmissions after discharge, death

indicates death after discharge. Length of stay is the number of nights of the first readmission after discharge within 90 days. Number of bed days indicates the total number of bed days within 90 days from discharge including all readmissions. All analysis includes GP-practice fixed effects quarter of the year fixed effects. We risk adjust on the individual level by including average GP-levels of: gender of the patients, age of the patients, residential hospital admission, residential hospital discharge, Elixhauser co-morbidities of the patients, and the primary diagnosis group of the patients.

The effects represent the change in the probability of readmission or death (percentage points divided by 100) or the change in average length of stay (LOS) and the number of bed days, due to the intervention. However, if the confidence interval includes zero, the effect is not statistically significant. We do not find a significant difference in the effect attributable to coding and medication review of the Bury intervention in the 'high performing' practices versus other GP practices, in Bury and in other CCGs (Appendix 3).

## 3.3. Key Outcome Evaluation Summary Points

- Despite the improvements in primary care processes associated with the Bury intervention there was no effect on hospital and mortality outcomes on average in the two years following the start of the Bury intervention in April 2016.
- There was no difference in outcomes between GP practices within Bury compared with those in other CCGs, that could be attributed to performance in terms of diagnostic coding and medication reviews (above average levels in 2017-18).
- Intervention effects may emerge in the longer-term; exploring the specific cause of readmission, severity of AKI, or for specific population sub-groups may be of use.

# 4. The Process Evaluation

## 4.1. Process Evaluation Methods

The overall aim of the qualitative study was to understand and explore the processes of implementing improvements to the post-discharge coding and management of patients who have had an episode of hospital care complicated by AKI. In order to gain an in-depth understanding of implementation within general practices, we adopted a qualitative approach and used semi-structured interviews. The sampling strategy was purposive, to ensure that we included general practices with a variety of approaches to implementing the intervention. Relevant stakeholders were invited to participate; general practitioners, practice nurses, practice managers and administrators, medicines optimisation pharmacists and technicians, CCG strategic leads.

The interviews focussed on the experiences of people involved in implementing the processes of care. This included exploration of the context in which they work in order to identify structures, systems, processes and practices relevant to implementing the intervention, experiences of and views about the intervention and the working practices involved in its implementation. Key areas of questioning were: experiences of managing the risk of AKI generally, prior to the project; experiences of the audit, feedback and education intervention; experiences of and views about the processes of care and how these could impact on patient health; experiences of communicating with patients about AKI, and how the project fits within the wider health and social care system.

The interviews were audio recorded using digital recorders and transcribed by professional transcribers. Ethical approval was obtained from a University research ethics committee. Informed written consent was obtained from all participants. Data analysis followed a thematic approach and was informed by the study objectives and relevant academic theories.

## 4.2. Process Evaluation Results

Eighteen people participated in interviews between June and November 2017. The interviews lasted between 16 and 53 minutes, with most being around half an hour in duration. The interviews took place across eight general practices. Table 8 summarises the participants by practice and occupational role. Throughout this report, all participants have been anonymised with a reference relating to their occupational role and the general practice they were based at, for example, Practice manager 01 was based at practice 1, GP 03 was based at practice 3.

*Table 8 Interviewees by occupational role*

| Practice | Occupation | | | |
|---|---|---|---|---|
| | **Practice manager/ administrator** | **General practitioner** | **Pharmacist** | **Total** |
| **1** | 1 | 1 | 0 | 2 |
| **2** | 1 | 0 | 1 | 2 |
| **3** | 1 | 1 | 1 | 3 |
| **4** | 1 | 1 | 1 | 3 |
| **5** | 1 | 1 | 0 | 2 |
| **6** | 2 | 1 | 1 | 4 |
| **7** | 1 | 0 | 1 | 2 |
| **8** | 0 | 0 | 1 | 1 |
| **Total** | 8 | 5 | 6 | 19* |

*one individual double-counted due to role spanning practices 6 and 7

**Context and Educational Events**

Practices in NHS Bury CCG had previously been involved with work focussed on CKD and the project was generally seen as building on this. Although those in clinical roles unsurprisingly had knowledge about the kidneys and how they function, they had had little experience of dealing with AKI directly:

> *'there isn't good awareness across the board is there, be it primary or secondary care, of AKI...I think it's one of those things that…I think clinicians are aware there's a problem, but it's such a big problem it's almost unspoken of…It seems like it's an issue that if you tackle it you're opening Pandora's box to a certain extent.'* (GP 01).

