Improving coding and primary care management for people with Chronic Kidney Disease: an observational controlled study in east London.

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How this Fits in

Diagnostic coding for Chronic Kidney Disease (CKD) in the GP record is less than optimal. Absence of coding is associated with poorer blood pressure control and management of cardiovascular risk, observational data also demonstrate higher rates of unplanned hospital admission among uncoded cases.

This project demonstrates that a rapid and sustained improvement in CKD coding can be achieved across clinical commissioning groups using a range of quality improvement techniques.

Abstract

Background

Evidence from the UK national chronic kidney disease (CKD) audit in primary care shows that diagnostic coding in the electronic health record for CKD averages 70% with wide practice variation. Coding is associated with improvements to risk factor management, and there is evidence that CKD cases coded in primary care have lower rates of unplanned hospital admission.

Aim

To increase the diagnostic coding of CKD (stages 3-5) and key aspects of primary care management, including blood pressure to target and prescription of lipid lowering medication to reduce cardiovascular disease (CVD) risk.

Design and Setting

Prospective, controlled, cross sectional study set in four clinical commissioning groups (CCGs) in east London.

Method

Interventions to improve coding formed part of a larger system change to the delivery of renal services in both primary and secondary care in east London. These included dashboards with key performance indicators, searches to enable practices to identify un-coded cases and monitor progress, and safety tools to identify cases with a falling estimated glomerular filtration rate (eGFR). This was supplemented with practice-based facilitation on using the quality improvement (QI) tools, and with education sessions. Additional renal specific clinical facilitation was provided for practices in the lowest decile of CKD coding.

Quarterly anonymised data on CKD coding, blood pressure values and statin prescriptions were extracted from practice computer systems for a one year period pre and post the start of the intervention.

Results

All three intervention CCGs showed significant coding improvement over a one year period following the intervention (regression for post intervention trend $p<0.001$). The CCG with highest coding rates increased from 76% to 90% of CKD cases coded, the lowest coding CCG increased from 52% to 76%. The comparison CCG showed no change in coding rates.

Combined data from all practices in the intervention CCGs showed a significant increase in the proportion of cases with blood pressure achieving target levels (difference in proportion $p<0.001$) over the two year study period. Differences in statin prescribing were not significant.

Conclusions

Clinically important improvements to coding and management of CKD in primary care can be achieved by QI interventions which use shared data to track and monitor change supported by practice based facilitation. Alignment of clinical and CCG priorities and the provision of clinical targets, financial incentives and educational resource were additional important elements of the intervention.

Background

The estimated prevalence of Chronic Kidney Disease (CKD) stages 3-5 in the UK is 5-6% (1). Early identification of people with CKD in primary care, particularly among those with risk factors such as diabetes and hypertension, enables proactive management of blood pressure, cardiovascular risk and lifestyle factors and referral to specialist services where there is evidence of progressive disease (2). There is some evidence, albeit inconsistent (3) that progression of CKD can be delayed by reduction of blood pressure (4). High rates of cardiovascular risk associated with CKD can be reduced by blood pressure control and the use of statins (5, 6). There is evidence that delivery of these interventions in primary care can be extended through the target population by the use of quality improvement tools including local audits of CKD management, feedback and education. (7, 8).

Delivering improvements to the management of CKD in primary care involves a range of organisational and clinical negotiations. There is a continuing debate on whether the early identification of CKD is clinically important, or whether it is an example of over diagnosis and prone to over treatment (9, 10). This contributes to ambivalence among clinicians around disclosing a diagnosis of CKD to individuals. In turn this subverts the opportunities for patient engagement with lifestyle changes which lie at the heart of early management (11). Additional challenges include the uncertainty of best clinical management in older and multimorbid patients (12, 13), and the complexity of the Read codes used for labelling CKD stage in GP computer systems.

Adding a diagnostic CKD Read code to the electronic health record (EHR) enables regular recall for review, and provides a marker for the increased clinical scrutiny necessary for better management – in particular blood pressure control, an offer of lipid lowering medication, and the avoidance of hazardous prescribing. The first report from the UK national CKD audit in primary care (1) demonstrated that on average 70% of biochemically confirmed cases of CKD (stages 3-5) were given a diagnostic Read code. There was wide variation between practices, with the proportion of CKD cases un-coded ranging between 0% to 80%. Further analysis based on data from the NCKD audit demonstrates an association between coding status and management activity in primary care. Coded cases had higher rates of blood pressure to target, statin use, assessment of urinary albumin creatinine ratio and immunisations (14).

The second part of the national CKD audit linked hospital data on outcomes to the cases identified in primary care (15). There were associations between lack of coding in primary care with higher rates of unplanned hospital admissions, acute kidney injury admissions and deaths. The magnitude of the difference in admission rates between coded and un-coded patients increases as kidney function declines. As the eGFR declines below 40ml/min the unplanned admission rate doubles for un-coded cases (15).

Translating evidence into routine clinical practice faces multiple challenges, including understanding professional knowledge and beliefs and an appreciation of the structure, organisation and context of healthcare in any given locality. Some of the key strategies for change management described by Kotter (16) were reflected in planning the implementation of this programme. These include: building the case for change and forming a guiding coalition which includes both clinicians and managers, empowering others to act on the programme by the provision of education, comparative performance data and quality improvement (QI) tools, creating early wins for the programme and consolidating the new approach into work as usual to ensure sustainability.

Aims

This quality improvement programme aimed to modify health professional behaviour to increase the recorded diagnosis of CKD (stages 3-5) and improve key aspects of primary care management including blood pressure control and provision of lipid lowering medication for cardiovascular risk reduction.

Methods

Study design and setting

This prospective, controlled, cross sectional study was set in east London primary care between 2016-2018. All 130 GP practices in three inner east London CCGs (City and Hackney, Newham and Tower Hamlets) received all elements of the intervention. The 37 practices in a fourth CCG (Waltham Forest) did not start the intervention package until one year later and acted as a comparison group. In the 2011 UK Census, almost half of the population in each of these CCGs was recorded to be of non-white ethnic origin (17), and the English indices of deprivation 2015 show that all three intervention localities fall in the lowest decile for social deprivation in England (18).

Intervention

The intervention was conceived as a renal learning health system (19), in which data from all parts of the system are used as feedback to improve both the future organisation and clinical performance within it. The interventions which supported CKD coding were part of a larger system change to the delivery of renal care, which encompassed the patient pathway from diagnostic identification and management in primary care through to attendance at the nephrology outpatient clinic.

The system wide changes to the delivery of renal care had four components.

a) A package of IT tools which support practices to identify patients requiring diagnostic coding, improvements to blood pressure and cardiovascular management, and alerts to identify cases with a falling estimated glomerular filtration rate (eGFR). Regular practice facilitation on clinical data management as offered routinely by the Clinical Effectiveness Group (CEG) supported this package (https://www.qmul.ac.uk/blizard/ceg/). Additional renal specific clinical facilitation, which focussed on the importance of CKD coding, CVD and BP management, was offered to practice teams in the lowest decile of CKD coding.

b) Renal education and case discussions for general practitioners and practice nurses at CCG, cluster and practice events in all participating CCGs.

c) A virtual CKD hospital clinic enabling nephrologists to view the primary care electronic health record (EHR), with informed patient consent, and document advice in the shared record available for all primary care clinicians to see. The clinic had a short wait time (approximately 7 days – previously the average wait was 64 days) with the aim of providing

timely clinical advice for GPs in the EHR, and triaging the minority of patients who required further investigation into out-patient clinics.

d) Specialist renal nurse led patient education sessions for those referred into the service.