The educational events were generally well received by all types of participant. GPs did not generally think the content had added to their clinical knowledge, whereas pharmacists particularly appreciated the clinical material in the presentations and also the resources supplied. Pharmacists contrasted the content of the events with other, pharmacy training they had attended, which they thought gave too much attention to soft communication skills and did not equip them with clinical knowledge compared with the

educational events for this project. Practice managers and administrators tended to have little or no knowledge about AKI before the events and felt relieved to discover that people in other practices were in a similar position of not recognising or being able to act on it. Most practices sent one or two members of staff to the events and the content was fed back to colleagues, for example during regular protected training times. All groups of participants said it had increased their appreciation of the importance of identifying and managing AKI, by following the processes of care and felt they had been provided with useful sources of information. Participants generally felt that the sessions had helped equip them for producing action plans and implementing the processes.

The project was generally seen as extending existing work, with the main changes being the increased recording of information, both through Read coding of AKI and also the recording of the processes of care. There was a recurring sense that GPs were aware that there would be occurrences of AKI that would not have been recorded in their patient records; we asked participants for their response to the manual audit figures for their practice and most were unsurprised that the numbers of patients Read coded with AKI were low:

> *'[the audit] highlighted to me that we weren't necessarily at the time Read coding patients that had been picked up as having AKI on discharge…there were…patients that the information was on but the correct Read code wasn't on.'* (GP 05)

GPs had been monitoring patients' kidney function and reviewing their medication before the project, so those processes of care were not new, but there was general agreement that these were being done more consistently:

> *'We used to do them selectively...but now everyone with a diagnosis of AKI will go through the same process, so it's more organised, more focussed.'* (GP 04)

There was general agreement that the project had encouraged a more organised approach to the care of patients with AKI. Various changes in the way information was recorded and acted on were mentioned:

> *'It's just identifying that we're already doing something might not be …putting the right Read code on or maybe not necessarily Read coding that you've done a medication review, even though you have…it's more a case of falling into a [standardised] process rather than doing something new.'* (Practice pharmacist 02)

There was a recurring sense that the project had encouraged a more active focus on AKI:

*'I'm more actively looking for AKI on discharge summaries. I'm actively looking for the risk of having AKIs in patients…I'm actively looking at patients' blood results and looking at whether they're at risk. So maybe I can do something about it before they actually have the episode. I think that's key for me because when I do medication reviews we're looking at how the patient's treated, what can we do to make their conditions better, medicines are optimised…now…for me it's looking at what we can do to prevent AKI from occurring.'* (Pharmacist 04)

The intervention was focussed on improving the identification and recording of AKI and streamlining care processes that already existed, rather than implementing a new process. Accordingly, it was not surprising that participants tended to report that the relevant processes, particularly performing blood tests and reviewing patients' medication, were already occurring in their practices but that the project had brought an increased focus on AKI and encouraged more organised management of AKI patients.

**Workforce and Roles**

At the practices, people in a range of roles were involved in carrying out the processes of care. Reviewing discharge summaries and Read coding of patients with AKI tended to be carried out by GPs and/or administrators, for example, at practice 1 an administrator worked through all the discharge summaries and Read coded those with AKI, with the deputy practice manager acting as a 'safety net' by double checking the coding, whilst at practice 6 the GPs read the discharge summaries first and then passed them to an administrator for Read coding. The GP at practice 3 thought administrative staff were better placed than clinicians to be coding as they have more opportunity to focus on that rather than dealing with the patients in front of them and the practice manager described the key role that administrators played in coding:

*'So having the laminated sheet [of Read codes provided by the CLAHRC team] on the medical secretary's desk is as important as having it on the clinician's desk. 'Cause she'll see the letters first, and if it's an AKI diagnosis she should be recording it as a matter of course. If she misses it, and it goes through to the clinician then he or she will also be able to record it. But the first point of call is probably the medical secretary.'* (Practice manager 03)

The clinical follow-ups did not necessarily need to be done by GPs:

*'As far as the clinical role goes often a lot of that stuff falls in my lap. Or at least for me to help organise from a clinical perspective. That doesn't necessarily have to be me. We've got our pharmacists in our surgery, as well. We've got practice nurses. So the whole team, really, should chip in. If there's something that a non-GP can do, I'm keen for them to do it. […] So while the HCA can do the repeat blood test,*

> *there's no reason for him to see me for that. Perhaps, I see him after that to review…and then we've got a pharmacist, excellent with medication reviews. Perhaps, sees some scenarios better than GPs. So I think, as long as I'm directing the traffic to the right clinician, I think that's important.'* (GP 02)