Within this framework the interventions which primarily targeted the improvement of CKD coding and management included: practice based education sessions, the package of computerised quality improvement tools with facilitation, data sharing across practices and CCG provision of financial incentives for target achievement at practice and cluster level.

Important contextual background to the intervention is that all 130 practices in the three intervention CCGs had prior experience of working with clinical data entry templates, quality improvement tools and performance dashboards developed by the Clinical Effectiveness Group and the associated practice facilitation supporting the effective use of primary care data for better management of long term conditions. (20) All three intervention clinical commissioning groups (CCGs) supported the renal programme with a range of practice targets and financial incentives built into the enhanced service element of general practice contracts during the intervention period.

The control CCG began implementation of the virtual CKD clinic during the intervention year, and had clinician education sessions, but had no quality improvement tools or regular facilitation.

Data collection

Renal function, expressed as the estimated glomerular filtration rate (eGFR), was calculated from recorded creatinine using the four variable modification of diet in renal disease (MDRD) equation, which adjusts for gender and Black ethnicity. (21) The study population with CKD (stages 3-5) in each CCG was identified from eGFR values of <60 ml/min/1.73m^2 in the two most recent readings at least three months apart.

Demographic and clinical data were obtained for all adults over the age of 18 with biochemical evidence of CKD. Patient-level variables included, age, sex, ethnicity, latest blood pressure values and diagnostic Read codes for diabetes mellitus, hypertension and CKD. All data were anonymised, and managed according to UK NHS information governance requirements.

Anonymised practice coding and primary care management data were collected on a quarterly basis through EMIS Web. (https://www.emishealth.com/products/emis-

web?tab=primary-caref) This was collated into CCG and practice level dashboards and shared with commissioners and practice staff. Quarterly data from the control CCG was not available prior to April 2016. Reflecting the open cohort design, the population at each quarter differed from the previous one, reflecting the additions and losses from GP registered lists. A quarterly CKD service newsletter was also circulated providing further feedback to practices on coding performance.

All statistical analyses were performed using Stata v.14. (https://www.stata.com/) Linear regression analysis was used to examine the change in trend of the proportion of patients with a CKD Read code pre and post intervention for each CCG. Proportions with 'BP to target' and statin prescriptions were examined, pre and post intervention. 'BP to target' refers to all patients with biochemical evidence of CKD with a BP <140/70 mm/Hg, or <130/80 mm/Hg for those with diabetes or a urinary albumin creatinine ratio (uACR) >70 mg/g . For non-diabetic patients with no recorded uACR values, we used the higher BP target. A two-level multilevel logistic regression model was used to observe the univariate and adjusted odds ratios (OR) in patients on statins and patients with a BP to target, comparing intervention and control CCGs at the beginning and end of the study period. Standard errors were adjusted by clustering by practice.

The study conformed to the Standards for Quality Improvement Reporting Excellence (SQUIRE V2.0) guidance(22).

Results

Data were collected for 167 practices, of which 130 were in the intervention CCGs and 37 were in the control group. At the final data collection point (April 2018) the number of people with biochemical evidence of CKD (stages 3-5) across all practices was 21,428.

Baseline CKD coding data were collected quarterly for each of the three intervention CCGs for one year prior to the start of the intervention. All three intervention CCGs showed significant coding improvement over a one year period following the intervention (regression for post intervention trend $p<0.001$). The CCG which started with the highest coding rates increased from 76% to 90% of CKD cases coded, the CCG with lowest coding rates increased from 52% to 76%. (see figure 1.) The control CCG showed no change in coding over the two year period (April 2016 to April 2018). Variation in practice performance was also reduced. (figure 2)

Changes in the proportion of CKD cases with BP to target, and those prescribed lipid-lowering medication over the two year period were examined for all people with CKD in the three intervention CCGs combined. There was a significant increase in the proportion of people with blood pressure achieving target levels (difference in proportion $p<0.001$) differences in statin prescribing were not significant, see table 1.

The management of BP and CVD risk (statin prescribing) between control and intervention CCGs was compared at baseline (April 2016) and at the end of the study period (April 2018). At both baseline and endpoint the intervention CCGs performed better than the control CCG. Endpoint comparison shows BP to target (adjusted OR 1.48, 95%CI 1.29 to 1.71) and statin prescribing (adjusted OR 1.41, 95%CI 1.23 to 1.60), see tables 2-4.

Differences in BP and statin prescribing were also examined by each participating CCG. This demonstrates almost twice the odds of statin use in those with CKD in Tower Hamlets compared with Waltham Forest (adjusted OR 1.95 95% CI 1.69 to 2.24) and almost twice the odds of blood pressure to target in those with CKD in City and Hackney compared with Waltham Forest (adjusted OR 1.92, 95% CI 1.64 to 2.24) (see tables in appendix).

The average difference in mean systolic BP for people with CKD between the combined intervention CCGs and the control CCGs was 2.2 mmHg (intervention CCGs 130.5 SD 15, control CCG 132.7 SD 15.5, t-test for comparison of means, $p<0.001$) see appendix table 3.

Discussion

Main findings

Over a two year study period a linked set of interventions to improve CKD coding and management, embedded within a system wide renal service change, has significantly increased CKD coding among general practices in three geographically contiguous CCGs. This has been accompanied by significant improvements in management of BP to target.

In comparison to the control CCG practices in the two intervention CCGs had a significantly higher odds of achieving BP to target and prescribing statins for CVD protection. These are two aspects of care for people with renal impairment which make an important difference to the risk of a CVD event. (23) However these differences were also present at the start of the observation period and cannot be attributed to the intervention.

The average difference in BP between the people with CKD in the intervention and control group was 2.2 mmHg. Such changes to whole population blood pressure control may reduce the progression of kidney disease, particularly for those with proteinuria. (4)

Strengths and limitations

A strength of this study is the application of this complex service change to whole health economies, rather than to selected practices. The inclusion of a natural control CCG strengthens the impact of the intervention. In the financial year 2017-18 there was partial change to the renal service in the control CCG. Some diffusion of the intervention was likely, as the service change was widely reported by CCGs at sustainability and transformation plan (STP) events. This would be expected to reduce the between group differences.

The involvement of consultant nephrologists and specialist renal nurses in all elements of service delivery was a key aspect of the success of this programme, which builds on the core elements of quality improvement and change management which the Clinical Effectiveness Group has delivered in other clinical domains. (24-26) The importance of demonstrating early programme success, by regular feedback of coding improvement, reflects the use of the '*strategy for change'* described by Kotter.(16)

This was a pragmatic programme evaluation, recognising variation in the way the intervention was implemented in each of the three CCGs, for example some minor differences in the choice of practice level achievement targets and the delivery of financial incentives for coding. The decision to concentrate specialist renal nurse facilitation in Newham CCG, which had the lowest baseline coding rates, also creates unevenness in implementation of the different elements of the programme. The importance of recognising these contextual differences between CCGs in their approach to implementing and incentivising change within constituent practices is an essential consideration in future decisions on scaling up such interventions. Differences in context may determine the effectiveness of implementation, and hence the likelihood of achieving similar changes to that reported in this study.

Comparisons with existing literature

Other studies have demonstrated the existing shortfall in the primary care management of CKD in comparison to national guidance, Hull et al in 2011 found that 50% of those with a diagnosis of hypertension and an eGFR<60 ml/min/1.73m^2 had a BP <130/80 (27), while Van Gelder et al 2016, in the Netherlands, found coding rates of 31% and BP managed to target in 43% (28), Fraser and others have demonstrated the burden of co-morbidities among those with CKD managed in primary care. (29)

Previous trials and quality improvement strategies, which show evidence of effectiveness for improving BP management, have largely focussed on selected high risk populations with CKD rather than unselected primary care populations. (30) A pragmatic trial in primary care using audit-based education found a similar 2mmHg reduction in systolic BP comparing practices exposed to guidelines and prompts or to usual care.(8)

A number of studies have demonstrated associations between CKD and risk of all cause hospitalisation.(31) A recent matched primary care cohort found twice the risk of admission for heart failure and a fivefold risk of AKI admission among those with CKD stage 3B in comparison to no CKD. (32) This suggests that a focus on improved coding and management for those with CKD and associated conditions such as heart failure could contribute to a reduction in hospital admissions.