Pharmacists were involved in the processes of care at several practices, particularly with providing medication reviews. At practice 6, the pharmacist acted as a point of contact for the project within the practice, using the practice computer system to identify patients needing medication review and undertaking these and signposting GPs to information resources (such as the Think Kidneys resources). Pharmacists described working alongside GPs, for example, where a GP had initially stopped some medicines for a patient with AKI, the pharmacist could pick this up and perform a more detailed medication review. However, whilst pharmacists were enthusiastic about their contribution to AKI care, there was a sense of a lack of direction as to what their remit should and could be. There was a marked difference in levels of pharmacist's involvement and the level of responsibility they were given for different pharmacists and across different GP practices. Reasons mentioned for this included: the complex nature of AKI patients; how experienced and confident the pharmacist was; how the system for coding and work allocation is set up in different GP Practices; and the level of delegation generally that individual GPs are happy with. In addition, pharmacists were employed directly by individual practices, by the GP federation and by the CCG and all pharmacists interviewed worked in at least two different practices; these issues meant that pharmacists' work arrangements were complex and they had to manage competing demands on their time.

> *'As a pharmacist I'd like to sit down [with the patient] and go through all of their medicines and explain what they do…so providing information as to how to prevent AKI…that's a section…that I find difficult to complete and feel positive and confident that it's actually been done properly…according to the GPs if it's something that you can do over the phone they'd rather you do it over the phone…to check to see if somebody understands something over the phone is a lot harder than to do just do it in person.'* (Pharmacist 02)

The project highlighted the need for multidisciplinary working to manage patients with AKI. For pharmacists in particular, there were opportunities to expand their contribution in primary care. However, various challenges to doing this were also experienced.

**Communication and Engagement**

Several interviewees referred to a constantly changing primary care environment, where new 'hot topics' or requirements for new services or new tests are constantly emerging

and it can seem that 'everything's really important'. Each practice had multiple care pathways running simultaneously, so it was important for the project to be actively managed, separately from the general work of the practice. The process or parts of it were proactively managed by people in different roles co-ordinating the processes or taking responsibility for particular parts. For example, practice 2 had two systems running, which provided information about patients' medication changes. The pharmacists can access these systems, so in theory they would be able to identify AKI patients needing medication reviews, however, the practice thought that patients would get 'lost in the general work' and so details of all AKI patients were sent directly to one pharmacist, which they thought was beneficial. A GP at another practice described a similar approach:

> *'There's a specific admin team member that's been identified to take leadership…It's quite complex and lots of appointments are needed…I think if you just allow that just to go into the ether to a certain extent it's quite easy to lose the thread and…they don't get the bloods, they don't get the medication review.'* GP 01.

Communication between primary care and hospitals about patients with AKI has tended to be limited. Patients registered at Bury practices used different hospitals and the standard of discharge summaries varied between hospitals. Although the standard was generally acknowledged to be good, AKI diagnoses were not always prominent and could be missed. GPs also reported that the information provided on discharge summaries was sometimes conflicting, for example, a diagnosis would be mentioned on the summary but the tick box designed to indicate a diagnosis of AKI was not used:

> *'I think how clear it is on the discharge as well is a bit of an issue. I think it's nice and clear on the Pennine discharges. I think some of the other hospitals in the Greater Manchester area I think it's less easy to pick up that there's an alert on there…I think some discharges are really clear and easy to read, and I have to say Pennine's quite good…most of them will be going to Pennine. I think both central and Salford's discharge form is…there's a block of text rather than clear, distinct sections. I think it's difficult to pick up that somebody's written something in the section if it's just there, whereas, say, Stockport does say, which is quite a good example, and Pennine has quite clear, distinct sections of inpatient… Obviously if they wanted us to be picking up that something has happened it needs to be clear and the discharge form needs to be readable*.' (GP 01).

> *'This last week I've had about three or four…on the discharge as a diagnosis [of AKI] but further on they've got a box that says 'has this patient had AKI?' and that said 'no'. So…I've got to go back to have a look…and…pull the results from the hospital and confirm that yes, it actually was an episode of AKI.'* (GP 04)

Communication with patients about AKI was undertaken by GPs and pharmacists, overall, both groups of professionals found that patients' awareness about kidney health in general and AKI in particular tended to be low. GP 04 reported that over the last 12 months or so she had started to have more conversations with patients about kidney health. Some of these conversations were initiated by her, typically when prescribing NSAIDs, about sick day guidance. Patients were also noticing CKD and AKI written on letters they had received and had been asking her what the terms meant. The leaflets about risk of AKI were provided to patients during consultations and were also posted out.

## 4.3 Key Process Evaluation Summary Points

- The educational events were generally well received by all types of participant. GPs did not generally think the content had added to their clinical knowledge, whereas pharmacists particularly appreciated the clinical material in the presentations and also the resources supplied.

- The project was generally seen as extending existing work, with the main changes being the increased recording of information, both through Read coding in the patient notes that they had had AKI and also recording the processes of care that were then put in place.

- The project highlighted the need for multidisciplinary working to manage patients with AKI. For pharmacists in particular, there were opportunities to expand their contribution in primary care; however, various challenges to doing this were also experienced.

- The standard of discharge summaries was generally good, but there were inconsistencies between trusts and AKI was not always prominent and could be missed.

# 5. Discussion

### Summary of key findings

The evaluation demonstrated improvements in post-AKI care processes. Activity increased significantly for all four audit measures during the study period: diagnostic coding of AKI in primary care, medication review, communication of AKI risk to patients; and monitoring of kidney function. Improved diagnostic coding was associated with improvements in subsequent processes of care.

Despite improvements in primary care processes, on average, compared with comparator CCGs there was no effect on hospital and mortality outcomes in the two years following the start of the Bury Intervention. This included no difference in outcomes being observed between higher and lower performing practices as defined by evidence of diagnostic coding and medication reviews.

The audit noted improved annotation of information on discharge summaries; with greater diagnosis, medication information and blood result details. However, qualitative data suggests some information on discharge summaries could be interpreted as conflicting, and lacking a clear plan of action for ongoing care, which may benefit from further refinement.

The educational events were generally well received by GPs, pharmacists, practice managers and administrators. There was agreement the events increased appreciation of the importance of identifying and managing AKI and also helped participants feel better prepared for planning and implementing the relevant care processes. Pharmacists in particular appreciated the clinical content of the sessions, which they thought was important in equipping them to provide care to patients with AKI. This was contrasted to previous pharmacy training that focussed more on ‘soft’ skills but provided less clinical knowledge. Challenges faced by pharmacists includedfitting the demands of the project in with their conflicting workload priorities and their concern about patient understanding when they were not able to communicate with patients face to face.

### Strengths and limitations

Across the UK and worldwide, there is increasing recognition of a need to invest in the design and evaluation of interventions to improve post-AKI care.[32] Through local incentives, Bury CCG implemented a relatively non-intensive intervention package comprising: audit; education; and practice action plans. In doing so, this project provides a framework to support delivery of a national NHS patient safety alert requiring all NHS

providers to ‘develop an action plan to ensure any relevant resources are used to improve local systems and processes for the care of patients with AKI.’[33]

The findings from the evaluation demonstrate that, in isolation, the introduction of national incentives in secondary care (CQUIN) are insufficient to transform care and outcomes across settings for this high risk patient population.[11] Rather, the CQUIN can be seen as a starting point, with the evaluation suggesting it was the CQUIN implementation in conjunction with the Bury CCG intervention that has supported delivery of a key national goal to improve awareness and engagement amongst GPs on AKI.[11]

Effects on health outcomes may emerge in the longer-term through the continued improved provision of targeted care. Future impact evaluations should seek to understand intervention effects by specific cause of readmission, severity of AKI, or by specific population sub-groups. The current estimated effect is an average across patients of with different severity levels and the effects of the intervention on more severe patients may be diluted.

Evaluation of implementation in post-AKI care processes in NHS Bury CCG was limited to use of before and after study methods. Furthermore, the approved information governance agreement restricted the audit to patients who were alive and registered at the time of the annual audit (excluding about 60% of patients). However, an output from the project has been the development of ‘AKI Business Rules’. That is, through collaboration with Vision, the manual audit supported the identification of relevant Read codes leading to the development of an algorithm to measure key care processes. It offers the potential for more timely audit and feedback within and across practices. The ‘AKI Business Rules’ also provides a platform to scale up the evaluation of post-AKI care through implementation in other CCGs or through existing databases (e.g. Clinical Practice Research Datalink[34] SAIL Databank[35]). In doing so, the project represents a key step to understanding and addressing variation in care delivery both regionally and nationally.