Implications for practice

This report forms part of the evaluation of a system change in the delivery of care for people with CKD across primary and secondary settings in east London.

The learning renal health system we describe has implications for clinical practice and patient safety on a national scale. If all CCGs in England adopted a similar approach to improve CKD coding and the management of BP in the CKD population, this would have a significant effect on the risk of CVD events, and may possibly reduce hospital admissions.

The three intervention CCGs had a well-developed working relationship with the CEG (20) and the range of primary care support services they offer. Historically the clinicians and managers in these CCGs have been early adopters of evidence based clinical change of value to patients and the health economy. Such interventions require an IT infrastructure to enable the delivery of practice dashboards and the facilitation required to engage practice teams in using IT tools to support clinical change. They also require a stable and respectful relationship between managers, clinicians and secondary care specialists to engage in data sharing for learning across the whole patient pathway, and hence utilise to the full the opportunities for service change and development.

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Ethical approval
Ethical approval was not required as patient-level data are anonymised, and only aggregated patient data are reported in this study. All GPs in the participating east London practices consented to the use of their anonymised patient data for research and development for patient benefit.

Competing interests
The authors have declared no competing interests.

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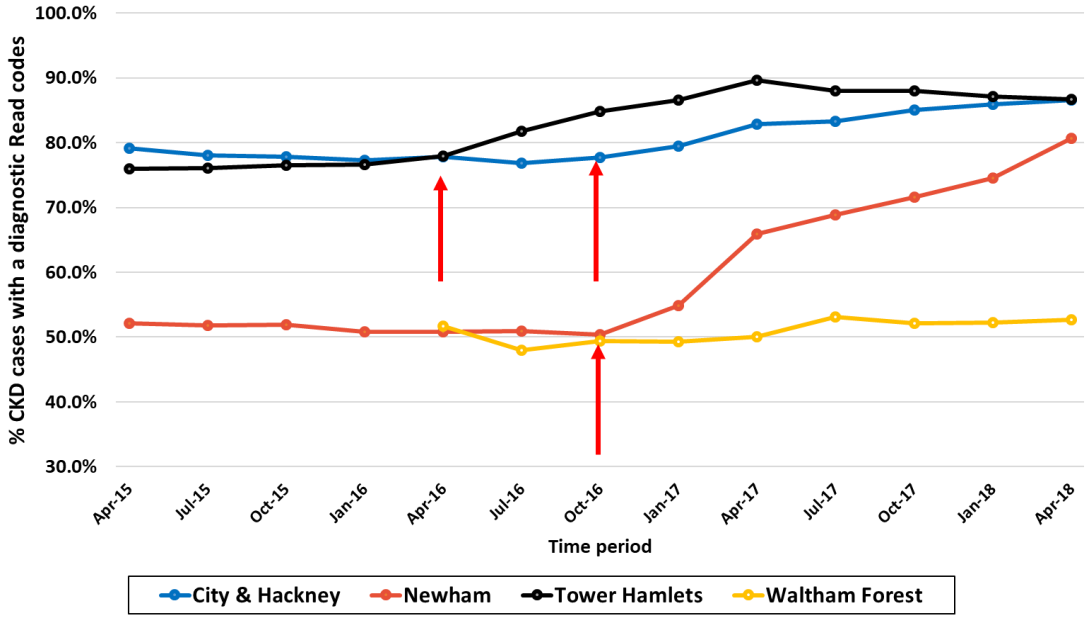
Figure 1. Coding improvement across 3 intervention CCGs in east London compared to the control CCG (Waltham Forest)



The red arrows indicate the start of the intervention. Tower Hamlets in April 2016, Newham and City & Hackney in October 2016. Data from Waltham Forest was only available from April 2016.