A key national aim is to develop an evidence based approach to improve care and outcomes for people who have had an episode of illness complicated by AKI. Evaluation of this intervention enabled greater understanding in the implementation of care recommended processes (coding; medication review; communication of AKI risk; kidney monitoring). Further research is required to understand medicine reconciliation and its association with outcomes following hospital discharge.[36,37]

**Comparison with the existing literature**

The rates of readmission in NHS Bury CCG in 2017/18 were 19.4% at 30 days and 29% at 90 days. This is comparable with data from Canada. Silver et al (2017) conducted a large population based study of patients discharged following a hospitalisation complicated by

AKI across 197 hospitals in Ontario between 2003 and 2013. Of the 156,690 patients identified, they found a readmission rate of 18% at 30 days post-discharge with a median time to readmission of 11 days.[26] Sawhney et al (2017) analysed data from a large population 2003 cohort in Scotland, which showed 18.6% of patients had been readmitted or died within 90 days of discharge.[38]

The quantitative evaluation indicated that respiratory causes (pneumonia and exacerbation of COPD), urinary tract infections, further AKI; congestive health failure and sepsis were the most common reasons for readmission. These findings resonate with evidence from Canada and Scotland.[26,38] Silver et al showed that heart failure, AKI, COPD, palliation and urinary tract infections were the most common causes for 30-day rehospitalisation and acute pulmonary oedema was the most common cause for readmission in Scotland.[26,38] In doing so, it highlights a need to align AKI-related care with guidelines for the management of patients with existing co-morbidities including heart failure and COPD. In conjunction with the wider literature, they also suggest a need to embed AKI strategies within the assessment and management of sepsis.[39] The relationship between post-AKI care and the introduction of policies and strategies focused on frailty also warrants consideration.[40]

Though there was evidence of improvement in post-AKI care processes, no effect was demonstrated in terms of effects on re-hospitalisation or mortality. Currently, guidance on post-discharge care is largely consensus based focused on ensuring accurate coding and timely follow-up in terms of communication of AKI risk, medicines optimisation and monitoring of kidney function. Longer term follow-up may be required to evaluate the effects of the Bury intervention. However, an alternative hypothesis is that the intervention enabled engagement but that a more intensive intervention across the interface may be required.

A recent multi-centre stepped-wedge trial indicated that AKI complicates around 8% of all hospital admissions.[41] However, in 2016/17, NICE piloting of AKI indicators showed low levels of diagnostic coding, with an average of 3 patients per practice/year (range 0-9) being assigned the relevant Read codes in general practice post-discharge.[22] The Bury intervention has demonstrated that it is possible to address this implementation gap. As such, it represents an important next step to ensure safer transitions of care for this high risk patient population. Historically, there has been a reticence to communicate the risks associated with CKD and reduced kidney function. A key principle underpinning the project has been a need to navigate the challenge of over-diagnosis: to maximise the utility of AKI as a driver of quality and safety whilst minimise the potential for treatment burden for patients and carers as well as unnecessary workload for clinicians and primary care teams. The process evaluation indicates that GPs' view AKI as part of their existing work and that it also resonates with pharmacist's clinical practice. It suggests that ensuring AKI-related activity that is aligned with existing work (e.g. care planning for vulnerable patients)

contributed to buy-in and improvements in care processes. The intervention was informed by an evidence base that demonstrates the benefits in combining incentives, education and informatics feedback to reduce high risk prescribing behaviour in UK primary care.[18] The Bury post-AKI care project built on a previous practice engagement with an NIHR CLAHRC GM CKD Quality Improvement project, and the fact it aligned with the local quality improvement contract was also seen by some to provide resource to focus on AKI QI activity in an environment of competing priorities.

For pharmacists in particular, there were opportunities to expand their contribution in primary care; however, various challenges to doing this were also experienced. Pharmacists reported difficulties in terms of fitting the demands of the project in with their conflicting workload priorities. Their concern about patient understanding when they were not able to communicate with patients face to face are similar to the issues reported in a previous AKI initiative, where pharmacists were based in GP practices.[42] Another recent study in primary care found that whilst there was good role recognition for pharmacists working in GP practices, there was still sometimes confusion over the nature of their role.[43]

**Implications, added value and recommendations**

Current best practice suggests clinicians focus improvements in the following areas to improve care for patients with AKI. We identify those key areas, backed up with evidence derived from this study, and identify recommendations for activity moving forward.

***Ensuring Safer Transitions of Care***

It is a requirement for all NHS providers to 'develop an action plan to ensure any relevant resources are used to improve local systems and processes for the care of patients with AKI'.[33]

- Through this project, we have developed and implemented a model of care to improve post-discharge care for patients who have experienced illness complicated by AKI.

There is evidence that quality improvement activities focused on tackling the harm associated by AKI are recognised by the Care Quality Commission (CQC) as a feature of outstanding practice. Practices and CCGs may wish to focus on AKI as an exemplar for embedding safe systems of care for patients with complex health and social care needs. In 2018, with regards to Salford Royal Foundation Trust, the CQC stated that 'The trust was working to improve outcomes for patients with AKI and the wards involved had seen a reduction in patients developing AKI while in hospital and a reduction in patients progressing from early stage AKI to more severe AKI'.[44]

- Some practices reported benefits in developing a practice protocol to help clarify roles and ensure collective responsibility. As a marker of vulnerability, there was

evidence of aligning AKI-related care within existing approaches to care planning.

- Some practices in NHS Bury CCG conducted AKI case note reviews as part of another NIHR CLAHRC GM study, which in conjunction with learning generated through this project informed the development of the RCGP Acute Kidney Injury Toolkit.[45]
- The wider literature highlights a need for quality improvement activities to focus on system factors impacting on patient safety; aggregate data to encourage learning and improvement within and across organisations that involve patients and carers.[46-48] AKI provides a lens to improve safety across the interface between primary and secondary care.
- Feedback from the educational events was very positive, and qualitative interviews supported that they had been important in driving understanding, ownership of the work, and subsequent activity. Due to the turnover of staff, it therefore may be beneficial to ensure the developing workforce continue to have access to AKI education/resources going forwards. NIHR CLAHRC GM have co-produced an Royal College of GPs AKI toolkit specifically designed for multi-workforce primary care staff which may be of use to support this.[45]

***AKI Diagnostic Coding***

NICE (NM152) recommend that practices establish and maintain a register of all patients who have had an episode of AKI.[49]

- There is evidence that practices in NHS Bury CCG have engaged with this national recommendation leading to significant local improvements in diagnostic coding.
- The audit showed that Read coding of AKI in primary care is positively associated with improvements in downstream management; therefore the CCG may wish to consider approaches to improve coding further for this patient population.
- The variation in achievement of audit criteria differed significantly between practices; therefore a pragmatic/targeted focus where there is greatest need would be constructive.
- Inconsistencies in the mention of AKI on discharge summaries can lead to confusion and may benefit from further refinement. Greater clarity in discharge summaries is required to improve primary care confidence in the diagnosis and ongoing management. Key information requested by GPs include: the reason for the AKI; its severity; provision of blood pressure and serum creatinine at discharge as well as evidence of communication of the diagnosis with patients and carers.

- The manual audit conducted as part of the project has supported the development of a Vision informatics tool (Kidney Manager). The CCG and practices may wish to consider use of such software to support ongoing implementation.
- Bury practices have demonstrated significant improvements in coding of episodes of AKI. Implementation of the AKI Business Rules (underpinning the Vision informatics tool) in other CCGs, both regionally and nationally, will enable comparison and in doing so, understand and address variations in care. Importantly however, the tool currently is only able to identify patients coded with AKI.

***Medicine Reconciliation***

National and international consensus guidance emphasise the importance of conducting medication reviews for patients who have had an episode of illness complicated by AKI.[36,50]

- Medicines optimisation is a key element of post-AKI care and is particularly relevant in the management of 'patients previously stabilised on drugs for the treatment of heart failure'.[36] Future work, locally and nationally, may benefit from focusing on greater understanding of medicines reconciliation in patients with existing high risk co-morbidities.[51,52]

***Communication with Patients and Carers***

NICE recommends people who are at risk of AKI are made aware of the potential causes.[12,53] This includes individuals who have a history of AKI; existing CKD; or people with neurological or cognitive impairments or disability with limited access to fluids because of a reliance on a carer.[12]

- Practices across NHS Bury CCG have demonstrated significant improvement in providing written information to patients who have had an episode of illness complicated by AKI.
- Improved coding does not necessarily equate with improved quality of care. Through the lens of AKI, NHS Bury CCG may wish to support patient and carer in participation in future quality improvement initiatives to ensure sufficient understanding, safer transitions of care and support better response to future episodes of acute illness.
- The RCGP Acute Kidney Injury Toolkit[45] provides resources to support communication with patients and carers.