Regression for post intervention trend

CCG	Coding change/quarter	P value	95% confidence intervals
Tower Hamlets	2.85%	P<0.001	1.73 to 3.96
City and Hackney	2.76%	P<0.001	1.96 to 3.55
Newham	5.03%	P<0.001	3.76 to 6.28

Figure 2. Practice CKD coding: improvement and reduction in practice variation Newham CCG 2016-18.

Each dot represents a practice. The funnel plot on the L shows practice coding performance at the start of the intervention. The funnel plot on the R shows coding performance at the end of the project.
The tracer plots on the R hand side show the changes in coding rates, tracked over 2 years, by 8 practices which started in the lowest coding quintile.

Table 1. Changes in the proportion of people with CKD achieving BP to target[1] and statin prescribing in the three intervention CCGs over the two-year study period.

	Pre-intervention: January 2016 (N=16298)	Post intervention: April 2018 (N=15811)	P-value[2]
Blood pressure to target: *N=16,300*	Mean proportion 0.52	0.54	P <0.001
Statin use: *N=16,300*	Mean proportion 0.75	0.76	p = 0.064

[1] All CKD patients with BP <140/90 and <130/80 if diabetes/uACR>70

[2] A test of proportion was conducted to compare proportions one year pre- and post-intervention

Table 2. Characteristics of all study patients with biochemical evidence of CKD (Stages 3-5) at the end of the study period

	Total All N (%) 21428 (100)	Waltham Forest N (%) 5617 (26.2)	Tower Hamlets N (%) 4933 (23.0)	Newham N (%) 7250 (33.8)	City & Hackney N (%) 3628 (16.9)
Gender					
Female	12200 (56.9)	3222 (57.4)	2798 (56.7)	4124 (56.9)	2056 (56.7)
Male	9226 (43.1)	2393 (42.6)	2135 (43.3)	3126 (43.1)	1572 (43.3)
Age group					
<60	3510 (16.4)	797 (14.2)	749 (15.2)	1381 (19.0)	583 (16.1)
60 - 69	4103 (19.2)	977 (17.4)	956 (19.4)	1555 (21.5)	615 (17.0)
70 - 79	6245 (29.1)	1730 (30.8)	1346 (27.3)	2159 (29.8)	1010 (27.8)
≥80	7570 (35.3)	2113 (37.6)	1882 (38.2)	2155 (29.7)	1420 (39.1)
Ethnic group					
White	10624 (49.6)	3213 (57.2)	2588 (52.5)	2941 (40.6)	1882 (51.9)
South Asian	6069 (28.3)	1042 (18.6)	1782 (36.1)	2846 (39.3)	399 (11.0)
Black	2999 (14.0)	657 (11.7)	330 (6.7)	1068 (14.7)	944 (26.0)
Other	851 (4.0)	174 (3.1)	134 (2.7)	289 (4.0)	254 (7.0)
Not stated	885 (4.1)	531 (9.5)	99 (2.0)	106 (1.5)	149 (4.1)
Diabetes					
No	12477 (58.2)	3612 (64.3)	2682 (54.4)	4131 (57.0)	2052 (56.6)
Yes	8951 (41.8)	2005 (35.7)	2251 (45.6)	3119 (43.0)	1576 (43.4)
Hypertension					
No	5167 (24.1)	1529 (27.2)	1227 (24.9)	1746 (24.1)	665 (18.3)
Yes	16261 (75.9)	4088 (72.8)	3706 (75.1)	5504 (75.9)	2963 (81.7)
Statins					
No	5784 (27.0)	1932 (34.4)	913 (18.5)	1999 (27.6)	940 (25.9)
Yes	15644 (73.0)	3685 (65.6)	4020 (81.5)	5251 (72.4)	2688 (74.1)
BP to target[1]					
No	10396 (48.5)	3026 (53.9)	2185 (44.3)	3666 (50.6)	1519 (41.9)
Yes	11032 (51.5)	2591 (46.1)	2748 (55.7)	3584 (49.4)	2109 (58.1)
Mean Systolic BP (SD)	131.1 (15.2)	132.7 (15.5)	130.6 (15.5)	131.1 (14.8)	129.2 (14.7)