***Kidney Monitoring and Recovery***

NICE recommend a need to 'monitor people for the development or progression of CKD for at least 2-3 years after AKI, even if serum creatinine has returned to baseline'.[53]

Consensus based international (KDIGO) guidelines state that kidney function should be tested 3 months after an AKI event.[2]

- The evaluation demonstrated improvements in post-AKI kidney monitoring.
- The audit focused on monitoring of serum creatinine. Future quality improvement initiatives may wish to consider assessment of proteinuria as part of post-AKI care.
- Greater clarity in discharge summaries including the reason for the AKI, its severity and provision of serum creatinine values at discharge compared to baseline may improve primary care confidence in the diagnosis and help determine the urgency of follow-up, kidney monitoring and ongoing management.[50]

**Conclusions**

Both in the UK and worldwide, targeting AKI is an increasing priority to ensure the delivery of safe and effective care, particularly for people living with complex health and social care needs. To date, the development and evaluation of interventions to improve health outcomes have largely focused on secondary care. Aligned with and building on national patient safety drivers, this project represents an important next step to improve care and outcomes for individuals who have had an episode of illness complicated by AKI. This evaluation suggests that the combination of: incentives; education; and audit and feedback are likely to be important to change activity, but may be insufficient to improve outcomes for this patient population.

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# 8. Appendices

Appendix 1 Episodes of AKI audited indicators by year and quarter, NHS Bury CCG, 2016-17 and 2017-18

| | AKI Episodes | | | Total AKI episodes with: | | | AKI episodes coded in Vision with: | | | AKI episodes not coded in Vision with: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total with AKI reported in discharge summary | With AKI in discharge summary and coded in Vision | With AKI in discharge summary but not coded in Vision | Medication Review within 1 month | Serum creatinine check within 3 months | Written information provided | Medication Review within 1 month | Serum creatinine check within 3 months | Written information provided | Medication Review within 1 month | Serum creatinine check within 3 months | Written information provided |
| **Number of episodes 2016/17** | **633** | **229** | **404** | **100** | **415** | **40** | **52** | **181** | **35** | **48** | **234** | **5** |
| 2016/17 (q1) | 111 | 36 | 75 | 10 | 77 | 4 | 3 | 28 | 3 | 7 | 49 | 1 |
| 2016/17 (q2) | 146 | 38 | 108 | 19 | 98 | 2 | 8 | 30 | 1 | 11 | 68 | 1 |
| 2016/17 (q3) | 168 | 63 | 105 | 32 | 107 | 14 | 14 | 47 | 14 | 18 | 60 | 0 |
| 2016/17 (q4) | 208 | 92 | 116 | 39 | 133 | 20 | 27 | 76 | 17 | 12 | 57 | 3 |
| **Number of episodes 2017/18** | **605** | **303** | **302** | **267** | **438** | **276** | **214** | **272** | **251** | **53** | **166** | **25** |
| 2017/18 (q1) | 137 | 71 | 66 | 71 | 104 | 68 | 55 | 66 | 65 | 16 | 38 | 3 |
| 2017/18 (q2) | 114 | 47 | 67 | 47 | 78 | 50 | 34 | 43 | 41 | 13 | 35 | 9 |
| 2017/18 (q3) | 148 | 74 | 74 | 56 | 95 | 61 | 49 | 63 | 57 | 7 | 32 | 4 |
| 2017/18 (q4) | 206 | 111 | 95 | 93 | 161 | 97 | 76 | 100 | 88 | 17 | 61 | 9 |
| **Percentages 2016/17** | **100** | **36** | **64** | **16** | **66** | **6** | **23** | **79** | **15** | **12** | **58** | **1** |
| 2016/17 (q1) | 100 | 32 | 68 | 9 | 69 | 4 | 8 | 78 | 8 | 9 | 65 | 1 |
| 2016/17 (q2) | 100 | 26 | 74 | 13 | 67 | 1 | 21 | 79 | 3 | 10 | 63 | 1 |
| 2016/17 (q3) | 100 | 38 | 63 | 19 | 64 | 8 | 22 | 75 | 22 | 17 | 57 | 0 |
| 2016/17 (q4) | 100 | 44 | 56 | 19 | 64 | 10 | 29 | 83 | 18 | 10 | 49 | 3 |
| **Percentages 2017/18** | **100** | **50** | **50** | **44** | **72** | **46** | **71** | **90** | **83** | **18** | **55** | **8** |
| 2017/18 (q1) | 100 | 52 | 48 | 52 | 76 | 50 | 77 | 93 | 92 | 24 | 58 | 5 |
| 2017/18 (q2) | 100 | 41 | 59 | 41 | 68 | 44 | 72 | 91 | 87 | 19 | 52 | 13 |
| 2017/18 (q3) | 100 | 50 | 50 | 38 | 64 | 41 | 66 | 85 | 77 | 9 | 43 | 5 |
| 2017/18 (q4) | 100 | 54 | 46 | 45 | 78 | 47 | 68 | 90 | 79 | 18 | 64 | 9 |

Appendix 2 AKI Read codes identified in Vision and screened for inclusion/exclusion in the audit

| Diagnosis Read code | Description | Codes included/ excluded |
|---|---|---|
| K04..12 | Acute Kidney Injury | Yes |
| K04C.00 | AKI Stage 1 | Yes |
| K04E.00 | AKI Stage 2 | Yes |
| K04D.00 | AKI Stage 3 | Yes |
| 14D8.00 | H/O: AKI | No |
| 451L.00 | AKI warning stage | No |
| K04..00 | Acute renal failure | No |
| S76..00 | Injury to kidney | No |
| H2y..00 | Other specified pneumonia or influenza b pneumonia with AKI | No |
| K06..00 | Renal failure unspecified | No |

| Medication review Read code | Description | Codes included/ excluded |
|---|---|---|
| 8B3S.00 | Medication review | Yes |
| 8B31400 | Medication review | Yes |
| 8B3x.00 | Medication review with patient | Yes |
| 8B3V.00 | Medication review done | Yes |
| 8BMX.00 | Medication review done by medicines management technician | Yes |
| 8B3y.00 | Medication review of medical notes | Yes |
| 8BIC.00 | Medication review done by pharmacist | Yes |
| 8BI..00 | Other medication review | Yes |
| 8b3h.00 | Medication review without patient | Yes |
| 8B31B00 | Polypharmacy medication review | Yes |
| 8B31800 | Medication reconciliation | Yes |
| 6A…00 | Patient reviewed | No |
| 9b0O.00 | Initial post discharge review | No |
| 8B31300 | Medication commenced | No |
| 8B3A.100 | Medication increased | No |
| 8B3U.00 | Medication review due | No |
| 9p…00 | Medication monitoring administration | No |

Appendix 3 Effect of Bury intervention on readmission, mortality, length of stay and number of bed days for GP practices above and below average levels of diagnostic coding and provision of a medication review within one month of discharge.

| Outcome | Period | Mean outcomes | | Parallel trends | Effect for Bury below Average vs. controls | 95% Confidence interval | Effect for Bury above Average vs. Bury below Average | 95% Confidence interval |
|---|---|---|---|---|---|---|---|---|
| | | Bury Above Average | Bury Below Average | | | | | |
| Readmission within 30 days | Pre | 0.15 | 0.19 | Non-parallel | -0.017 | [-0.048; 0.014] | 0.012 | [-0.025; 0.049] |
| *(Probability: 0 to 1)* | Post | 0.19 | 0.18 | | | | | |
| Readmission within 90 days | Pre | 0.27 | 0.30 | Non-parallel | -0.011 | [-0.046; 0.024] | 0.003 | [-0.042; 0.048] |
| *(Probability: 0 to 1)* | Post | 0.28 | 0.27 | | | | | |
| Mortality within 30 days | Pre | 0.09 | 0.08 | Non-parallel | -0.007 | [-0.029; 0.015] | 0.025 | [-0.002; 0.052] |
| *(Probability: 0 to 1)* | Post | 0.09 | 0.08 | | | | | |
| Mortality within 90 days | Pre | 0.15 | 0.13 | Non-parallel | -0.004 | [-0.031; 0.023] | 0.011 | [-0.024; 0.046] |
| *(Probability: 0 to 1)* | Post | 0.14 | 0.13 | | | | | |
| Readmission length of stay | Pre | 2.74 | 2.66 | Non-parallel | -0.100 | [-0.553; 0.353] | 0.200 | [-0.265; 0.665] |
| *(Number of days)* | Post | 2.39 | 2.15 | | | | | |
| Bed days within 90 days | Pre | 4.09 | 4.35 | Non-parallel | 0.245 | [-0.708; 1.200] | -0.251 | [-1.209; 0.707] |
| *(Number of days)* | Post | 3.57 | 3.66 | | | | | |

We report estimation results from the lagged dependent variable estimation if the parallel trends assumption fails. The total number of observations is 2,234. Outcomes relate to the first admission complicated by AKI in the time period covered by the analysis. Readmission indicates unplanned readmissions after discharge, death indicates death after discharge. Length of stay is the number of nights of the first readmission after discharge within 90 days. Number of bed days indicates the total number of bed days within 90 days from discharge including all readmissions. All analysis includes GP-practice fixed effects quarter of the year fixed effects. We risk adjust on the individual level by including average GP-levels of: gender of the patients, age of the patients, residential hospital admission, residential hospital discharge, Elixhauser co-morbidities of the patients, and the primary diagnosis group of the patients.

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