[1]All CKD patients with BP <140/90 and <130/80 if diabetes/uACR>70

Table 3. Odds ratios for statin use in people with CKD. Comparing intervention CCGs with control CCG at baseline and one-year post intervention[1]

Baseline comparison (March 2016)			Comparison one-year post intervention		
CCG	N	**Adjusted OR (95% CI)**	**CCG**	N	**Adjusted OR (95% CI)**
Without intervention	4909	1	**Without intervention**	5617	1
With intervention	16059	1.53 (1.35-1.73)	**With intervention**	15811	1.41 (1.23-1.60)

[1]*Adjusted for age, sex, ethnicity, presence of diabetes, hypertension and CKD coding. Standard errors are adjusted for clustering by practice.*

Table 4. Odds ratios for blood pressure to target[1] in people with CKD, comparing intervention CCGs with control CCG at baseline and one-year post intervention[2]

Baseline comparison (March 2016)			Comparison one-year post intervention		
CCG	N	**Adjusted OR (95% CI)**	**CCG**	N	**Adjusted OR (95% CI)**
Without intervention	4909	1	**Without intervention**	5617	1
With intervention	16059	1.65 (1.43-1.89)	**With intervention**	15811	1.48 (1.29-1.71)

[1] *All CKD patients with BP <140/90 and <130/80 if diabetes/uACR>70*
[2]*Adjusted for age, sex, ethnicity, presence of diabetes, hypertension and CKD coding. Standard errors are adjusted for clustering by practice*

Appendix Table 1. Odds ratios for statin use in people with CKD, comparing individual intervention CCGs with control CCG at one year after the intervention[1]

	N	Unadjusted OR (95% CI)	p-value	Adjusted[2] OR (95% CI)	p-value
CCG					
Waltham Forest	5617	1.0		1.0	
Tower Hamlets	4933	2.25 (1.92-2.62)	<0.001	1.95 (1.69-2.24)	<0.001
Newham	7250	1.34 (1.17-1.54)	<0.001	1.16 (1.02-1.32)	0.018
City & Hackney	3628	1.48 (1.27-1.73)	<0.001	1.34 (1.17-1.55)	<0.001
Age group (years)					
<60	3510	1.0		1.0	
60 - 69	4103	3.03 (2.74-3.35)	<0.001	2.47 (2.21-2.75)	<0.001
70 - 79	6245	4.29 (3.90-4.71)	<0.001	3.42 (3.09-3.80)	<0.001
≥80	7570	2.87 (2.63-3.13)	<0.001	2.29 (2.07-2.52)	<0.001
Gender					
Female	12200	1.0		1.0	
Male	9226	1.37 (1.29-1.46)	<0.001	1.33 (1.24-1.42)	<0.001
White	10624	1.0		1.0	
South Asian	6069	1.73 (1.59-1.88)	<0.001	1.33 (1.21-1.47)	<0.001
Black	2999	0.99 (0.90-1.09)	0.887	0.69 (0.62-0.76)	<0.001
Other	851	1.01 (0.86-1.19)	0.882	0.82 (0.69-0.98)	0.030
Not stated	885	0.50 (0.43-0.58)	<0.001	0.65 (0.55-0.76)	<0.001
Diabetes					
No	12477	1.0		1.0	
Yes	8951	5.76 (5.32-6.23)	<0.001	4.67 (4.29-5.07)	<0.001
Hypertension					
No	5167	1.0		1.0	
Yes	16261	2.95 (2.76-3.16)	<0.001	2.27 (2.10-2.45)	<0.001
Coded					
No	5191	1.0		1.0	
Yes	16237	1.93 (1.79-2.08)	<0.001	1.32 (1.21- 1.43)	<0.001

[1]Adjusted for age, sex, ethnicity, prevalence of diabetes, hypertension and practice coding rates. Standard errors are adjusted for clustering by practice.

Appendix Table 2. Odds ratios for blood pressure to target[1] in people with CKD, comparing each intervention CCG with the control CCG at one year post intervention[2].

	N	Unadjusted OR (95% CI)	p-value	Adjusted[2] OR (95% CI)	p-value
CCG					
Waltham Forest	5617	1.0		1.0	
Tower Hamlets	4933	1.52 (1.32-1.75)	<0.001	1.61 (1.38-1.87)	<0.001
Newham	7250	1.12 (0.99-1.27)	0.083	1.16 (1.01-1.34)	0.039
City & Hackney	3628	1.69 (1.47-1.95)	<0.001	1.92 (1.64-2.24)	<0.001
Diabetes					
No	12477	1.0		1.0	
Yes	8951	0.32 (0.30-0.32)	<0.001	0.31 (0.29-0.33)	<0.001
Hypertension					
No	5167	1.0		1.0	
Yes	16261	0.75 (0.71-0.80)	<0.001	0.90 (0.84-0.96)	0.003
CKD Coded					
No	5191	1.0		1.0	
Yes	16237	0.96 (0.90-1.03)	0.25	1.14 (1.06-1.23)	0.001
Gender					
Female	12200	1.0		1.0	
Male	9226	1.06 (1.00-1.12)	0.055	1.16 (1.09-1.23)	<0.001
Age group (years)					
<60	3510	1.0		1.0	
60 - 69	4103	0.96 (0.87-1.05)	0.327	1.18 (1.07-1.30)	0.001
70 - 79	6245	0.98 (0.90-1.07)	0.699	1.22 (1.12-1.34)	<0.001
≥80	7570	1.00 (0.92-1.09)	0.992	1.15 (1.05-1.26)	0.002
Ethnic group					
White	10624	1.0		1.0	
South Asian	6069	0.76 (0.71-0.81)	<0.001	1.08 (1.00-1.16)	0.062
Black	2999	0.60 (0.55-0.66)	<0.001	0.76 (0.70-0.84)	<0.001
Other	851	0.88 (0.76-1.02)	0.085	1.05 (0.76-1.02)	0.551

[1] All CKD patients with BP <140/90 and <130/80 if diabetes/uACR≥70

[2]Adjusted for age, sex, ethnicity, diabetes, hypertension and coding. Standard errors are adjusted for clustering by practice.

Appendix Table 3. Mean systolic BP (SD) for people with CKD post intervention. Comparing intervention CCGs with control CCG.

	All	Waltham Forest (Control)	Tower Hamlets	Newham	City and Hackney	Intervention CCGs	p-value
Mean BP							
Systolic BP	131.1 (15.2)	132.7 (15.5)	130.6 (15.5)	131.1 (14.8)	129.2 (14.7)	130.5 (15.0)	<0.001
Diabetic or uACR≥70							
Systolic BP	131.2 (15.1)	132.9 (15.3)	131.1 (15.6)	131.3 (14.6)	129.2 (14.6)	130.7 (15.0)	<0.001
No diabetes, uACR≤70							
Systolic BP	130.9 (15.2)	132.6 (15.6)	130.1 (15.3)	130.9 (15.0)	129.2 (14.7)	130.2 (15.1)	<0.001